Nature News

周二, 10 10月 2017

Nature News

[周二, 10 10月 2017]

- **Nature News**

Nature News

Nature is a weekly international journal publishing the finest peer-reviewed research in all fields of science and technology on the basis of its originality, importance, interdisciplinary interest, timeliness, accessibility, elegance and surprising conclusions. Nature also provides rapid, authoritative, insightful and arresting news and interpretation of topical and coming trends affecting science, scientists and the wider public.

- **Cancer-genome study challenges mouse 'avatars'** [周一, 09 10月 08:00]
  Grafting human cancer cells into mice alters tumour evolution.
- **LIGO's unsung heroes** [周一, 09 10月 08:00]
  Nature highlights just a few of the people who played a crucial part in the discovery of gravitational waves — but didn't win the Nobel Prize.
- **Build on the outer space treaty** [周一, 09 10月 08:00]
  Fifty years on, the agreement is being pushed to its limits by changing geopolitics, technology and commercial interests, warns Joan Johnson-Freese.
- **Navajo Nation reconsiders ban on genetic research** [周五, 06 10月 08:00]
  Tribal leaders are developing a policy for genetic research and data sharing, potentially ending a 15-year moratorium.
- **The scientist who spots fake videos** [周五, 06 10月 08:00]
  Hany Farid discusses how to detect image manipulations — and the increasing sophistication of forgers.
- **Proton-size puzzle deepens** [周四, 05 10月 08:00]
  Measurement in ordinary hydrogen agrees with a surprising 2010 result on the element's exotic cousin — but gives a smaller value than virtually every other experiment.
- **Controversial pesticides found in honey samples from six continents** [周四, 05 10月 08:00]
  Neonicotinoids are at the centre of a long-running debate about whether they harm bees.
- **Antikythera shipwreck yields statue pieces and mystery bronze disc** [周三, 04 10月 08:00]
  Archaeologists think that at least seven life-sized sculptures are hidden nearby.
- **Cryo-electron microscopy wins chemistry Nobel** [周三, 04 10月 08:00]
  Jacques Dubochet, Joachim Frank and Richard Henderson share the prize for developing a technique to image biomolecules.
- **Crash in sea-turtle births stumps ecologists** [周三, 04 10月 08:00]
  Leading suspect — climate change — doesn't fully explain what is happening to leatherback turtles in the US Virgin Islands.

- **Scientists plead with Brazilian government to restore funding** [周三, 04 10月 08:00]
  If officials don't act soon, research institutions could start shutting down next year.
- **Supercomputer redesign of aeroplane wing mirrors bird anatomy** [周三, 04 10月 08:00]
  Bird-bone structures emerge from an evolution-like algorithm.
- **Elite Hungarian university may be saved** [周三, 04 10月 08:00]
  Hungary-New York agreement could allow Central European University to sidestep law change.
- **Science without walls is good for all** [周三, 04 10月 08:00]
  International mobility and collaboration are linked to stronger research.
- **Nobel prizes, giant telescope and buried treasure** [周三, 04 10月 08:00]
  The week in science: 29 September–5 October 2017.
- **Why fake islands might be a real boon for science** [周三, 04 10月 08:00]
  The seasteading movement is getting close to building its first prototype, an artificial archipelago where people will live, play and do research.
- **How fracking is upending the chemical industry** [周三, 04 10月 08:00]
  As shale-gas compounds flood the market, chemists are working out the best ways to convert them into the ingredients of modern life.
- **Scientists have most impact when they're free to move** [周三, 04 10月 08:00]
  An analysis of researchers' global mobility reveals that limiting the circulation of scholars will damage the scientific system, say Cassidy R. Sugimoto and colleagues.
- **Open countries have strong science** [周三, 04 10月 08:00]
  Caroline S. Wagner and Koen Jonkers find a clear correlation between a nation's scientific influence and the links it fosters with foreign researchers.
- **Neuroscience: The mother lode of invention** [周三, 04 10月 08:00]
  Dan Jones compares three studies on the origins and fruits of human creativity.
- **Health: The war on germs** [周三, 04 10月 08:00]
  Tilli Tansey hails a history of Joseph Lister's drive to vanquish post-operative infection and putrefaction.
- **New in paperback** [周三, 04 10月 08:00]
  Highlights of this season's releases
- **Sustainability: China's path to ecotopia** [周三, 04 10月 08:00]
  Xuemei Bai critiques a critique of the country's eco-city initiative.
- **Ornithology: All eyes on the 10,000 species** [周三, 04 10月 08:00]
  Stuart Pimm considers the obsessive, sometimes dark side to the joyous pursuit of watching birds.

- **[Theoretical physics: When the doer met the dreamer]** [周三, 04 10月 08:00]
  Graham Farmelo applauds a study on the productive friendship of two very different physicists.
- **[Technology: Into cyberia]** [周三, 04 10月 08:00]
  Li Gong weighs up three tomes on Silicon Valley's vast influence, for good or ill.
- **[Fossil fuels: Heed local impact of coal mining]** [周三, 04 10月 08:00]
- **[Hurricanes: rescue natural defences]** [周三, 04 10月 08:00]
- **[Hurricanes: enlist nature's protection]** [周三, 04 10月 08:00]
- **[World Heritage Site: UNESCO honour for Polish mining facility]** [周三, 04 10月 08:00]
- **[Food supply: Blockchain could boost food security]** [周三, 04 10月 08:00]
- **[Collaborative software development made easy]** [周三, 04 10月 08:00]
  Save time and protect critical code with 'continuous integration' services.
- **[A taste of Toolbox]** [周三, 04 10月 08:00]
  Nature 's technology editor, Jeffrey Perkel, started blogging about workplace technology in science in 2016. Here are some highlights.
- **[The daughter you've always wanted]** [周三, 04 10月 08:00]
  Family matters.
- **[South Korea cracks down on dirty air]** [周二, 03 10月 08:00]
  Despite huge clean-up effort, scientists say country’s pollution problem could get worse over next five years.
- **[Xenon view, butterfly wings and a strange squid]** [周二, 03 10月 08:00]
  September’s sharpest science shots, selected by Nature ’s photo team.
- **[Europe’s Joint Research Centre, although improving, must think bigger]** [周二, 03 10月 08:00]
  External report criticizes lack of exploratory research.
- **[Make plans to eliminate cholera outbreaks]** [周二, 03 10月 08:00]
  Governments must stop denying the occurrence of cholera and unite in long-term prevention strategies, says Anita Zaidi.
- **[Ethics of Internet research trigger scrutiny]** [周二, 03 10月 08:00]
  Concern over the use of public data spurs guideline update.
- **[Gravitational wave detection wins physics Nobel]** [周二, 03 10月 08:00]
  Rainer Weiss, Barry Barish and Kip Thorne share the 2017 prize for their work at LIGO to detect ripples in space-time.
- **[Risk of human-triggered earthquakes laid out in biggest-

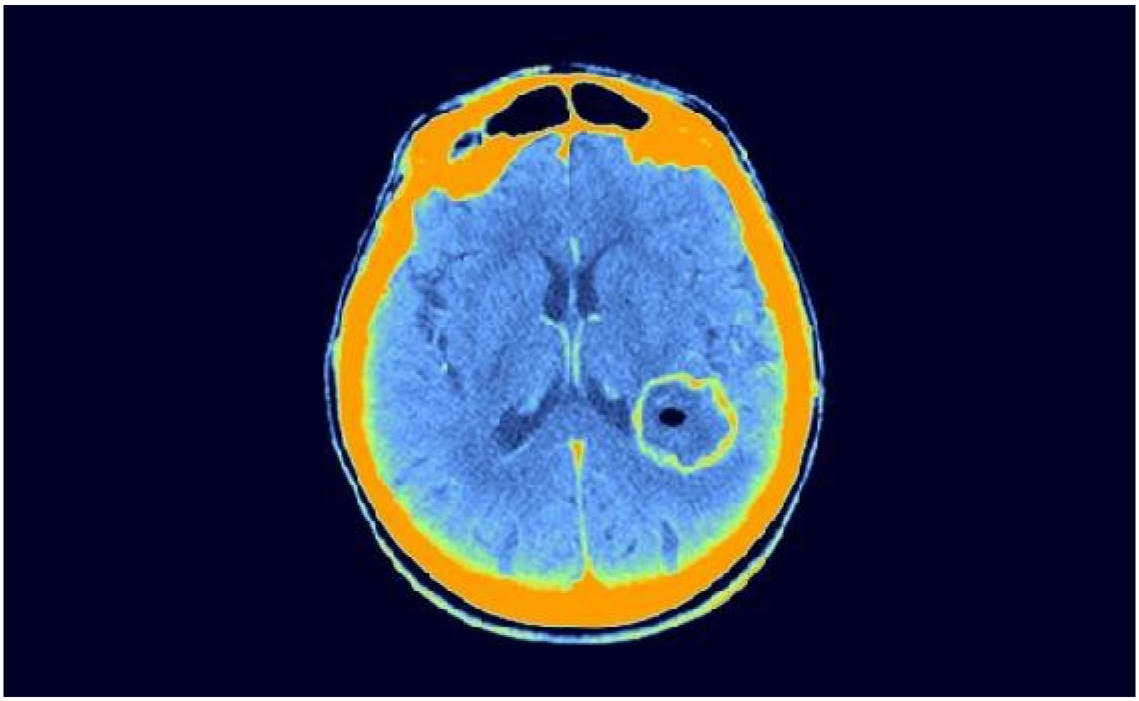
ever database [周一, 02 10月 08:00]
Geologists track hundreds of quakes caused by people and the projects that set them off.

- ## Discoveries have awkward first dates [周一, 02 10月 08:00]
  Fuzzy timings over a plate-tectonics anniversary highlight the rolling nature of scientific discovery.
- ## Chinese scientists fix genetic disorder in cloned human embryos [周一, 02 10月 08:00]
  A method for precisely editing genes in human embryos hints at a cure for a blood disease.
- ## Medicine Nobel awarded for work on circadian clocks [周一, 02 10月 08:00]
  Jeffrey Hall, Michael Rosbash and Michael Young unpicked molecular workings of cells' daily rhythms.

Cancer-genome study challenges mouse 'avatars'

Grafting human cancer cells into mice alters tumour evolution.

09 October 2017



Centre Jean Perrin/ISM/SPL

A brain tumour called glioblastoma, shown here as the circular region in a patient's brain scan, is among the cancers that have been tested in mouse avatars.

An analysis of more than 1,000 mouse models of cancer has challenged their ability to predict patients’ response to therapy.

The study, published today in *Nature Genetics*[1], catalogues the genetic

changes that occur in human tumours after they have been grafted into mouse hosts. Such models, called patient-derived xenografts (PDXs), are used in basic research and as ‘avatars’ for individual patients. Researchers use these avatar mice to test a bevy of chemotherapies against a person's tumour, in the hope of tailoring a treatment plan for the patient's specific cancer.

But fresh data from geneticists at the Broad Institute of MIT and Harvard in Cambridge, Massachusetts, suggest that transplanting human cancer cells into a mouse alters the cells' evolution, reshaping the tumour's genome in ways that could affect responses to chemotherapy.

“The assumption is that what grows out in the PDX is reflective of the bulk of the tumour in the patient,” says cancer geneticist Todd Golub, a lead author on the study. “But there’s quite dramatic resculpting of the tumour genome.”

No animal model is perfect, and researchers have long acknowledged that PDXs have their limitations. To avoid an immune assault on the foreign tumour, for example, PDXs are typically grafted into mice that lack a functioning immune system. This compromises scientists' ability to study how immune cells interact with the tumour — an area of increasing interest given the success of cancer therapies that unleash the immune system.

PDXs can also take months to generate, making them too slow to serve as avatars for those patients who need to make immediate decisions about their therapy.

Reasonable reproductions

But previous research had suggested that the PDXs were reasonably faithful reproductions of the human tumours they are meant to model, offering researchers a chance to explore the tumour’s interaction with its environment in ways that are not possible using cells grown in a Petri dish. The US National Cancer Institute has developed a library of more than 100 PDXs for distribution to researchers, and European scientists have launched EurOPDX, a consortium that boasts more than 1,500 models for more than 30 tumour

types. One company, Champions Oncology of Hackensack, New Jersey, creates and tests mouse avatars for individual patients and for pharmaceutical companies to use in research.

For the latest study, Golub and Broad Institute cancer geneticist Rameen Beroukhim, together with their colleagues, decided to examine how PDXs changed over time. The researchers studied data from tumour cells that were implanted into a mouse, allowed to grow into a tumour, and then harvested and re-implanted into a fresh mouse — sometimes for multiple cycles.

The researchers looked for alterations in the number of copies of a given gene in the cell. They did so for more than 1,000 PDX samples representing 24 cancer types, often extrapolating gene copy number from data on gene expression.

The analysis suggests that tumours implanted in mice change in ways that are not commonly seen in the human body. For example, human brain tumours called glioblastomas tend to gain extra copies of chromosome 7. But the mouse PDXs tend to lose those extra copies over time, says Beroukhim.

Some of these genetic changes were also associated with differences in how the PDXs responded to cancer drugs. For researchers studying many PDXs and looking for relationships between genetics and drug sensitivity, the finding does not spell disaster, says Golub. “That’s not to say that PDXs should be abandoned as a model — far from it,” he says. “But they’re not a panacea.”

Golub is more worried about using PDXs to predict outcomes in individual patients. “It raises some important questions around how to interpret the results of avatars,” he says.

But Champions Oncology founder David Sidransky, an oncologist at Johns Hopkins University School of Medicine in Baltimore, Maryland, points to his team's study of 92 patients, published in August. That showed an 87% association between the drug responses in a patient and their corresponding PDX[2].

The genetic analysis by Golub and his team could offer clues as to what goes

wrong in the other 15% of PDXs, Sidransky says.

The work is important, says David Tuveson, a cancer researcher at Cold Spring Harbor Laboratory in New York. But Tuveson also notes that PDX approaches are changing. Researchers are increasingly likely to graft a human tumour into the analogous location in the mouse avatar — for instance, by transplanting human pancreatic cancer cells into a mouse pancreas — rather than merely grafting them under the skin. This, he says, is thought to be an environment that is more similar to that of the original tumour.

Researchers are also turning to mice that have been 'humanized' in various ways, perhaps by introducing aspects of a human immune system or human versions of proteins that interact with the tumour.

As for those PDXs that have already been generated, researchers will continue to embrace them, says Carlos Caldas, a researcher at the Cancer Research UK Cambridge Institute at the University of Cambridge, UK.

Caldas notes that his own studies with breast cancer PDXs have not found such dramatic differences between PDXs and the tumours from which they were made. "We're going to continue to see a lot of activity with these models — they are a great development, not a hindrance," he says. "They are here to stay."

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22782

Comments

Comments

There are currently no comments.

LIGO's unsung heroes

Nature highlights just a few of the people who played a crucial part in the discovery of gravitational waves — but didn't win the Nobel Prize.

09 October 2017

Joe McNally/Getty

LIGO hunts gravitational waves with the help of two laser interferometers — and hundreds of people.

Every October, the announcements of the Nobel Prizes bring with them some controversy. This year's physics prize — in recognition of the Laser Interferometer Gravitational-Wave Observatory (LIGO) in the United States — was less debated than most. The three winners — Kip Thorne and Barry Barish, both at the California Institute of Technology (Caltech) in Pasadena,

and Rainer Weiss at the Massachusetts Institute of Technology (MIT) in Cambridge — had attracted near-universal praise for their roles in the project’s success.

But the award has still put into stark relief the difficulty of singling out just a few individuals from the large collaborations of today’s 'Big Science'. The LIGO collaboration uses two giant laser interferometers to listen for deformations in space-time caused by some of the Universe’s most cataclysmic events. Physicists detected their first gravitational waves — interpreted as being produced by the collision of two black holes more than a billion years ago — in September 2015. The resulting paper, published in February 2016[1], has a mind-boggling 1,004 authors.

Some of those are members of the LIGO Laboratory, the Caltech–MIT consortium that manages LIGO’s two interferometers in Louisiana and Washington State. But the list also includes the larger LIGO Scientific Collaboration: researchers from 18 countries, some of which — such as Germany and the United Kingdom — have made crucial contributions to the detectors.

Yet more authors are from LIGO’s sister Virgo Collaboration, led by France and Italy, which built the Virgo interferometer near Pisa, Italy. The two experiments pool their data and analyse them together. Countless other people not named on the paper have also been involved in LIGO’s design, development, construction and operation since Weiss first detailed how to build a laser interferometer in 1972.

To honour the many unsung heroes of gravitational waves, *Nature* collected testimonials about just a few of them. Like the Nobel Prize, this list is inevitably very incomplete.

1. The pioneer: Joseph Weber

Researchers using two detectors in the United States shook the world when they announced their discovery of gravitational waves. The year was 1969, and the detectors were not LIGO but tonne-sized cylinders of aluminium built

by Joseph Weber, a physicist at the University of Maryland in College Park. His claim was later found to be invalid, but many physicists still credit Weber for having founded the field. “Joe Weber indeed started thinking about how to detect gravitational waves in about 1957,” Virginia Trimble, an astrophysicist and Weber’s widow, told *Nature* in an e-mail. At that time, many researchers were not even sure that gravitational waves existed. In the 1960s, Weber was also one of the first researchers to consider the possibility of using interferometers to detect them.

2. The German connection: Heinz Billing

The founder of Germany’s side of LIGO, Heinz Billing, a physicist at the Max Planck Institute for Astrophysics near Munich, first heard of Weiss’s pioneering interferometer designs in 1975, when he was asked to review Weiss’s request to the National Science Foundation to fund a prototype at MIT. Billing and his team liked it so much that they started building one themselves. “The Munich group quickly invented some of the most important ingredients that made the detectors possible,” says Karsten Danzmann, a director at the Max Planck Institute for Gravitational Physics in Hanover, Germany. Billing, in particular, came up with an idea to stabilize the laser that was later used in the UK–German GEO600 interferometer based near Hanover — and in LIGO itself. GEO600 is still a crucial testing and development centre for technologies introduced in the successive rounds of LIGO upgrades. “There is an awful lot of GEO in LIGO,” says Danzmann. Billing, who died on 4 January at the age of 102, was also a pioneer in magnetic data storage.

3. The laser expert: Alain Brillet

The 1980s were years of intense research and development for gravitational-wave detectors. Alain Brillet, an optical physicist with extensive experience in interferometers, then at the University of Paris-Sud in Orsay, France, saw an opportunity to contribute. “I decided to start with the optical part, the lasers and optics, because that was my specialty,” he says. Brillet went on to co-found Virgo. But many of his ideas — in particular, the type of laser that

would give the most stable signal — were implemented in LIGO and other interferometers as well, says MIT physicist David Shoemaker, who studied with Brillet in Orsay and is now LIGO’s spokesperson.

4. The facilitator: Richard Isaacson

Gravitational theorist Richard Isaacson went to Washington DC to work at the National Science Foundation (NSF) in 1973 for what he thought would be a brief stint as one of the programme directors. During the handover, his predecessor advised him to pay attention to an “interesting guy” called Rainer Weiss. Isaacson secured Weiss a small grant for his 1975 prototype, and later became LIGO’s chief advocate inside government. He was instrumental in the project's winning hundreds of millions of dollars in funding, despite the uncertain prospect of success. It was the first time that the NSF had managed a large project: US facilities such as particle accelerators were traditionally the remit of the Department of Energy, which had field offices staffed with dozens of experts. Isaacson did it by himself for more than ten years, and by the early 1990s he had paid a high personal cost. “Eventually, my health broke and my marriage went bad,” says Isaacson. By the time he retired in 2001, the construction of LIGO had been completed.

5. The first director: Rochus ‘Robbie’ Vogt

Before Barry Barish took the reins of LIGO, another director had left his mark on the collaboration: Rochus Vogt. The Caltech physicist, a veteran of the NASA Voyager mission, was put in charge in 1987. Until then, the project had been led by the ‘troika’ of visionary founders — Thorne, Weiss, and the physicist Ronald Drever, who started UK research on gravitational waves at the University of Glasgow before moving to Caltech — but managing large organizations was not their strength. “Thank God that was done,” Weiss recalled in a talk at NSF headquarters last year. “You don't manage it with three guys who are sort of a little bit flaky.” Vogt, who was once described as a taller and leaner Henry Kissinger, had a booming voice and forceful style that did not please everyone. But he was able to put together the first major request for NSF funding and, Thorne recalled in a 5

October press conference, “laid the foundations for moving LIGO forward to our construction”.

6. The theorist: Alessandra Buonanno

As Thorne realized early on, in the future field of gravitational-wave astronomy, it would not be enough to collect data; researchers would also need to know what signals to look for. But it is notoriously difficult to extract quantitative predictions from the equations of Einstein’s general relativity. Theoretical physicist Alessandra Buonanno had devised formulae for calculating the approximate orbits of spiralling objects and the gravitational waves they would generate in work she had done, in part with her PhD adviser Thibault Damour, at the Institute of Advanced Scientific Studies near Paris. The LIGO and Virgo collaborations use a database of hundreds of thousands of these waveforms for spotting gravitational waves in their data in real time. Buonanno is now a director at the Max Planck Institute for Gravitational Physics in Potsdam and a senior member of the LIGO Scientific Collaboration.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22786

Comments

2 comments

1. *Pentcho Valev* • 2017-10-09 02:33 PM
"As Thorne realized early on, in the future field of gravitational-wave astronomy, it would not be enough to collect data; researchers would also need to know what signals to look for. But it is notoriously difficult to extract quantitative predictions from the equations of Einstein's general relativity. Theoretical physicist Alessandra Buonanno had devised formulae for calculating the

approximate orbits of spiralling objects and the gravitational waves they would generate in work she had done, in part with her PhD adviser Thibault Damour, at the Institute of Advanced Scientific Studies near Paris. The LIGO and Virgo collaborations use a database of hundreds of thousands of these waveforms for spotting gravitational waves in their data in real time." Not true. Actually LIGO conspirators don't use theoretically calculated waveforms in detecting (more precisely, faking) gravitational wave signals: The Nobel Committee for Physics: "While these waveforms provide a reasonable match, further important improvements are obtained using numerical methods that are very computationally intensive [23]. The analytical methods are crucial to producing the big library of template waveforms used by LIGO. While the waveforms produced in this way are necessary for determining the detailed properties of the objects involved, as well as identifying weak signals, they were not essential for the very first detection of GW150914. This was a model-independent detection of a gravitational-wave transient." https://www.nobelprize.org/nobel_prizes/physics/laureates/2017/adv physicsprize2017.pdf According to Rana Adhikari, professor of Physics at Caltech and a member of the LIGO team, LIGO conspirators have no preliminary knowledge about the signals. Adhikari declares: "the only thing that we really know is what we measure. And that's the mantra of the true empirical person": Rana Adhikari: "You split it in two and you send it in two separate directions, and then when the waves come back, they interfere with each other. And you look at differences in that interference to tell you the difference in how long it took for one beam to go one way, and the other beam to go the other way. The way I said it was really careful there because there's a lot of confusion about the idea of, these are waves and space is bending, and everything is shrinking, and how come the light's not shrinking, and so on. We don't really know. There's no real difference between the ideas of space and time warping. It could be space warping or time warping but the only thing that we really know is what we measure. And that's the mantra of the true empirical person. We sent out the light and the light comes back and interferes, and the pattern changes. And that tells us something about effectively the delay that the light's on. And it could be that the space-time curved so that the light took longer to get there. But you could also imagine that there was a change in the time in one path as opposed to the other instead of the space but it's a mixture of space and time. So it sort of depends on your viewpoint." https://blog.ycombinator.com/the-technical-challenges-of-measuring-gravitational-waves-rana-adhikari-of-ligo/ Pentcho Valev

2. *Pentcho Valev* • 2017-10-09 04:23 PM

   Another sword of Damocles hanging over LIGO conspirators (and over the Nobel committee as well). They had no idea what they were measuring (faking) and produced signal correlation but also noise correlation that they are unable to explain: James Creswell, Sebastian von Hausegger, Andrew D. Jackson, Hao Liu, Pavel Naselsky, June 27, 2017: "As a member of the LIGO collaboration, Ian Harry states that he "tried to reproduce the results quoted in 'On the time lags of the LIGO signals'", but that he "[could] not reproduce the correlations claimed in section 3". Subsequent discussions with Ian Harry have revealed that this failure was due to several errors in his code. After necessary corrections were made, his script reproduces our results. His published version was subsequently updated. [...] It would appear that the 7 ms time delay associated with the GW150914 signal is also an intrinsic property of the noise. The purpose in having two independent detectors is precisely to ensure that, after sufficient cleaning, the only genuine correlations between them will be due to gravitational wave effects. The results presented here suggest this level of cleaning has not yet been obtained and that the identification of the GW events needs to be re-evaluated with a more careful consideration of noise properties." http://www.nbi.ku.dk/gravitational-waves/gravitational-waves.html James Creswell, Sebastian von Hausegger, Andrew D. Jackson, Hao Liu, Pavel Naselsky, August 21, 2017: "In view of unsubstantiated claims of errors in our calculations, we appreciated the opportunity to go through our respective codes together - line by line when necessary - until agreement was reached. This check did not lead to revisions in the results of calculations reported in versions 1 and 2 of arXiv:1706.04191 or in the version of our paper published in JCAP. It did result in changes to the codes used by our visitors [LIGO conspirators]. [...] In light of the above, our view should be clear: We believe that LIGO has not yet attained acceptable standards of data cleaning. Since we regard proof of suitable cleaning as a mandatory prerequisite for any meaningful comparison with specific astrophysical models of GW events, we continue to regard LIGO's claims of GW discovery as interesting but premature." http://www.nbi.ku.dk/gravitational-waves/gravitational-waves-comment2.html Here is Sabine Hossenfelder's article: Sabine Hossenfelder: "Was It All Just Noise? Independent Analysis Casts Doubt On LIGO's Detections. A team of five researchers - James Creswell, Sebastian von Hausegger, Andrew D. Jackson, Hao Liu, and Pavel Naselsky - from the Niels Bohr Institute in Copenhagen, presented their own analysis of the openly available LIGO data. And, unlike the LIGO collaboration itself, they come to a disturbing conclusion: that these gravitational waves might not be signals at all, but rather patterns in the noise that have hoodwinked even the best scientists working on this puzzle. [...] A few weeks ago, Andrew Jackson presented his results in Munich. A member of the local physics faculty (who'd rather not be named) finds the results "quite disturbing" and hopes that the collaboration will take the criticism of the Danes to heart. "Until LIGO will provide clear scientific(!) explanation why these findings are wrong, I would say the result of the paper to some extent invalidates the reliability of the LIGO discovery." https://www.forbes.com/sites/startswithabang/2017/06/16/was-it-all-just-noise-independent-analysis-casts-doubt-on-ligos-detections/ In a world different from our post-truth world the disclosure of the noise correlation would mark the end of the LIGO project and the beginning of an interrogation. In the post-truth world the glory of the fraudsters can only increase - if the absurd noise correlation cannot topple them, nothing can! Immediate Nobel prize - should have been given to LIGO fraudsters a year ago! Pentcho Valev

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Build on the outer space treaty

09 October 2017

Fifty years on, the agreement is being pushed to its limits by changing geopolitics, technology and commercial interests, warns Joan Johnson-Freese.

Reuters

The Long March-5 Y2 rocket takes off from Wenchang Satellite Launch Center in Wenchang, Hainan Province, China in July 2017.

On 10 October 1967, the Outer Space Treaty went into force. Agreed on during a golden age of cooperation between the then-dominant superpowers, the Soviet Union and the United States, the treaty deems space a domain to

be shared by all nations. It states: “The exploration and use of outer space, including the moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind.”

The treaty gave rise to a series of others that govern space today: the Rescue Agreement (1968), the Liability Convention (1972), the Registration Convention (1976) and the Moon Agreement (1984). Although the United States and Soviet Union declined to sign the Moon Agreement, to avoid having to share lunar resources and technologies, most issues were seemingly covered — liability for damage caused by space objects, the safety and rescue of spacecraft and astronauts, and the rules governing the exploitation of space resources and settling disputes.

A lot has changed since. Launch costs have plummeted — from US$20,000 to send one kilogram into orbit in the late twentieth and early twenty-first centuries to as little as $5,000 now. And more nations, people, businesses and organizations are seeking to establish themselves in space. 'NewSpace' entities — non-governmental actors, often with commercial interests and financed through personal wealth — are diversifying the space landscape, with motivations ranging from human settlement to economic development. SpaceX founder Elon Musk, for example, has said that becoming an interplanetary species is the only way for humanity to avoid an eventual extinction event on Earth, and that he wants to “die on Mars, just not on impact”. Planetary Resources, a US-based asteroid-mining company, states that its vision is to extend the economy into space.

Meanwhile, conventional interests of prestige, geostrategic influence and military missions in space have come to the fore. Access to space is considered a “vital national interest” by the United States[1], an area of revitalized national interest by Russia, and an aspiration of China, India[2] and a growing number of other countries. India and China's 'space race', crucial to each country's national prestige, is arguably fiercer than even the twentieth-century US–Soviet race.

In terms of military competition, the United States sees China's encroachment

on space as heightening the risk of a space war[3]. China's launch of a 'science mission' in May 2013 that nearly reached geosynchronous orbit (about 36,000 kilometres above Earth) caused quiet panic in the Pentagon and in US intelligence circles. The United States had considered that orbit a sanctuary, out of reach of foes, for some of its most strategically important spy satellites, such as those in the Keyhole series.

LISTEN

Earlier this year, the Nature Podcast marked half a century since the Outer Space Treaty was opened. Here, reporter Adam Levy looks at its relevance to our relationship with space today.

You may need a more recent browser or to install the latest version of the Adobe Flash Plugin.

Fifty years on, the Outer Space Treaty and its spin-offs are still appropriate. But interpretations of its provisions are, more than ever, being influenced by commercial interests and politics. Supplementary rules and norms are needed. In an era in which international cooperation on treaties is tenuous, informal agreements and resolutions must guide space-faring actors, protect the environment and prevent wars.

Competing interests

The United States is the largest player in terms of space spending, capabilities and assets in orbit. The government alone spends about $40 billion each year on space activities through the Department of Defense and NASA, with China and Russia next, at about $6 billion each. Japan, France, Germany, Italy, India, Canada and the United Kingdom together spend around $11 billion. As of 1 January, there were 1,459 satellites in orbit, of which 593 belong to the United States, 135 to Russia and 192 to China.

US strategic thinking will largely shape the direction of future global space policies. And the 2011 US National Security Space Strategy described the

official US view of space as “congested, contested, and competitive”. Active satellites and debris from old missions clutter the skies. More than 500,000 pieces of debris, ranging in size from a baseball to a school bus, are being tracked in Earth orbit. Millions of smaller but nonetheless dangerous pieces are not.

The number of countries, consortia and companies involved in space is growing. In 1959, when the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) was formed, there were 24 members. Today, there are 84. Although few countries can afford to develop their own launch capabilities, none wishes to be left out of the expanding information age facilitated by space technology. Data that were once available only to or through governments, such as remotely sensed data, are now available through private companies. Commercial communications satellites increasingly carry military traffic. In 2013, US troops operating in Africa began using a Chinese Apstar-7 satellite to carry data.

Almost 50 commercial and non-profit organizations are listed in the informal directory of the Space Frontier Foundation in Arlington, Virgina, which is committed to facilitating the human settlement of space. These companies are exploring ideas from satellite refuelling to mining asteroids for water and providing extraterrestrial human habitats, among other projects.

The main driver of change in US thinking about space security is the number of countries that are developing capabilities with potential military uses. Since the 1990–91 Gulf War, when the use of the Global Positioning System (GPS) allowed coalition troops and equipment to be moved across the desert without being detected, the US military has reaped the advantages of its advanced space-based technologies. Satellites are used for command, control, communications, reconnaissance and intelligence.

AL SEIB/Los Angeles Times/Getty

Sir Richard Branson presents Virgin Galactic SpaceShipTwo, part of the company's space-travel efforts.

Many countries desire similar capabilities and are developing a wide range of 'dual-use' space technologies, which are of value to both the civil and military sectors. China and Russia have their own versions of GPS. Missile-defence systems being built by the United States, China, Russia and India use targeting systems similar to those required for an anti-satellite weapon. Yet, so far, no country has crossed the Rubicon of explicitly and officially developing a space weapon.

Space security

Two debates have broken out among space-security analysts. First, are more rules needed for managing the space environment sustainably for all? Second, is space warfare inevitable or how should one deter it?

Space-resource ownership and traffic need to be managed. In 2015, the US Congress enacted legislation to protect the interests and investments of US companies, such as Planetary Resources, that seek to harvest the potentially vast mineral and water resources of the asteroid belt as early as the 2020s. The Spurring Private Aerospace Competitiveness and Entrepreneurship Act of 2015, or SPACE Act, entitles US citizens to “possess, own, transport, use and sell” extracted materials, subject to the obligations of the United States under the various treaties it has previously signed[4].

Some argue that this act violates Article II of the Outer Space Treaty. It states: “Outer space, including the moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means.” Even without making territorial claims, appropriation of resources could restrict access to resources for others and potentially encourage environmentally risky exploitation of the Moon, planets and asteroids.

Space-traffic management is the equivalent of air-traffic control. It is in no one's interest to have thousands of planes flying around unchecked, and so is the case with satellites. You need to know where they are and where they will be. Traffic-management systems must be able to notify parties of potential collisions and events, such as when a satellite 'goes rogue' and is beyond control, or suddenly comes back to life, as the LES-1 satellite did in 2016 after 46 years of silence.

Public organizations such as the US military's Joint Space Operations Center (JSpOC) and private bodies such as the Space Data Association are making progress on these issues, including coordination between the public and private sectors. The addition of a Commercial Integration Cell, where commercial operators are able to interact with their military counterparts, at JSpOC in 2015 was seen as a landmark in commercial–military cooperation. Nevertheless, some satellite owners, especially intelligence agencies, are reluctant to share too much information. That spurs the question of whether traffic rules for operation are needed, or even acceptable. Rules restrict actions, which neither companies nor governments welcome.

The United States has largely shunned multilateral rules for coordinating and limiting space operations beyond the provisions already in place through the

Outer Space Treaty. Three key arms-control provisions of the Outer Space Treaty reside in Article IV. First, parties should not place in orbit around Earth any objects carrying nuclear weapons or other weapons of mass destruction, install such weapons on celestial bodies or station them in outer space. Second, the Moon and other celestial bodies must be used exclusively for peaceful purposes. And third, it is forbidden to establish military bases, installations or fortifications, or to test any type of weapon or conduct military manoeuvres on celestial bodies.

However, military personnel's involvement in scientific research or other peaceful endeavours is not prohibited. Many early astronauts and cosmonauts were members of the military. Similarly permitted is the use of military equipment or facilities for peaceful purposes. But the dual-use nature of many space technologies means that civilian efforts often concurrently improve military capabilities. For example, developing tracking stations for human spaceflight missions also improves missile-tracking ability. The many definitions of peaceful — ranging from non-military to non-offensive — have allowed space to slip through the cracks of arms-control efforts since 1984.

Although weapons of mass destruction are banned in space, weapons in general are not. Releasing energy or kinetic force in space, through lasers and electromagnetic pulses, flak or collisions, can pollute the orbital environment for decades. From the 1962 US Starfish Prime test of nuclear weapons in space to the more recent anti-satellite weapons test carried out by China in 2007, the debris created can take decades to clear. The 2007 Chinese test generated some 3,000 pieces of space debris through some of the most populated low-Earth-orbit positions. As more satellites switch off and remnants break up, space becomes more difficult, expensive and dangerous to use. The International Space Station, for example, has had to manoeuvre several times to avoid colliding with space junk.

Since the contentious May 2013 Chinese launch, the United States has shifted its position on space warfare. Previously, its stance was strategic restraint, refraining from introducing offensive space capabilities in the hope of moderating the behaviour of friends and potential foes; since 2013 it has been preparing for war in space, whatever that might look like. US officials are

now actively exploring offensive and defensive space-based activities, with the only caveat being to avoid creating debris.

In 2008 and again in 2014, China and Russia submitted a joint proposal to the United Nations for a Treaty on Prevention of the Placement of Weapons in Outer Space and of the Threat or Use of Force Against Outer Space Objects, dubbed the PPWT. Each time, the United States rejected the proposal as “fundamentally flawed”. Among the reasons cited are that it is unverifiable — it is difficult to define a space weapon owing to the dual-use nature of most of the technology; it does not prohibit the development and stockpiling of space arms; and it does not consider ground-based space weapons, such as that demonstrated by the Chinese in 2007.

Rather than shift to aggressive policies, nations should instead show further restraint and cooperation.

The way forward

Space laws need to be updated for our time. Extending the Outer Space Treaty or writing a new one is unlikely to work, as US hesitancy to sign the PPWT shows. 'Soft law', driven by need, seems the best option for revising the rules for space operators.

Soft law comprises rules or guidelines that have legal significance but are not binding. It sets standards of conduct for agreeing parties, much like those that protect the environment and endangered species. 'Rules of the road' and best practices for space should be developed. These could take a similar form to the navigation guidelines set out in the 1972 Convention on International Regulations for Preventing Collisions at Sea, which govern when one vessel should give way to another, as well as other interactions.

Soft law works when it is in the interest of all parties to abide by it. If countries and companies want to maintain the space environment as a usable domain, then it is in their interests to accommodate a variety of operations. Space is more complex to manage than air, land or sea because of the distance, physics and technology involved. Just as in the cyber domain,

technology has preceded regulation, making it difficult to impose after the fact.

The first focus of an analogous set of space guidelines should be environmental protection and debris avoidance, areas that most spacefaring nations agree on. Governments are engaged in groups such as the 13-member Inter-Agency Space Debris Coordination Committee (IADC). The 84-member COPUOS works through two subsidiary bodies to develop best practices for sustaining the space environment, including mitigating debris. COPUOS working groups will begin meeting again in January 2018 to continue developing best practices, with new proposals to be presented to the committee in June 2018. Commercial perspectives should be included through national delegations and external observers.

Politicization of any guiding principles must be resisted, for example, by seeking consensus. The IADC Steering Committee releases information and materials to the public only when all parties agree, and it works through sub-committees operating from a technical rather than a political perspective. COPUOS discussions are progressing, albeit slowly.

Encouraging mutual understanding and building trust between nations is crucial to avoid conflict. It is impossible to verify exactly what is happening in space if a satellite ceases to function: has there been an intentional attack, an act of nature or a technical glitch? This problem of distance and the nature of dual-use technology create ripe circumstances for mishaps. Transparency and confidence-building measures developed in 2013 by the UN-sponsored Group of Governmental Experts are designed to help avoid misunderstanding and miscalculations and should be widely adopted.

A coordinated human spaceflight mission, in which different nations work together towards a common goal, could build the kind of space environment envisioned in the Outer Space Treaty. US–Russian cooperation on the International Space Station has shown that when terrestrial tensions get high, working together can maintain ties.

Coordination is easier than cooperation when there are technology-transfer concerns. Proposing a big mission and inviting other countries to join would give the US human spaceflight programme a direction, as well as serving

strategic purposes. A crewed fly-by mission of Venus and Mars, for example, has been on the table since the days of the Apollo missions and could yet be resurrected. An encouraging example is the 'space armada' of coordinated missions to study Halley's comet in 1986, involving the Soviet Union, European Space Agency and Japan.

With the expansion of national and commercial space activities, the Outer Space Treaty will be stretched to its limits. In that regard, it will be serving its intent — paving the way for the peaceful exploration and development of space.

Journal name:
Nature
Volume:
550,
Pages:
182–184
Date published:
(12 October 2017)
DOI:
doi:10.1038/550182a

Comments

Comments

There are currently no comments.

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Navajo Nation reconsiders ban on genetic research

Tribal leaders are developing a policy for genetic research and data sharing, potentially ending a 15-year moratorium.

06 October 2017

Ricky Carioti/The Washington Post/Getty

Children play on the Navajo Nation's vast reservation in the southwestern United States.

When the Navajo Nation opens its first oncology centre next year in Tuba City, Arizona, clinicians there may be able to offer a service that has been banned on tribal lands for 15 years: analyzing the DNA of Navajo tribe

members to guide treatments and study the genetic roots of disease.

That's because the Navajo, the second-largest Native American group in the United States, are considering whether to lift their longstanding moratorium on genetic research. The tribal government banned DNA studies in 2002 to prevent the misuse of its members' genetic material. Although there is still some apprehension about the risk of allowing researchers access to Navajo DNA, the tribe's leaders increasingly see genetic research as a tool to improve medical care for the 174,000 residents of their sprawling reservation, which is roughly the size of Scotland.

As it now stands, Navajo people who live on the reservation must drive hundreds of kilometres to access specialized medical care off tribal lands, in large cities such as Phoenix, Arizona. “We spend millions of dollars outsourcing [care] for cancer and diabetes,” says Walter Phelps, a delegate to the Navajo Nation Council. As the tribe — a nation independent of the United States — tries to expand the health services it offers to its members, he says, “the moratorium could become a barrier when blood and tissue have to be collected”.

Phelps is working on the effort to create a policy by which the Navajo Nation would approve genetic-research projects and maintain control of DNA samples. The research-ethics board run by the tribal government’s department of health is working with tribal officials and traditional leaders and holding a series of public hearings to solicit opinions on the matter from tribe members. The group hopes to deliver a draft proposal by the end of October. Whatever the tribe decides could influence the hundreds of other Native American groups, who have tended to be wary of genetic studies because of a history of scientists conducting research without consent or adequate privacy controls.

The Navajo Nation's new oncology centre provides part of the impetus for revisiting the genetic-research ban. It will be the first such facility on Native American lands outside of Alaska. Allowing some genetic testing at the centre could help physicians to identify the most effective therapies for each patient, says Lynette Bonar, chief executive of the Tuba City Regional Health Care Corporation in Arizona, which will run the facility.

That would match the standard of care that many Navajo people with cancer

have received at medical facilities off the reservation. And creating a repository for such genetic material on Navajo land would enable research into the genetic and environmental factors underlying a broad range of diseases, not just cancer.

So far, Phelps says, the idea of allowing some genetic research has not drawn major opposition. Many tribe members consulted about lifting the moratorium have generally supported the idea after learning how physicians could use genetic data to diagnose disease and tailor treatments. And the number of Navajo tribe members who are geneticists and medical experts has grown since 2002, bolstering the tribe’s ability to evaluate proposed protocols and represent its own interests.

Fraught history

Still, some Navajo have lingering questions about whether the tribal government can protect the privacy of their genetic material and maintain control over its use. Such concerns helped to shape the current ban back in the early 2000s, when the Navajo Nation’s department of health conducted an outreach campaign about genetics and medical research. “In the absence of a research code and lack of expertise at the time, they decided it was not a good time to move forward with genetic research until they were able to develop a research policy,” says Nanibaa’ Garrison, a member of the Navajo Nation who is a geneticist and bioethicist at Seattle Children’s Hospital in Washington.

The tribe had reason to be cautious. “As Native Americans, we have a problem with trust because we have been violated so much,” says David Begay, a pharmaceutical scientist at the University of New Mexico in Albuquerque and a member of the Navajo Nation’s human-research review board. “In the past, our data have been misused."

Native Americans in the southwestern United States want to avoid repeating the experience of the region's Havasupai tribe. In 2004, the group sued Arizona State University in Tempe over alleged misuse of tribe members’ blood samples. The Havasupai said that the samples, which had been

collected for diabetes research, had later been used in studies of schizophrenia, migration and inbreeding without their consent. The university made a settlement with the tribe in 2010, paying US$700,000 and returning the blood samples.

Sara Hull, a bioethicist at the US National Human Genome Research Institute in Bethesda, Maryland, says the case helped to change how researchers engage with the people they study, by raising awareness of the complexities of dealing with vulnerable minority populations. For Native Americans, such thorny issues can include privacy. Science-funding agencies and journals often require researchers to put the genetic data they collect into public repositories, but the relatively small size of many Native American tribes can make it easy to identify individual members in a genetic data base. In recognition of this, the US National Institutes of Health sometimes works with researchers it funds to develop methods for sharing data on a minority group without compromising its privacy.

Garrison, who is helping the Navajo Nation develop its new policy, says that the plan is likely to include rules on what types of research will be allowed, who will have access to tribe members' genetic material and information, and who will provide oversight. It is also likely to require that the tribe maintain ownership of its members' DNA samples and data.

The policy that the Navajo Nation ultimately produces could serve as a template for other Native American groups considering how — or whether — to engage with genetic research, says Ellen Clayton, a bioethicist at Vanderbilt University in Nashville, Tennessee. She expects other tribes to watch the development of the Navajo Nation's new policy. "If they reach an agreement, I think it will be influential."

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22780

Comments

Commenting is currently unavailable.

The scientist who spots fake videos

Hany Farid discusses how to detect image manipulations — and the increasing sophistication of forgers.

06 October 2017

Eli Burakian/Dartmouth College

Hany Farid.

Hany Farid, a computer scientist at Dartmouth College in Hanover, New Hampshire, specialises in detecting manipulated images and videos. Farid, who provides his services to clients as varied as universities, media organizations, and law courts, says that image manipulation is becoming both more frequent and more sophisticated. He spoke to *Nature* about the arms race to stay ahead of the forgers.

Where do you start when trying to spot a fake image?

One simple but powerful technique is reverse image search. You give the image to a site such as Google Image Search or TinEye, and they show you all other instances of it. A project at Columbia University, in New York City, is taking this to the next level, and starting to find parts of images that have been repurposed from other images**.**

Generally, we think about which patterns, geometries, colours or structures are going to be disrupted when someone manipulates a photo. For example, when people add an object into a scene, we know that where they put the shadow is usually wrong. A viral video called Golden Eagle Snatches Kid from 2012 is one of my favourite examples. It took us only 15 minutes of analysis to show shadow inconsistencies: the eagle and baby were computer-generated.

What about if fake images make only slight tweaks?

There are a number of analyses we can do. In a colour picture, every pixel needs three values — corresponding to the amounts of red, green and blue at that point. But in most cameras, every pixel records just one colour, and the camera fills in the gaps by taking the average values of the pixels around it. This means that, for any given colour in an image, each missing pixel has a particular correlation with its neighbours, which will be destroyed if we add or airbrush something, and we can detect that**.**

Another technique is JPEG compression. Almost every image is stored in a JPEG file, which throws away some information to save on storage. There is a huge amount of variation in how each camera does that. If a JPEG is unpacked — opened in Photoshop — and then put back together, it is always repackaged slightly differently, and we can detect that. I wish you could just upload any image and we could tell you if it's real or not, but it's still a very

difficult process and requires expertise to understand different components.

Who uses your digital forensic services?

I do analysis for organisations such as the Associated Press, Reuters, and *The New York Times*. There are only a handful of academics worldwide who are specialists in this, so it doesn't scale — and that means you can only do the analysis of really high-stakes images. But there are efforts under way to scale this up. Last year, the US Defense Advanced Research Projects Agency (DARPA) got into this game with a large project of which I'm part. Over the next five years they're trying to create a system that will allow you to analyse hundreds of thousands of images a day. It's a very ambitious programme.

I also do a lot of work in the courts. For example, here in the United States, child pornography is illegal, but computer-generated child pornography counts as 'protected speech' under the First Amendment. If someone's arrested they might say that the offending image isn't real, and I might have to prove that it is. I also get lots of e-mails from people about photo hoaxes — almost daily.

Do you apply your techniques to scientific papers?

I have worked on many cases of scientific misconduct, hired by universities conducting internal investigations. When I visited the US Office of Research Integrity recently, they asked me "how do we get our hands on automated tools?" The reality is we're still not there. But creating something that uses some of the tools, such as clone detection, which looks to see whether parts of an image have been copied and pasted from elsewhere, would be possible as a semi-automated process looking at dozens, not millions, of images a day. It's something my colleagues and I are thinking about, and it's a small but not insignificant part of the DARPA programme.

How about fake videos?

Researchers are now able to splice together footage to create videos of famous people seeming to say things they never said — for instance, this video of President Obama. And they can create fake images or short videos using machine learning techniques: in particular, generative adversarial networks (GANs), which learn to generate fake content. These pit a network that generates fake content against a 'classifer' network that attempts to discriminate between real and fake content, so that the faking network rapidly improves.

I've seen the technology get good enough that I'm now very concerned. In 5 or 10 years, this is going to get really good. At some point we will reach a stage where we can generate realistic video, with audio, of a world leader, and that's going to be very disconcerting. I would say that the field of digital forensics is now behind in video.

How can you detect fake video?

JPEG compression has an analogous construct in video, which is a bit harder to detect because video uses a more sophisticated version. Another approach is to use machine learning for detection. But we're taking an approach similar to what we do with images — which is based on the observation that computer-generated content lacks the imperfections that are present in a recorded video. It's created in almost too perfect a world. So one of the things we look at is, are we not seeing the statistical and geometric patterns we'd expect to see in the physical world?

Another technique is based on some beautiful work by William Freeman and colleagues at the Massachusetts Institute of Technology in Cambridge, who showed how if you magnify really small changes in a video of a person, you can see subtle changes in the colours in their face that correspond to their pulse rate. We showed that you can use this to distinguish real people from computer-generated people.

Couldn’t machine learning algorithms learn to include these features?

Perhaps in principle. But in practice, these algorithms have limited time and training data, and there is little control over which features a neural network will pick up on to discriminate between real and fake videos. A GAN is only trying to fool the classifier it’s trained on. That’s no guarantee that it will learn all aspects of what makes an image or video real or fake, or that it will fool another classifier.

My adversary will have to implement all the forensic techniques that I use, so that the neural network can learn to circumvent these analyses: for example, by adding a pulse in. In that way, I’ve made their job a little harder.

It’s an arms race. As we are developing faster, folks are creating more sophisticated technology to augment audio, images and video. The way this is going to end is that you take the ability to create a perfect fake out of the hands of the amateur. You make it harder, so it takes more time and skill, and there’s a greater risk of getting caught.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22784

Comments

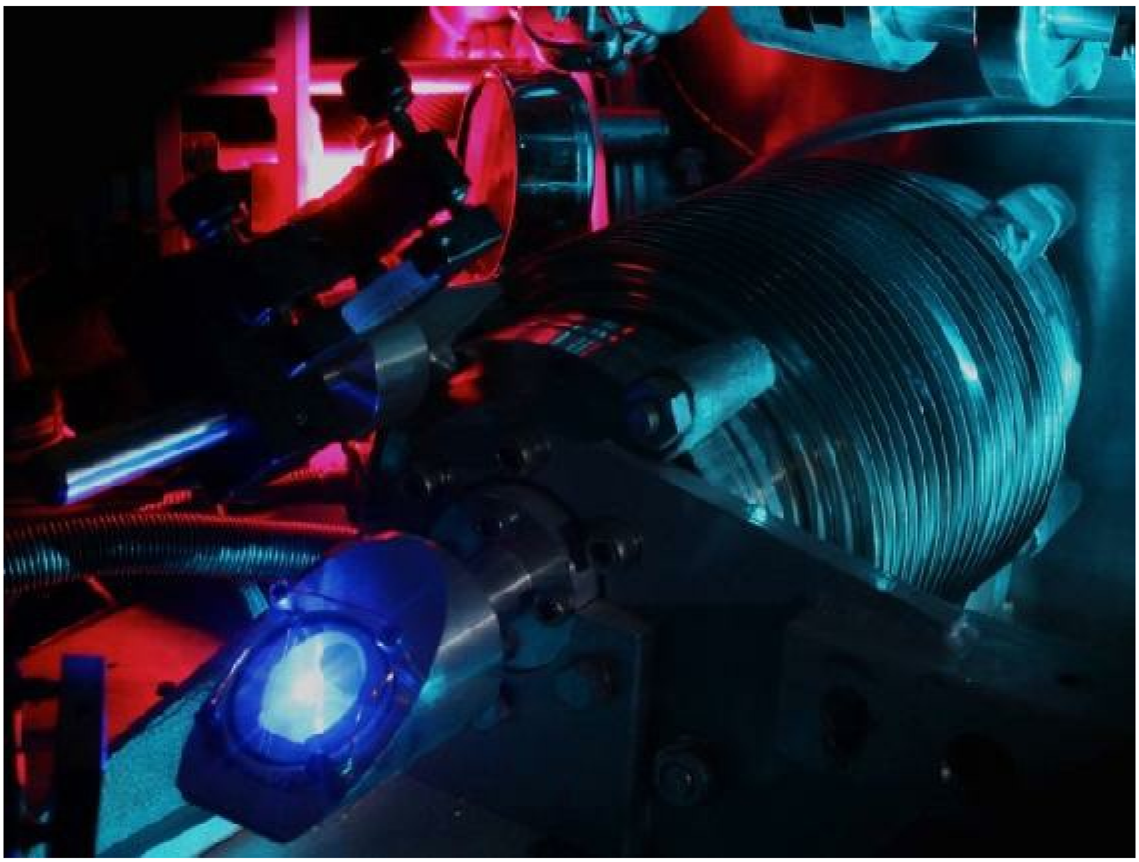
Comments

There are currently no comments.

Proton-size puzzle deepens

Measurement in ordinary hydrogen agrees with a surprising 2010 result on the element's exotic cousin — but gives a smaller value than virtually every other experiment.

05 October 2017



Axel Beyer

Researchers shone lasers at hydrogen atoms in a vacuum chamber to pinpoint the size of the protons inside.

The proton might truly be smaller than was thought. Experiments on an exotic form of hydrogen first found[1] a puzzling discrepancy with the

accepted size in 2010. Now, evidence from a German and Russian team points to a smaller value for the size of the proton with ordinary hydrogen, too.

The results, which appeared on 5 October in *Science*[2], could be the first step towards resolving a puzzle that has made physicists doubt their most precise measurements, and even their most cherished theories.

Still, “before any resolution, this new value has to be confirmed”, says Jan Bernauer, a physicist at the Massachusetts Institute of Technology in Cambridge. If other labs confirm it, he adds, “then we can find why the old experiments were wrong, hopefully”.

Method mix-up

For decades, physicists have estimated the size of the proton using one of two main techniques. Atomic physicists use spectroscopy to measure the energy levels of electrons orbiting an atomic nucleus — consisting of either the single proton in a hydrogen atom, or a bigger nucleus. The size of the nucleus affects those energies because electrons spend some time moving through the nucleus as they orbit it.

Meanwhile, nuclear physicists have used a similar technique to the one that enabled Ernest Rutherford to discover atomic nuclei in the first place. They hit the atoms with beams of fast-moving electrons and measure how the electrons bounce off.

As their precision improved, both methods roughly came to agree on a radius of about 0.8768 femtometres (millionths of a millionth of a millimetre).

But in 2010, a novel kind of experiment completed at the Paul Scherrer Institute in Villigen, Switzerland, disrupted the consensus. After a decade of unsuccessful attempts, a multinational collaboration led by Randolf Pohl, then at the Max Planck Institute of Quantum Optics (MPQ) in Garching, Germany, measured energy transitions not in ordinary hydrogen, but in lab-made ‘muonic’ hydrogen. These are atoms in which the electron has been replaced by a muon — a particle similar to an electron in most of its

properties, but 200 times more massive. The heavier particle spends more time inside the nucleus, which means that the proton's size has a much larger effect on the muon's energies — which, in turn, should lead to a much more precise estimate of the proton's radius.

Pohl's team found the proton to be 4% smaller than the accepted value. Some researchers speculated that perhaps some previously unknown physics could make muons act differently than electrons. This would have required a revision of the standard model of particle physics, which predicts that muons and electrons should be identical in every way except for their masses — and might have pointed to the existence of yet-to-be-discovered elementary particles.

Exciting technique

In the latest paper[2], Pohl, now at the Johannes Gutenberg University in Mainz, Germany, and his collaborators tickled hydrogen atoms — containing ordinary electrons — with two different lasers. The first one sent the atoms' electrons into an excited state, and the second one put them into a higher-energy excitation. The team then detected the photons that the atoms released as their electrons fell back into lower-energy excitation states.

The team combined its data with an earlier, high-precision measurement to calculate the Rydberg constant, which expresses the energy that it takes to rip the electron off the hydrogen atom. Standard theory then enabled the researchers to calculate the radius of the proton from this constant. The value they found was consistent with the muonic-hydrogen measurement, and 5% smaller than the 'official' proton radius.

To ensure that they eliminated any spurious experimental effects, the team spent three years analysing its data, says Lothar Maisenbacher, a co-author of the paper and an atomic physicist at the MPQ.

Bernauer, who works on the electron–proton scattering technique, is impressed. "It's a great experiment," he says. "I think they really advanced their field with this."

The care that they took is “very impressive”, and makes their measurement more reliable than many others, says Krzysztof Pachucki, a theoretical physicist at the University of Warsaw who is on the task group of the Committee on Data for Science and Technology (CODATA).

CODATA, the international agency that publishes the best-known values of the fundamental constants, is taking notice of the Mainz experiment. “We will take this result very seriously,” says Pachucki. The committee is due to revise the ‘official’ handbook of universal constants of nature next year. Because of this experiment, CODATA will "most probably” change its values for the proton radius and Rydberg constant, he says.

More evidence needed

But the German–Russian group is not quite ready to claim that the puzzle has been solved, Maisenbacher says. “We have not identified any conclusive reason why the other measurements should not be correct themselves,” he says. “We would like to see more experiments from other people.”

A number of teams around the world are doing just that. Bernauer is interested, for example, in the results of spectroscopy experiments being done at York University in Toronto, Canada. If their measurement is also small, “then I would start to believe that the old data has a problem”, Bernauer says. But that would still leave open the matter of the electron–proton scattering results.

In those experiments, researchers have conventionally used electrons that have a range of different energies. Estimating the size of the proton required extrapolating all the way to an ideal situation, in which electrons had zero energy.

Ashot Gasparian, a particle and nuclear physicist at North Carolina A&T; State University in Greensboro and his team have recently conducted an experiment at the Thomas Jefferson National Accelerator Facility in Newport News, Virginia. They injected cold hydrogen gas directly into their electron accelerator, rather than bombarding liquid hydrogen kept in a plastic box, as

was previously done. This technique enabled them to remove some experimental uncertainties and also to use electrons with lower energies than before. In principle, this could reveal whether and where the previous extrapolations went wrong. They are now analysing their data and hope to have results next year. “The ball is in our court,” says Gasparian.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22760

Comments

Comments

There are currently no comments.

Controversial pesticides found in honey samples from six continents

Neonicotinoids are at the centre of a long-running debate about whether they harm bees.

05 October 2017

Fergus Gill/2020VISION/naturepl.com

Honey is a major source of food for honey bees.

Honey bees on every continent except Antarctica face significant exposure to neonicotinoid pesticides — chemicals that some studies suggest harm bees' health. Researchers who tested honey from nearly 200 sites worldwide found that 75% of their samples contained some level of the pesticides, according to

a report published on 6 October in *Science*[1].

The study is the first attempt to quantify the presence of neonicotinoids in honey on a global scale using standardized methods. Nearly half of the samples tested contained levels of neonicotinoids at least as high as those thought, on the basis of previous research, to impair bees' brain function and slow the growth of their colonies. The study also found that 45% of the samples contained two or more types of neonicotinoid.

"It's not a surprise, in a sense, that we find neonicotinoids in honey. Anybody could have guessed that," says lead author Edward Mitchell, a biologist at the University of Neuchâtel in Switzerland. "What's original is using the same protocol. We now have a worldwide map of the situation."

The research provides additional context for the long-running debate over whether and how neonicotinoids affect bees' health. Some studies have suggested that exposure to neonicotinoids lowers honey bees' nutritional status[2] and impairs their immunity[3]. And in June, a paper published in *Science* reported that neonicotinoids lower honey bees' chances of survival during the winter, and threaten the queen in particular, which can affect reproduction[4].

To assess the scale of honey bees' exposure to neonicotinoids around the world, the authors of the new study collected honey from 198 sites on six continents through a citizen-science project. Then they tested those samples to determine the concentrations of five of the most commonly used neonicotinoids. Honey collected in North America had the highest proportion of samples containing at least one neonicotinoid, at 86%, with Asia (80%) and Europe (79%) close behind.

The extent of the contamination, even in honey from remote places — including islands in the middle of the Pacific Ocean and off the coast of West Africa — is surprising, says Amro Zayed, an insect researcher at York University in Toronto, Canada. The findings suggest that bees the world over are exposed to neonicotinoids constantly over generations, he says, which is worrying because the insects depend so heavily on honey for food. "It's one thing to go out to a restaurant and get a bad meal, but if you have your fridge

at home contaminated with insecticides, that's an entirely different method of exposure," Zayed says.

Others say that the widespread presence of neonicotinoids in honey is to be expected, given how commonly the chemicals are used in staple crops such as canola and wheat, as well as in home gardens. "Yes, there is going to be long-term exposure, potentially, to neonics, but that doesn't say anything about the risk," says Chris Cutler, an entomologist at Dalhousie University in Halifax, Canada. "Just because it's there doesn't necessarily mean there's a problem."

Much of the debate about neocotinoids has focused on just this question: how problematic are the pesticides when bees are exposed to them at low levels, but over a long period of time? "One of the issues around assessing the impacts on bees has been the discussion of what a field-relevant level of exposure actually is," says Nigel Raine, a pollinator-health researcher at the University of Guelph in Canada. "This contributes toward that discussion substantially."

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22762

Comments

Comments

There are currently no comments.

Antikythera shipwreck yields statue pieces and mystery bronze disc

Archaeologists think that at least seven life-sized sculptures are hidden nearby.

04 October 2017

Brett Seymour/EUA/ARGO 2017

Archaeologist Brendan Foley discovers a bronze disc, at first thought to be part of the Antikythera mechanism.

Marine archaeologists investigating the ancient shipwreck that yielded the Antikythera mechanism — a complex, bronze, geared device that predicted eclipses and showed the movements of the Sun, Moon and planets in the sky

— have recovered a wealth of treasures, including bronze and marble statue pieces, a sarcophagus lid and a mysterious bronze disc decorated with a bull. The artefacts were trapped under boulders in a previously unexplored part of the site near the island of Antikythera, Greece, and the researchers think that large parts of at least seven statues are still buried nearby.

The discoveries are “extremely exciting”, says Kenneth Lapatin, curator of antiquities at the J. Paul Getty Museum in Los Angeles, California. Only a handful of bronze statues survive from the ancient world, and they have almost invariably been treated and altered by previous conservators, undergoing processes that destroyed much of the information scientists might have gleaned from them. “Technology has improved so much,” says Lapatin. “We can learn from these untreated finds.”

The first-century-BC cargo ship, discovered in 1900 by sponge divers, is famous for yielding a heavily encrusted and corroded geared device that used to predict eclipses and chart the skies. The sponge divers also retrieved many other priceless items, including luxury glassware, jewellery and a two-metre-tall bronze statue, dating from the fourth century BC, nicknamed the ‘Antikythera youth’.

Statue search

Courtesy of ARGO 2017

The bronze arm was one of the most significant recent findings.

The recovery of multiple ‘orphan’ statue pieces — limbs without matching heads or bodies, for example — suggested that several statues still lie buried here. So an international team of archaeologists and divers, co-led by Brendan Foley of the University of Lund in Sweden and Theotokis Theodoulou of the Greek Ephorate of Underwater Antiquities in Athens, is now re-excavating the 50-metre-deep wreck site to look for them.

The team has made a stream of discoveries since work began in 2014, including wine jars, giant anchors, gold jewellery and a human skeleton, which is now being analysed for DNA. But the statues have remained hidden until now.

On 4 October**,** the team announced that during a 16-day dive season the previous month, they found several major statue pieces, including two marble feet attached to a plinth, part of a bronze robe or toga, and a bronze male arm, with two fingers missing but otherwise beautifully preserved. A slim build and “turning hand” gesture suggest that the arm may belong to a philosopher,

says Theodoulou.

In 1900–01, the sponge divers salvaged orphan limbs from a minimum of six bronze statues. The newly discovered arm pushes that total to at least seven, says Theodoulou. The team is particularly excited because the statue pieces were found in an area undisturbed by any previous excavations, buried beneath large boulders dislodged from Antikythera’s steep cliffs over the course of 2,000 years by periodic earthquakes. “We think this means that everything is down there still,” says Foley.

The discovery of seven bronze statues, if they could be recovered, would significantly boost the world’s total from this time period, which stands not much greater than 50, Lapatin estimates. Few of those are complete. And although these ancient figures might look beautiful, they are hard to study because the aggressive treatments by generations of conservators have altered and damaged the bronze.

Technological advances

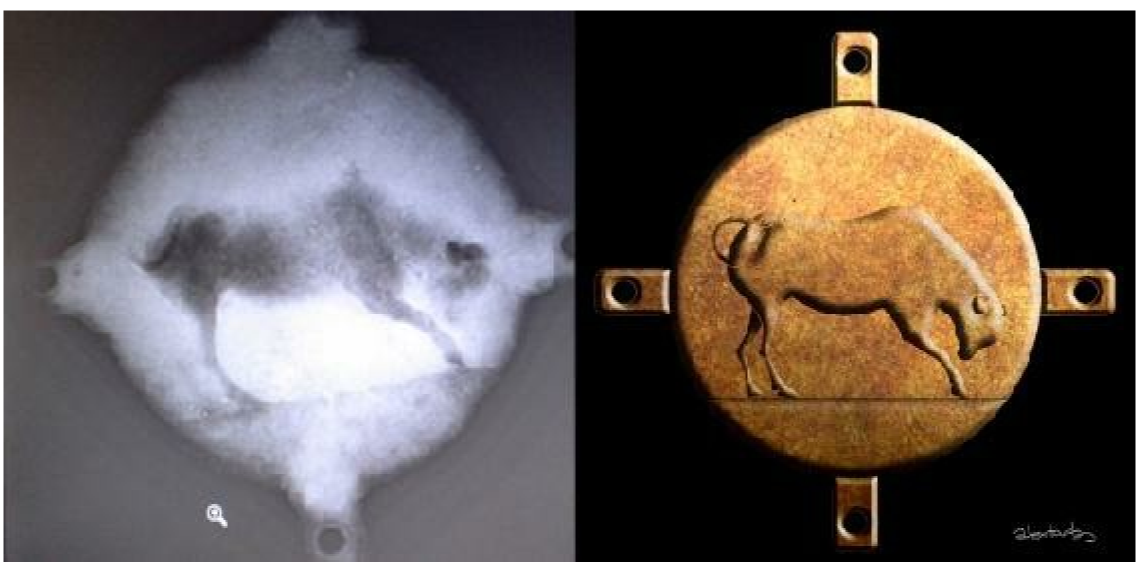
Fresh, untreated finds such as those from Antikythera will give researchers the opportunity to use modern techniques to study a significant aspect of ancient Greek life — for example, by looking at casting methods, which precise alloys were used and whether the statues were made for export or had been previously displayed. Meanwhile, any heads found might enable researchers to identify the people depicted, and to compare their likeness with any existing portraits, for example, marble statues or images etched on coins.

Brett Seymour/EUA/ARGO 2017

The bronze disc, which researchers at first thought might contain some of the lost gears of the Antikythera mechanism.

Foley and Theodoulou’s team also recovered an intriguing bronze disc or wheel, about eight centimetres across, attached to four metal arms with holes for pins. A layer of hardened sediment hides its internal structure, but it superficially resembles the Antikythera mechanism, and researchers had initially hoped that it might be part of that ancient device: perhaps the gearing that calculated the positions of the planets, which is missing from the find.

But preliminary X-ray imaging conducted in an Athens hospital on 25 September revealed a surprise: instead of gear wheels, the image of a bull appeared. The object might have been a decorative element, says Lapatin, perhaps attached to a box or a statue’s shield, or even — because of its sturdy construction — to the doomed ship. More-detailed radiography is planned for the next few weeks.



Left: EUA. Right: Alexander Tourtas.

The X-rays of the bronze disc, and artist's reconstruction of the bull.

Other discoveries this season include a sarcophagus lid made from fine, red marble, more human remains and wooden ship planks and frames that the researchers hope will reveal information about the vessel’s size and shape.

The team plans to return to Antikythera in May 2018, to break up the boulders and excavate beneath. “It’s going to be a major operation,” says Foley. “But we think it will be spectacular.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22735

Comments

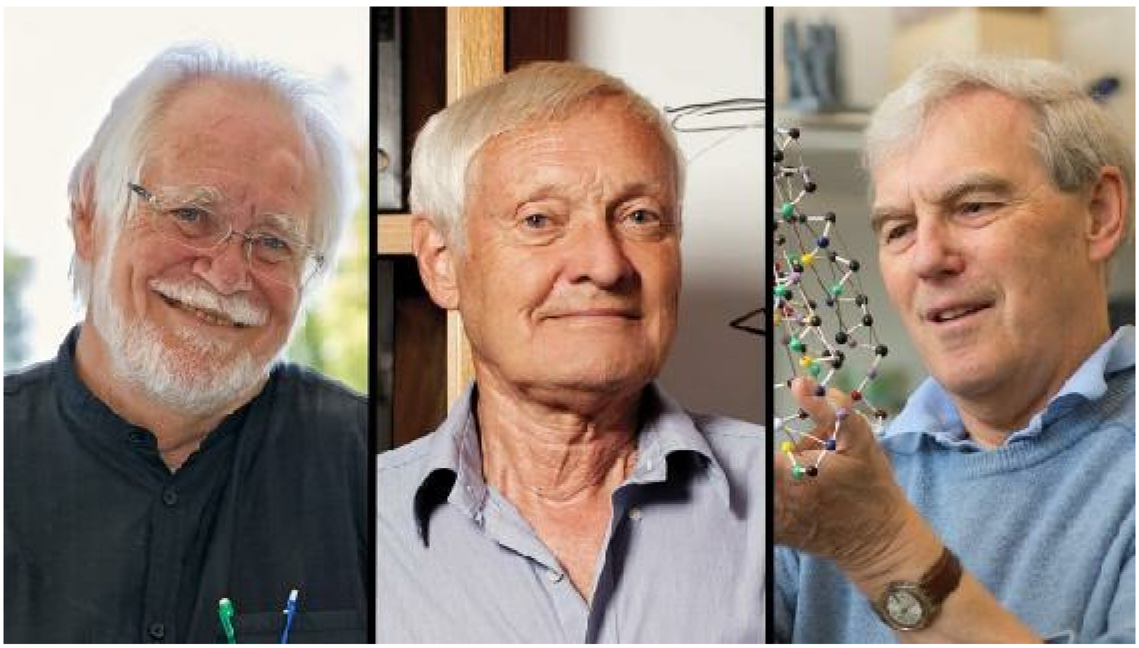
Commenting is currently unavailable.

Cryo-electron microscopy wins chemistry Nobel

Jacques Dubochet, Joachim Frank and Richard Henderson share the prize for developing a technique to image biomolecules.

04 October 2017 Corrected:

1. 05 October 2017



Left: Marietta Schupp/EMBL. Centre: Jorg Meyer. Right: LMB-MRC.

From left: Jacques Dubochet, Joachim Frank and Richard Henderson helped to develop cryo-electron microscopy.

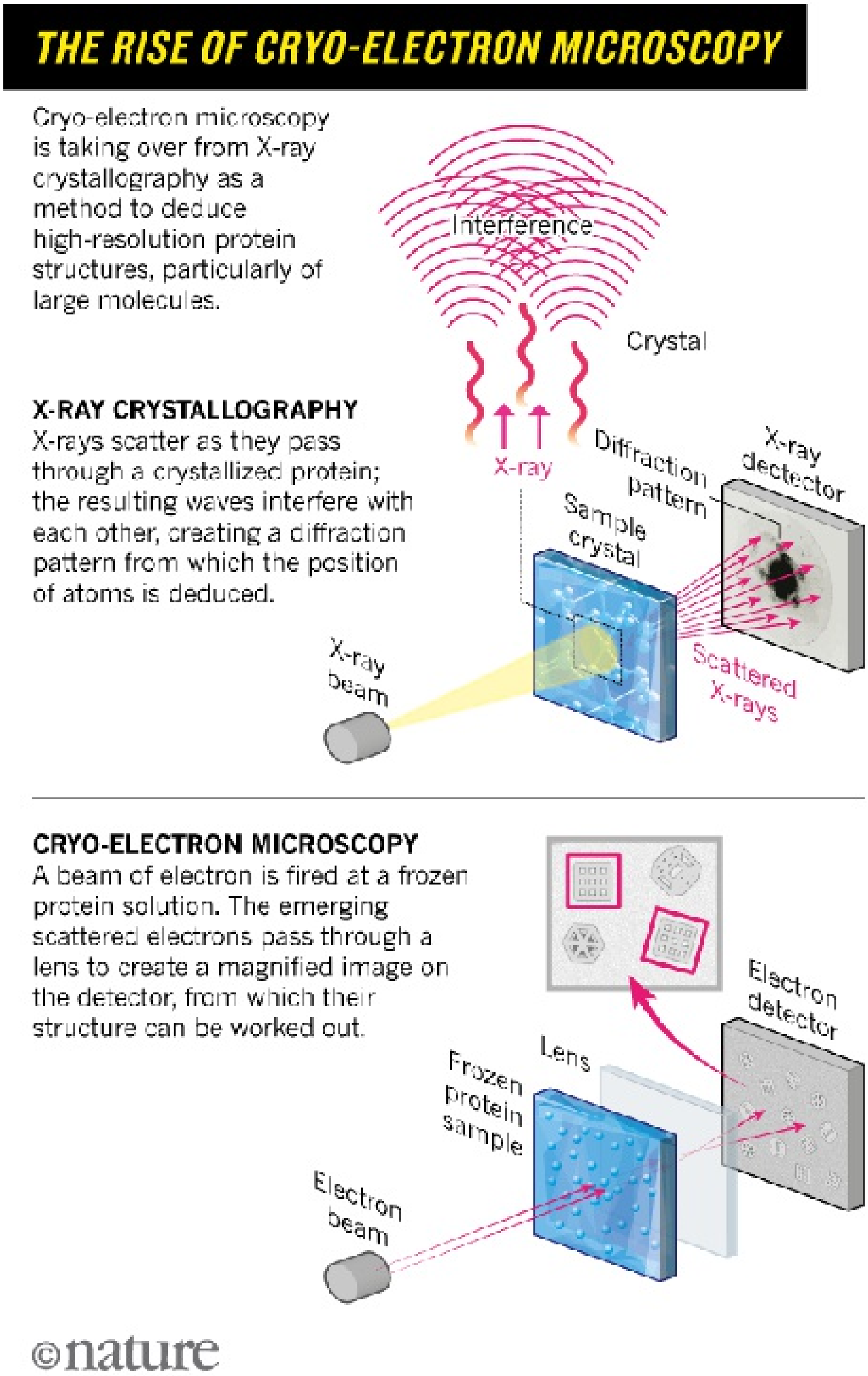
The 2017 Nobel Prize in Chemistry has been awarded for work that helps researchers see what biomolecules look like.

Jacques Dubochet, Joachim Frank and Richard Henderson were awarded the prize on 4 October for their work in developing cryo-electron microscopy (cryo-EM), a technique that fires beams of electrons at proteins that have been frozen in solution, to deduce the biomolecules' structure.

For decades, biologists have used X-ray crystallography — blasting X-rays at crystallized proteins — to image biomolecular structures. But labs are now racing to adopt the cryo-EM method, because it can take pictures of proteins that can't easily be formed into large crystals. The tool has "moved biochemistry into a new era", says the Royal Swedish Academy of Sciences, which awards the prize.

Imaging solutions

In the 1970s, Henderson, a molecular biologist who works at the MRC Laboratory of Molecular Biology in Cambridge, UK, and his colleague Nigel Unwin were trying to determine the shape of a protein called bacteriorhodopsin. The molecule, which uses light energy to move protons across a cell membrane, proved unsuitable for crystallography. So the researchers turned to electron microscopy (see 'The rise of cryo-electron microscopy') and, in 1975, produced their first 3D model of the protein[1].



During the same decade, Frank, a biophysicist who is now based at Columbia University in New York City, and his colleagues developed image-processing software to make sense of the fuzzy pictures that are produced when an

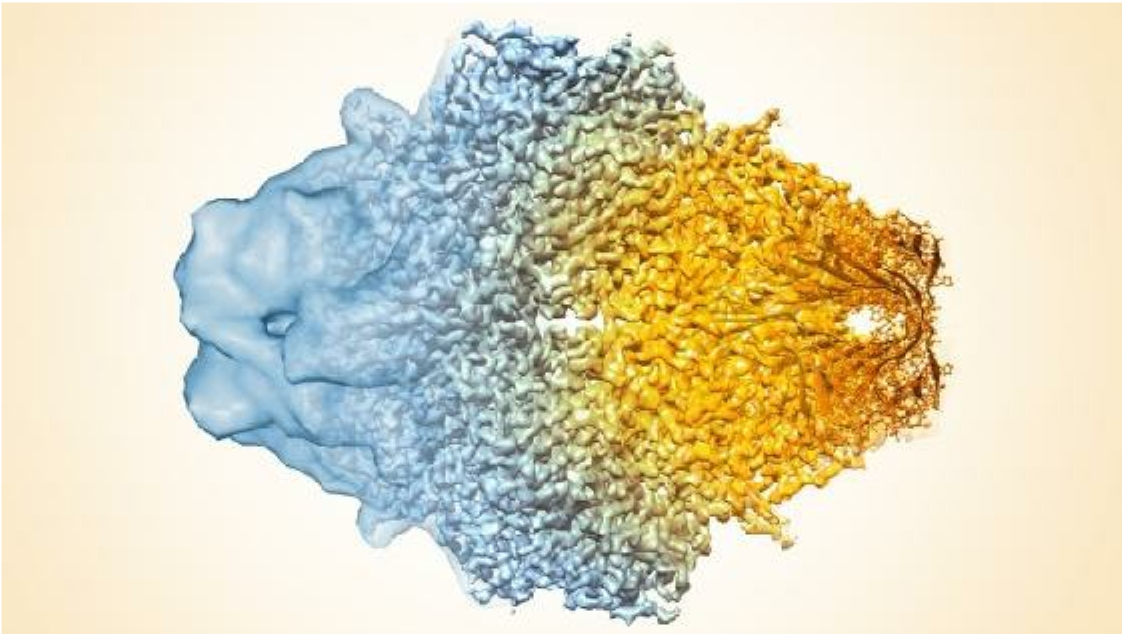
electron microscope is aimed at a protein, and to convert these two-dimensional blurs into 3D molecular structures.

In the early 1980s, a team led by Dubochet, who is now an honorary professor at the University of Lausanne in Switzerland, worked out how to prevent water-soluble biomolecules from drying out in the vacuum of an electron microscope, allowing the molecules to retain their natural shape during imaging. His team found a way to flash-freeze solutions of proteins using liquid ethane, keeping the molecules relatively still when they were pummelled with electrons. This allowed researchers to use electron microscopes to determine the structures of proteins at much higher resolution than before.

These and other improvements enabled Henderson to create the first atomic-resolution images of a protein using cryo-EM in 1990[2].

Resolution revolution

Although the research recognized by the Nobel Committee was conducted in the 1970s and 1980s, it laid the groundwork for what many scientists have dubbed a revolution in recent years. Subsequent improvements in the sensitivity of electron microscopes and in software used to transform their images into 3D structures have caused many labs to favour the technique over X-ray crystallography.



V. Falconieri, S. Subramaniam, NCI-NIH

Cryo-electron microscopy of proteins such as this β-galaxtosidase enzyme has progressed from the low-resolution density map on the left to the atomic coordinates on the right.

Frank told journalists gathered at the Royal Swedish Academy of Sciences in Stockholm that technological innovations can have a larger impact than discoveries. “Cryo-electron microscopy is about to completely transform structural biology,” he said. He added that the ribosome — the machinery that makes proteins inside cells — was the “coolest” molecule he had imaged.

Venki Ramakrishnan, a structural biologist at the Laboratory of Molecular Biology who shared the 2009 Nobel Prize in Chemistry for his work to reveal the structure of the ribosome using X-ray crystallography, is one of many converts to cryo-EM. After learning about the award from a *Nature* journalist, he said: “Oh, fantastic! Those are exactly the people I thought should win the Nobel prize.”

Benoît Zuber, a structural biologist at the University of Bern in Switzerland, who did his PhD with Dubochet, says his mentor was always confident that

cryo-EM would become a vital tool, even as others derided the field as “blobology” for the low-resolution molecular images it captured.“He had a vision and he was convinced about it, even when everybody was telling him that this was just a dream," says Zuber.

“It’s a great recognition for all the developments that have happened in the past. It’s fantastic,” says Sjors Scheres, a cryo-EM specialist who works alongside Henderson. The two were returning from a conference in Leicester, UK, yesterday, when Scheres asked Henderson whether he would keep his phone close in case the Nobel Committee called. “He said, ‘I think they should give it to Jacques Dubochet.’ He would never say that he should get one,” Scheres says. “It’s a well-deserved trio.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22738

Corrections

Corrected:

This story originally indicated that bacteriorhodopsin moves proteins across the cell membrane. In fact, it moves protons.

Comments

Commenting is currently unavailable.

Crash in sea-turtle births stumps ecologists

Leading suspect — climate change — doesn’t fully explain what is happening to leatherback turtles in the US Virgin Islands.

04 October 2017

Jurgen Freund/NPL/Getty

While buried in the sand, sea-turtle eggs are very sensitive to several environmental conditions that affect whether they hatch or not.

The mystery behind a dramatic fall in the number of leatherback sea-turtle (*Dermochelys coriacea*) hatchlings in the US Virgin Islands remains unsolved, despite the latest efforts of researchers. Rising temperatures and

changes in rainfall patterns — the top two suspects — don't seem to be connected to the decline, according to a study published on 4 October[1]. The finding contradicts previous work, leaving researchers scratching their heads over what could be happening.

The latest study focused on a nesting beach in the Sandy Point National Wildlife Refuge on St Croix island in the Caribbean Sea. The researchers found that about 74% of the leatherback sea-turtle eggs laid there in 1990 hatched, but that rate had plummeted to 55% by 2010.

The study analysed detailed temperature and precipitation data at these nests over the 20 years, and found no corresponding trend in either climate-change factor that could fully account for the decline. The researchers reported their results in *Royal Society Open Science*.

Increases in temperature and more-erratic precipitation patterns do affect the nests, but they aren't the sole reason for the hatching declines, says Anthony Rafferty, a marine biologist at Monash University in Melbourne, Australia, and a study co-author.

This trend is especially confusing in light of the increase in the adult sea-turtle population. "The number of nesting females and the population size has been trending upwards at this site," Rafferty says. "But there's been a decrease in hatching success that we are worried about." That could have negative effects on leatherback populations within one or two decades, he says, when those hatchlings come of age.

Conundrum continues

"It's hard to say how much of that is happening because of climate change," says Vincent Saba, a climate scientist at the US National Oceanic and Atmospheric Administration in Princeton, New Jersey. He co-authored a 2015 study[2] that did find a relationship between air temperature, precipitation patterns and declines in leatherback hatching success. That study examined data from 1982 to 2010 and looked at seasonal rainfall, unlike the latest paper, which analysed rainfall only during the nesting season. The study predicted that, by 2100, Sandy Point would have the most unfavourable climate conditions out of all leatherback nesting sites around the world.

“I like the study. They looked at the effect of climate in finer detail,” says Pilar Santidrián Tomillo, a marine biologist and science director of the Leatherback Trust, based in Playa Grande, Costa Rica. She was a co-author on the 2015 study, and appreciates the fuller picture of what could be happening at Sandy Point that the most recent study has provided.

Sea-turtle eggs are exquisitely sensitive to climate because heat, carbon dioxide, oxygen and water all pass freely through their permeable shells. The surrounding temperatures determine the sex of the hatchlings: warmer conditions produce more females, whereas cooler conditions yield males. And rainfall can influence hatchling development and their ability to escape the nest, says Rafferty. Too little rain might mean that the sand is too dry for the young turtles to climb out of it; too much rain during the early stages of egg development might lead to a reduction in oxygen supplies to the growing embryo.

“I think changes in precipitation levels or patterns could explain the decline in hatching success partially, but there could be other reasons, too, like decline in fertility or increase in pollutants, for example,” Santidrián Tomillo says.

Rafferty, who specializes in embryo research, now plans to look at how the age and health of a female sea turtle might affect her fertility, or where she lays her eggs.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22748

Comments

Comments

There are currently no comments.

| 章节菜单 | 主菜单 |

Scientists plead with Brazilian government to restore funding

If officials don't act soon, research institutions could start shutting down next year.

04 October 2017

Leonardo Benassatto/Reuters

Protests against Brazilian president Michel Temer's policies have consumed the country amid severe budget cuts this year.

Anxiety is growing in Brazil over the country’s collapsing research budgets. President Michel Temer had slashed funding for science by 44% in March and has proposed additional decreases for 2018 — even as some science

institutes run out of money for basic needs, such as paying electricity bills. The 2017 science budget, at 3.2 billion reais (US$1 billion), is the lowest the country has seen in at least 12 years.

On 3 October, the government announced that it will release 440 million reais to science agencies to help keep them afloat until the end of this year. But the money is only about 20% of what's needed, said the Brazilian Society for the Advancement of Science in a statement.

Researchers continue to voice their alarm, with a march scheduled for 8 October in São Paulo — the third such demonstration this year protesting the funding shortfalls. And on 10 October, a public awareness campaign called *Conhecimento Sem Cortes* (Knowledge without cuts) will deliver a petition to Congress with more than 80,000 signatures protesting both the cuts and a 2016 constitutional amendment that put a 20-year cap on federal spending.

Last week, 23 Nobel laureates and nine of the country's scientific societies warned Temer that continued budget reductions will seriously jeopardize Brazil's future. They say that the ongoing uncertainty over science funding risks dismantling research groups and prompting a brain drain.

They all hope to influence a revision of the 2018 budget proposal — first submitted to Congress by the executive branch in August — which included a 16% cut to the Ministry of Science, Technology, Innovations and Communications (MCTIC). The Temer administration has promised to release a revised budget in the coming weeks.

On life support

If the 16% cut remains, it would leave a total of about 2.7 billion reais for 22 federal laboratories and research institutes, 73 National Science and Technology Institutes and Brazil's major science funding agencies, the National Council for Scientific and Technological Development (CNPq) and the Funding Authority for Studies and Projects. "This means institutions will shut down by August next year", says physicist Luiz Davidovich, president of the Brazilian Academy of Sciences.

Davidovich's estimate is based on what has happened this year. MCTIC started 2017 at 5 billion reais, its smallest budget in a decade when adjusted for inflation. In March, after the 44% cut, the ministry was left with 2.8 billion reais, not including money for special projects such as the Sirius synchrotron. The budget rises to 3.2 billion reais with those projects. As a result, institutions began running out of cash in September.

“We don’t have money for electricity bills or for buying radiopharmaceuticals”, says José Augusto Perrotta at the federal Institute of Nuclear and Energy Research. Perrotta is the coordinator of the multi-purpose reactor, a 1.6-billion-reais project that is facing delays because of a lack of funding. This year, the reactor was supposed to receive 106 million reais but got nothing.

The Brazilian Center for Physics Research isn’t doing much better. “We‘ll be able to see it through December without layoffs, but next year I’ll have to cancel all equipment maintenance contracts”, says Ronald Shellard, the centre’s director. The institution’s proposed 2018 budget is 7.8 million reais — well below the 12.7 million reais Shellard says it needs to survive.

Brazil’s 1.6-billion-reais Sirius synchrotron is also in jeopardy. The 2018 budget proposal doesn’t provide funding for the facility’s construction, which is slated for completion in mid-2018.

The build is still on schedule after science minister Gilberto Kassab unfroze 85 million reais this month, says Antonio José Roque da Silva, director of the Brazilian Synchrotron Light Laboratory and head of the project. However, the synchrotron will need an additional 331 million reais to complete construction. “I pay contractors with cash, not with promises,” says Roque.

A skeleton crew

Also at risk is Brazil’s collaboration with CERN, Europe’s particle-physics laboratory near Geneva in Switzerland. The 2017 budget cuts eliminated Brazil’s financial support for CERN, and the proposed 2018 budget doesn’t resume those payments.

The biggest threat, however, is to CNPq, Brazil’s main source of federal research grants. The agency hasn’t paid out the grants it green-lit last year, didn’t launch its annual call for project proposals this year and is 400 million reais short of what it needs to honour its commitments in 2017. If the situation isn’t sorted, Marcelo Morales, a CNPq executive director, fears a repeat of 2016, when scholarships for undergraduates and scientists abroad were suspended.

The continuing funding crisis is already driving away students and young scientists. Sergio Ferreira, a neuroscientist at the Federal University of Rio de Janeiro, runs a lab whose budget has gone downhill since 2014. It's now an average of 85,000 reais — one-tenth of what it used to be. This year, five of Ferreira’s graduate students had to spend six months abroad working with his collaborators because he couldn’t afford the materials the students needed for their research.

“In my group I have several people who have left or are about to leave for good, with no plans to come back”, Ferreira says. “I can’t keep a skeleton colony of students.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22757

Comments

Comments

There are currently no comments.

Supercomputer redesign of aeroplane wing mirrors bird anatomy

Bird-bone structures emerge from an evolution-like algorithm.

04 October 2017

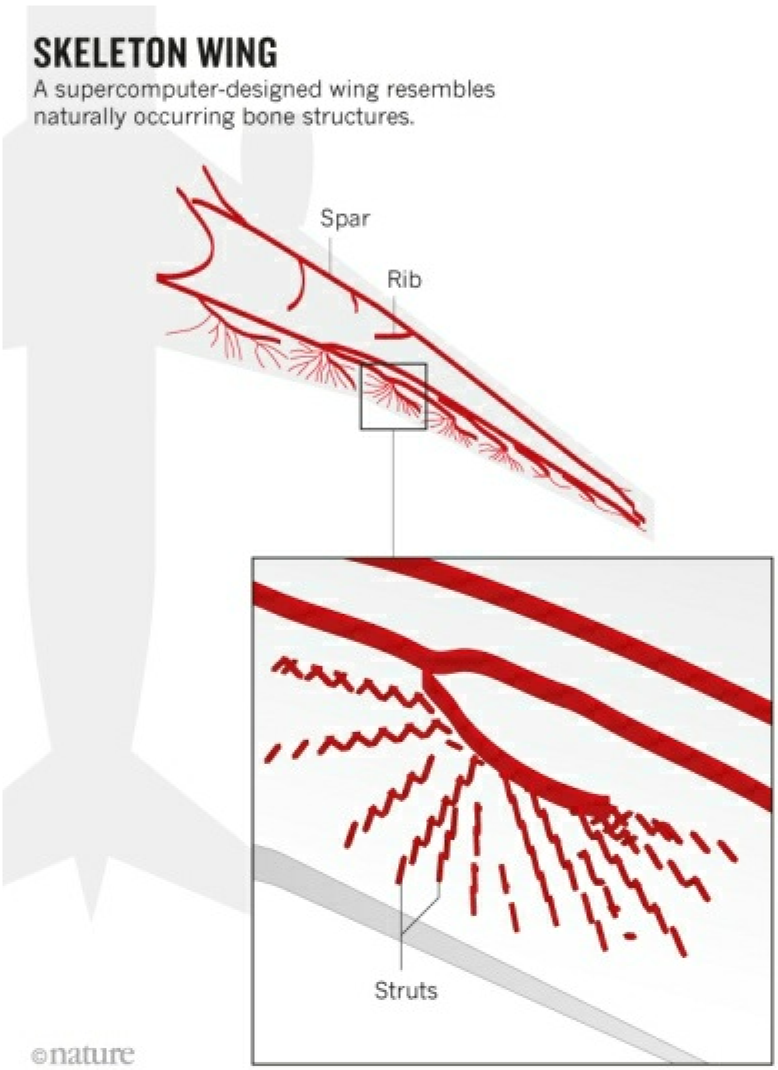
Samuel Taylor/Alamy

Conventional aeroplane wings are supported by straight bars and struts, but a supercomputer has suggested a more organic design.

Engineers have used a supercomputing technique that mimics natural selection to design the internal structure of an aircraft wing from scratch. The

resulting blueprint is not only lighter than existing wings, it also resembles natural formations, such as bird wing bones, that are not present in current aeroplanes. The organic-looking product is as stiff as a conventional aircraft wing but lighter, which could save up to 200 tonnes of fuel per year per plane.

“This is a really nice illustration of how to employ computing-based optimization methods at immensely high resolution,” says Matthew Santer, an aerospace engineer at Imperial College London. The method could feed into the design process, although there are a number of hurdles to using it in aerospace applications in its present form, he adds.



Engineers have been using these kinds of optimization techniques for around

20 years, but only for smaller-scale problems, such as individual wing components, or much simpler structures, says Niels Aage, an engineer at the Technical University of Denmark, near Copenhagen, who led the work[1]. Aage and his colleagues used the Curie supercomputer in Bruyères-le-Châtel near Paris to increase the resolution, enabling them to model the entire 27-metre-long wing of a Boeing 777.

The team started with a wing outline already optimized for maximum lift and minimum drag, known as an aerofoil, and split it into 1.1 billion 3D pixels or 'voxels'. Each is about the size of the smallest Lego brick — a resolution roughly 200 times greater than previous efforts. The algorithm began by simulating the force exerted on every block and distributing material in response to where the wing experienced a load. Without any human guidance, the program then repeated the analysis several hundred times, adding or removing material depending on the strain felt by each brick, until it reached a final optimum design. "The structure evolves through each design cycle," says Aage. "The process has many similarities to nature's own evolution."

Organic flight

Unlike conventional wings, the resulting structure did not contain the usual straight beams running the length of the wings, interspersed by crossing supports. Instead, the design looks organic, says Aage. Curved supports fan out at the trailing edge of the wing, resembling the bones in birds' wings, and intricate support structures in the leading edge look like the internal structure of a beak.

Without compromising stiffness (resistance to deformation), the design weighs 2–5% less than conventional wing structures. That translates into 200–500 kilograms per wing, potentially saving each plane between 40 and 200 tonnes of fuel per year, say the authors. The technique could also be applied to other industries, says Aage, for example, to design high-rise buildings in earthquake-prone zones that maintain their stiffness yet can withstand the dynamics of a quake. It could be used to optimize acoustics, ventilation systems and antennas, as well, he adds.

The technique’s high resolution, which allows the computer to design structures that include features that range in size from millimetres up to tens of metres, could lead to more-innovative designs in these other disciplines, says Liang Xia, a computational engineer at the Huazhong University of Science and Technology in Wuhan, China. But he stresses that running the algorithm requires a heavy computing burden — the equivalent of running a single standard computer for 100 years. This computing cost could be reduced, however, if the team were to employ more-advanced simulation methods, used in artificial intelligence, which in effect model only parts of the wing in such high resolution.

The design is also too intricate to be made by existing manufacturing methods, and would require a giant 3D printer to build. But for now, key aspects of it could be fed into structures produced using conventional methods, says Aage. “We’re speeding up evolution rapidly, meaning we can see how designs should be, and then extract the key features — or those we can afford.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22759

Comments

Commenting is currently unavailable.

Elite Hungarian university may be saved

Hungary-New York agreement could allow Central European University to sidestep law change.

04 October 2017

Bernadett Szabo/REUTERS

Seventy thousand people protested in Budapest last April against a law apparently targeting the Central European University.

The prestigious Central European University (CEU) in Budapest, Hungary, seems to have found a way around a threat to close it down. The university had been affected by a law change that is widely thought to be politically

motivated.

The threat arose in April, when the government rushed through an amendment to its higher-education law, requiring that all international universities operating in Hungary had also to operate as higher-education institutes in their countries of origin.

The law change seriously affected only the CEU, which is legally registered in New York state. The university was founded in 1991 by Hungarian-born philanthropist George Soros, whom Hungarian Prime Minister Viktor Orbán has described as an enemy, because of Soros's statements in support of refugees, which run counter to Orbán's policies. The revised law, which includes other, smaller amendments, comes into effect on 11 October.

New York connection

A CEU spokesperson said on 3 October that the university has now signed a Memorandum of Understanding with Bard College in Annandale-on-Hudson, New York, to provide educational activities. She added that negotiations between the State of New York and the government of Hungary, which opened at the end of June, have now concluded, although the agreement still has to be signed off by Hungary's government and Parliament.

The law change sparked immediate protest last April, when 70,000 protestors took to the streets in Budapest, and the Hungarian Academy of Sciences expressed concern. The European Commission is pursuing an infringement procedure against what it sees as an illegal restriction of academic freedom, and an investigation by legal experts of the Council of Europe, a powerful human-rights organization with 47 member states, published a preliminary opinion in August indicating that the law was inappropriate.

"It's no secret that it has been a hell of a way to treat a university," says CEU rector Michael Ignatieff.

The university has nearly 1,500 mostly postgraduate students from more than a hundred countries, including a large number from Hungary. It operates mainly in the humanities, but recently expanded to include the cognitive and

network sciences.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22761

Comments

Comments

There are currently no comments.

Science without walls is good for all

International mobility and collaboration are linked to stronger research.

04 October 2017

David Williams/Bloomberg/Getty

New studies highlight how closing borders would be bad for science.

Some US biotechnology labs have responded to President Donald Trump's attempts to restrict immigration by releasing contrasting group photographs showing what less-open international borders would do to their workforces. A first image typically shows everyone who works in the lab. A second image includes only those who are permanent US residents, then just US citizens, and then only those who were born in the United States and whose parents also were (see, for example, go.nature.com/2ft02xj). The shrinkage

from the first to the last image is striking — in some cases, about two-thirds of staff are lost. This reflects a widespread reality in research. A 2012 analysis showed that more than 60% of postdocs in the United States grew up overseas (see *Nature* **490,** 326–329; 2012).

When it comes to co-authorship, researchers in Europe are the most international. In 1981, only about one in six papers by a European scientist included co-authors from a different country. By 2011, that had risen to one in two. Papers with authors from more than one country also tend to be more highly cited (J. Adams *Nature* **497,** 557–560; 2013) .

This week, *Nature*'s Comment section publishes two bibliometric analyses that suggest international mobility has similar science-boosting effects.

The first finds that researchers build strong links between nations as they travel around the world. The authors track 16 million individuals who published papers in 2008–15. Only about 4% of these people changed countries, but those who did had 40% higher average citation rates than those publishing solely in one region, a trend that held true across 13 regions. Importantly, mobile scientists retained ties in the countries they left.

The second argues that countries with mobile scientific workforces produce papers that are more highly cited. (These are the same countries that have the greatest fraction of internationally authored papers.) The analysis shows that a nation's willingness to let scientists cross borders was a better predictor of highly cited papers than was the proportion of its gross domestic product that it spent on research.

These are complex issues. Citation rates are not necessarily a sign of quality, influence or long-term importance. And many confounding factors hamper attempts to link policies to impact. Still, such studies are necessary to provide evidence for policies on how to best support the scientific system.

The benefits of international movement are not entirely clear-cut. Leading scientists who change institutional affiliation (but not country) seem to boost both output and impact (G. Halevi *et al. Publ. Res. Q.* **32,** 22–37; 2016). Further work could reveal whether international papers — or more-open countries — prompt more innovative or worthy science. Details of the

relative benefits of collaboration, or how the effects of an international move are mediated by discipline or career stage, must be teased out. So must the effects of particular policies, such as the ease with which potential trainees and working scientists acquire visas or other travel support.

There is a bigger question: does the flow of leading scientists into a country bring tangible benefits for the citizens whose taxes fund their work? What about when one country's funds flow to a scientist's international collaborators? Evidence from patents and technological advances suggests that such investment is rewarded. But attention must be paid to ensure that a nation's connection to elite international scientists also supports work on local interests and needs.

Meanwhile, the scientific powerhouses of the United States and the United Kingdom seem determined to close their doors. US travel restrictions put in place last week tell working scientists from eight countries to stay away. And Britain's departure from the European Union puts scientific collaboration and access to European funds at serious risk.

Many nations with more-welcoming attitudes are poised to benefit. One long-term trend is clear: existing scientific powerhouses are not destined to stand forever. The picture can change — and quickly.

Journal name:
Nature
Volume:
550,
Pages:
7–8
Date published:
(05 October 2017)
DOI:
doi:10.1038/550007b

Comments

Comments

There are currently no comments.

Nobel prizes, giant telescope and buried treasure

The week in science: 29 September–5 October 2017.

04 October 2017

Events | Research | Funding | Facilities | People | Trend watch

EVENTS

Antikythera wreck yields more treasures Marine archaeologists investigating an ancient shipwreck near the island of Antikythera, Greece, announced on 4 October that they have recovered bronze and marble statue pieces, a sarcophagus lid and a mysterious bronze disc decorated with a bull. The cargo ship, which dates to the first century bc and was rediscovered in 1900, is famous for yielding the Antikythera mechanism, a complex bronze geared device that showed the movements of the Sun, Moon and planets in the sky. A team led by archaeologists Brendan Foley of Lund University, Sweden, and Theotokis Theodoulou of the Greek Ephorate of Underwater Antiquities in Athens found the latest artefacts under boulders in a previously unexplored part of the site. They think that at least seven complete statues are still buried nearby.

Brett Seymour/EUA/ARGO 2017

The bronze disc found near the shipwreck.

Volcano threats More than 100,000 residents on the Indonesian island of Bali have reportedly been evacuated to shelters following increased seismic activity from Mount Agung. The government's Center for Volcanology and Geological Hazard Mitigation said on 29 September that, on the basis of the latest information, an eruption was still a probability. Meanwhile, in Vanuatu, the government ordered the evacuation of all residents of Ambae island — about 11,000 people — on 28 September, after Manaro Voui started ejecting lava, poisonous gas and ash. On 1 October, the Vanuatu Meteorology and Geo-hazards Department said the volcano's activity was settling, and a large eruption was less likely. However, as *Nature* went to press, evacuations continued.

Time capsule On an Arctic island, scientists have buried a stainless-steel tube stuffed with artefacts that they say sum up science and technology in 2017. The time capsule, placed in an out-of-use borehole near the Polish

Polar Station in Hornsund, Svalbard, contains samples that include DNA, silicon-based electronics, an ancient meteorite fragment and other items to inform a future discoverer of our present understanding of technology, geology and biology. A team with the Polish Academy of Sciences described the capsule — created to celebrate the sixtieth anniversary of Poland's polar station — in a report in *Gondwana Research* on 28 September.

RESEARCH

Space-time ripples Physicists have announced the first discovery of gravitational waves made together by observatories in Europe and the United States, and the fourth-such discovery overall. At a 27 September press conference, researchers said that on 14 August, both the Virgo observatory near Pisa, Italy, and the twin laboratories of the US Advanced Laser Interferometer Gravitational-Wave Observatory (LIGO) in Livingston, Louisiana, and Hanford, Washington, had picked up gravitational vibrations emanating from a pair of merging black holes 540 million parsecs (1.8 billion light years) away. Observing the event with three detectors, rather than LIGO's two, enabled scientists to pinpoint the location of and distance to the black holes with much greater accuracy. Virgo rejoined the hunt for the waves only on 1 August, after a five-year upgrade.

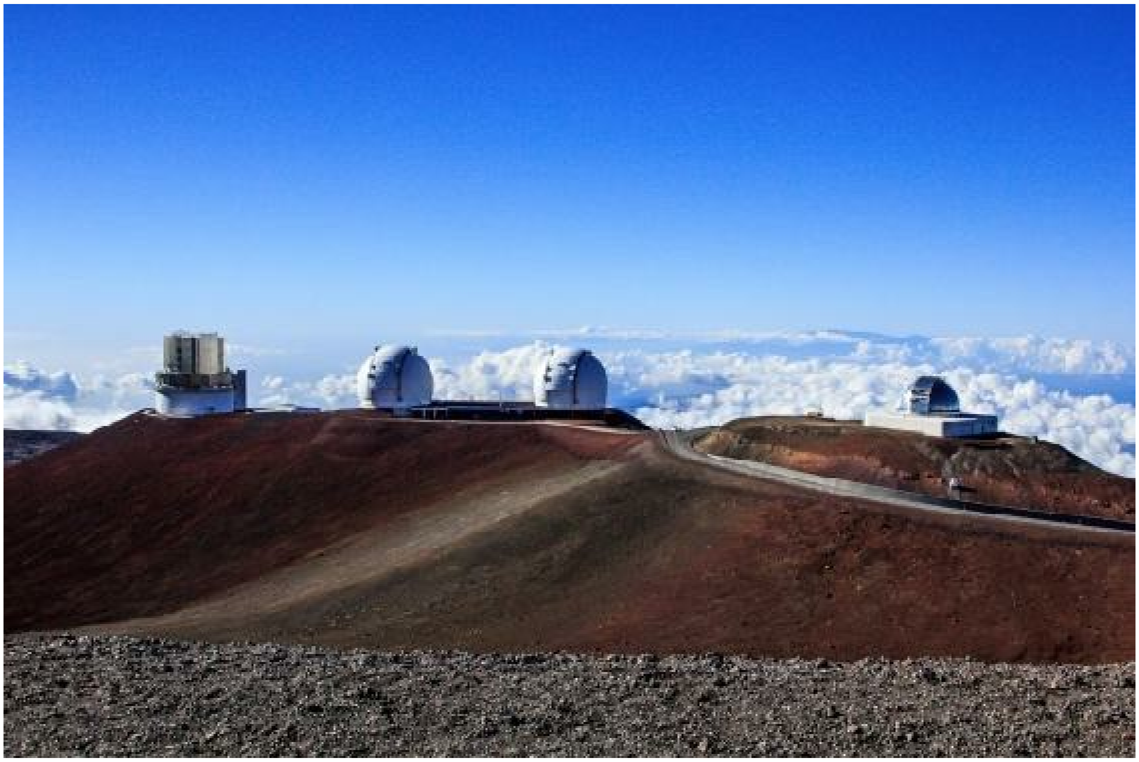
Monkey research The US Food and Drug Administration (FDA) has suspended a study on the effects of nicotine on monkeys after activists, including primatologist Jane Goodall, decried the experiments as cruel. On 25 September, FDA commissioner Scott Gottlieb responded to a 7 September letter from Goodall that called the experiments unnecessary, given that the effects of smoking are well known. The study, which began in 2014 at the FDA's lab in Jefferson, Arkansas, allows monkeys to self-administer nicotine. Gottlieb told Goodall that it would be halted while a team of experts assesses the monkeys' health and determines whether more precautions are needed. The team will also decide whether the study should resume.

FUNDING

French budget French research funding is set for a heartening increase in the country's first budget under President Emmanuel Macron, if draft 2018 plans released on 27 September are voted into law. The research portfolio of France's ministry of higher education, research and innovation would rise by more than 6%, to €8.4 billion (US$9.9 billion) in 2018. And a giant economic-recovery plan unveiled on 25 September by Prime Minister Edouard Philippe should divert an extra €2.4 billion to research over the next five years. Separately, in a 26 September speech, Macron backed the idea of a European Union funding agency to accelerate the commercial applications of basic science, an idea also suggested by EU research commissioner Carlos Moedas.

FACILITIES

Hawaii telescope Hawaii's board of land and natural resources granted a new construction permit to the Thirty Meter Telescope (TMT) on 28 September, reviving the chances that it could be built on the Hawaiian mountain of Mauna Kea. Some Native Hawaiians oppose the TMT, saying that its construction would further violate the sacred mountain, which already hosts multiple telescopes. Hawaii's supreme court invalidated the TMT's first construction permit in December 2015, ruling that the board had not followed appropriate procedures. The new permit gives the project the right to proceed on Mauna Kea, but telescope opponents have filed motions that would put the permit on hold until the state supreme court can hear an appeal.



Julie Thurston/Getty

PEOPLE

Nobel prizes Three biologists were awarded this year’s Nobel Prize in Physiology or Medicine for their work on circadian clocks. Jeffrey Hall and Michael Rosbash, both at Brandeis University in Waltham, Massachusetts, split the award with Michael Young at Rockefeller University in New York City. The physics prize was awarded to Rainer Weiss, at the Massachusetts Institute of Technology in Cambridge, and Barry Barish and Kip Thorne, both at the California Institute of Technology in Pasadena, for their work on detecting gravitational waves. *Nature* went to press before the chemistry prize was awarded, but full details will be available at go.nature.com/chem2017.

Science adviser On 26 September, Canadian prime minister Justin Trudeau appointed biochemist Mona Nemer as his country’s chief government science adviser, fulfilling his campaign promise to establish the position. Nemer was

most recently vice-president of research at the University of Ottawa and director of the Molecular Genetics and Cardiac Regeneration Laboratory there. Her scientific work has focused on the genetics of cardiovascular disease and birth defects. In her new role, Nemer will have a budget of Can$2 million (US$1.6 million) and report to Trudeau and science minister Kirsty Duncan. The country has been without a science adviser for nearly a decade; the last time such a post existed was from 2004 to 2008.

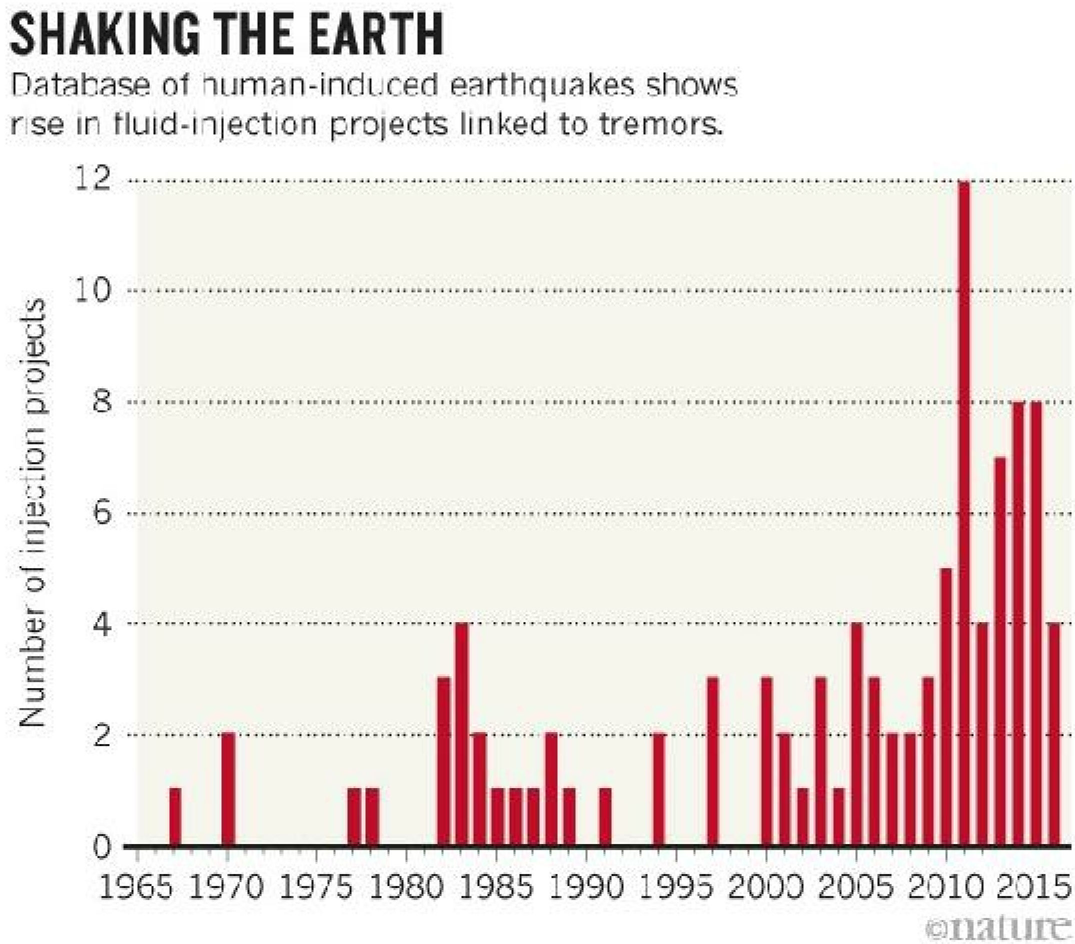
Russian academy After almost six months without a head, the Russian Academy of Sciences (RAS) has a new president: Alexander Sergeyev, a laser physicist and director of the RAS Institute of Applied Physics in Nizhny Novgorod. The academy, which operates a network of hundreds of institutes, is undergoing controversial reforms. In March, its planned presidential elections were unexpectedly cancelled at the last minute, allegedly following a row over voting procedures (see *Nature* **543,** 601; 2017). In the latest elections announced on 26 September, Sergeyev won a majority of votes from the academy's general assembly. A new state law requires that Russia's president Vladimir Putin must also approve the post, which he did the following day.

Defraud alert The FBI has charged bioengineer Yiheng Percival Zhang with defrauding the US government and his employer, the university Virginia Tech in Blacksburg. Zhang was arrested on 20 September and will remain in custody pending a trial, according to court documents. In an affidavit in support of a criminal complaint filed on 18 September, the FBI alleged that Zhang and two of his colleagues at the Tianjin Institute of Industrial Biotechnology in China — Zhiguang Zhu and Chun You — conspired to win US National Science Foundation (NSF) grants for studies that had already been completed in China. The affidavit also claims that Zhang withheld a portion of funds owed to his university from NSF and Department of Energy grants.

TREND WATCH

A database of human-induced earthquakes reveals a rise in tremors linked to wastewater injected into the ground by oil and gas operations. Such projects

spiked in the early 2010s, particularly in the central United States. The HiQuake database is described in *Seismological Research Letters*. Of 728 entries, 37% are linked to mining, 23% to water piling up behind a dam and 15% to conventional oil and gas development. Just 4% are linked to hydraulic fracturing, or fracking, for oil and gas.



Source: M. P. Wilson et al. Seismol. Res. Lett. http://dx.doi.org/10.1785/0220170112 (2017)

Journal name:
Nature
Volume:
550,
Pages:

12–13
Date published:
(05 October 2017)
DOI:
doi:10.1038/550012a

Comments

Comments

There are currently no comments.

Why fake islands might be a real boon for science

The seasteading movement is getting close to building its first prototype, an artificial archipelago where people will live, play and do research.

04 October 2017

Blue Frontiers

Early designs for a floating island in Tahiti aim to mimic a natural landscape.

The view is unbeatable. To the right, steep volcanic mountains, draped in green, rise up from a beachside coconut grove. To the left, the Pacific Ocean glitters turquoise under the midday sun. It is here in this Tahitian lagoon that a group of entrepreneurs plans to build an artificial island — three-quarters of a hectare of floating housing and research space, made up of linked platforms. If the team is successful, the vision could become reality by 2020. But it would be just the first step, says self-described “seavangelist” Joe Quirk. The ultimate goal is to build whole sovereign nations on the open seas, composed of modular floating units.

“French Polynesia has all the stepping stones: lagoons, atolls, shallow waters

right next to deeper waters," Quirk says.

Quirk, one of five managing directors for the company behind the project, and his colleagues propose that artificial islands could serve as laboratories for testing out new technologies and exploring different social structures, or act as life rafts for coastal peoples displaced by sea-level rise.

The non-profit Seasteading Institute was founded by former Google engineer Patri Friedman in 2008, and it has garnered support from influential people in the linked worlds of Silicon Valley, libertarian politics and the anything-goes desert festival, Burning Man. Most media reports have been sceptical, however. The project has been characterized as the dream of "two guys with a blog and a love of Ayn Rand"[1] and "a hacker's approach to government with a *Waterworld*-esque conception of Manifest Destiny"[2].

But the Seasteading Institute and the new for-profit spin-off, Blue Frontiers, have racked up some real-world achievements in the past year. They signed a memorandum of understanding with the government of French Polynesia in January that lays the groundwork for the construction of their prototype. And they gained momentum from a conference of interested parties in Tahiti in May, which hundreds of people attended. The project's focus has shifted from building a libertarian oasis to hosting experiments in governance styles and showcasing a smorgasbord of sustainable technologies for, among other things, desalination, renewable energy and floating food-production. The shift has brought some gravitas to the undertaking, and some ecologists have taken interest in the possibilities of full-time floating laboratories.

LISTEN

Reporter Geoff Marsh investigates ambitious plans to build artificial floating cities.

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But the project still faces some formidable challenges. The team must convince the people of French Polynesia that the synthetic islands will benefit them; it must raise enough money to actually build the prototype, which it estimates will cost up to US$60 million; and once it is built, the group must convince the world that artificial floating islands are more than just a gimmick. Producing solid science and broadly useful technology would go a long way towards making that case.

“What we are dreaming is that this structure will be a scientific laboratory,” says Winiki Sage, head of the Economic, Social, and Cultural Council of French Polynesia in Tahiti, who has been concerned about brain drain from his country.

Aesthetic appeal

Designs are surfacing for the prototype island, and its look is a key part of Blue Frontiers's public-relations strategy. The company's current plans don't entirely align with the concept art on the Seasteading Institute's website, which swings from tiki bar to Tomorrowland in various iterations. Bart Roeffen, a 'water pioneer' at the Dutch design firm Blue21 in Delft, has been drawing up new plans that fit with the landscape and culture.

“We are working together with Tahitian designers to make something that is not like an alien invasion,” Roeffen says. In particular, he plans to take cues from Polynesian shipbuilding. The elegant outrigger canoes, or *va'a*, used by islanders are stable and light; oceangoing versions are the type of boat rowed by the Tahitian voyagers who discovered Hawaii and New Zealand around AD 1100. Linked platforms would be arranged to ensure that no coral below is completely shaded and killed. The goal is to actually expand the habitat for reef species (see 'Seasteaders in paradise').

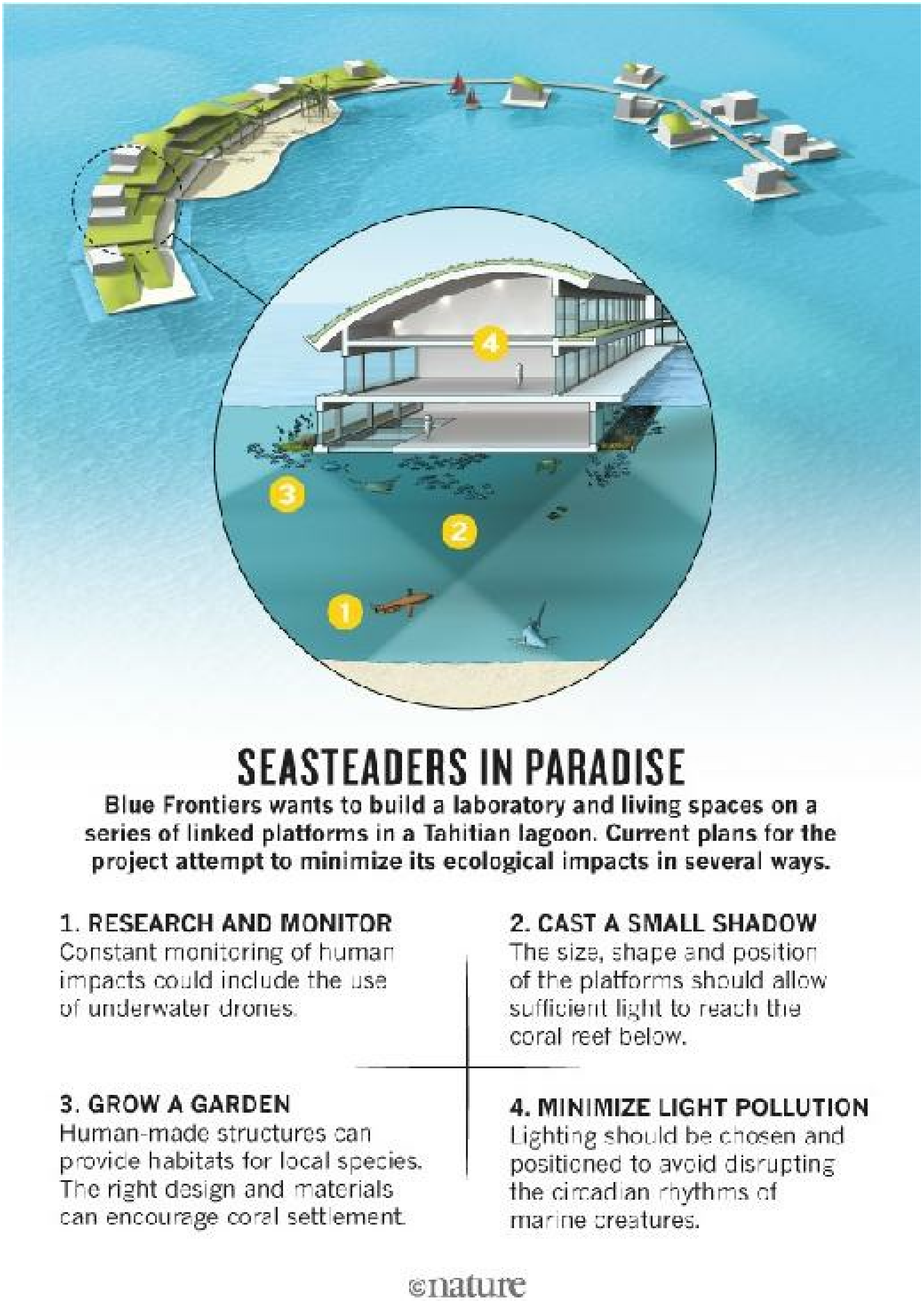


Illustration by Emily Cooper

The team would not provide direct information about funding. Paypal

founder and one-time Donald Trump enthusiast Peter Thiel provided a reported $1.7 million to the Seasteading Institute, but he last contributed to the project in 2014, and any recent investors are keeping a low profile. Quirk says that they have “a nice amount” of seed money and are preparing for what is called an initial coin offering — an investment mechanism that uses digital cryptocurrency. Looking ahead, the company hopes to generate revenue by renting out space on the island and acting as consultants for other would-be island builders. Along with hiring Quirk and the other four managing directors, Blue Frontiers has recruited ten staff members and commissioned environmental, legal and economic studies on the impacts of the project for investors and the government.

The “why?” — everyone's first question about seasteading — is answered differently by everyone involved. Some are captivated by the project because it is an excuse to push sustainable design to the next level. For people on low-lying islands, it looks like a life raft. Félix Tokoragi, mayor of Makemo, an atoll in the Tuamotu archipelago in French Polynesia, told Blue Frontiers that he's interested. The Tuamotus have experienced widespread flooding, and Tokoragi is worried that his people will become climate-change refugees. “We are attached to our atoll; we are attached to our culture,” he says. “We are not against this idea, since the technology can respond to the problems that we face.”

For others, the pull of the project comes down to autonomy and self-reliance, particularly with respect to governance: anyone who decides their island's political style is not for them can detach and depart for another system that they like better.

For at least one scientist advising the project, Neil Davies, executive director of a field station of the University of California, Berkeley, on the neighbouring island of Moorea, the island's appeal is as a base for research that would “fill the gap between oceanographic-research vessels and coastal marine labs”. Ships are on the water, but they are “phenomenally expensive”, he says, and they don't stay put. Coastal labs can gather long time-series of data in one place, but don't provide access to deeper water. Davies dreams about floating “sea stations” that would allow low-cost, long-term access to the ocean for research, especially for students in tropical countries “where

natural systems are among the most sensitive to human activities”, he says. Experiments could include modifying pH or temperature on small sections of a reef to simulate future environmental conditions, and 'planting' different corals to investigate which will thrive best in the future. Data could be gathered using semi-permanent sensors and cameras, along with regular biological-sample collection.

Some scientists not involved in the project see value in the concept, as well. “If you have a floating island and you want long-term study, that is a perfect way to do it,” says Ross Barnes, marine-operations superintendent at the University of Hawaii Marine Center in Honolulu, who oversees two large research vessels and on-shore labs. The university has been conducting research at a spot in the ocean that it calls Station ALOHA, which scientists have visited nearly 300 times by boat since 1988. A floating platform, he says, would mean that scientists could leave behind some instruments — and that some of them could stay as well — allowing for continuous measurement. “It's a good idea,” Barnes says.

Currently, Davies is advising the seasteaders on site selection and environmentally positive design choices. He also plans to help them to document the installation's performance using sensors that measure things such as energy expenditure and waste generation on the platforms, as well as water temperature and quality. And he sees it as a great teaching opportunity for the many students who visit his station. “Seasteading raises many social, legal, ethical, environmental issues, even if it never gets anywhere,” he says.

Whether the seasteaders make progress depends on whether the project is embraced by French Polynesia, a largely autonomous 'overseas collectivity' of France with a population of 287,000 on 67 islands spread out across an area nearly the size of Europe. At one level, a grand floating project could appeal to a nation of voyagers and boat builders. But French Polynesia has been burnt by big-science and technology projects before. From 1966 to 1996, France conducted 193 nuclear tests in its Polynesian possessions, many in the atmosphere. In February 2016, then-president of France François Hollande admitted that the testing had harmed the environment and human health. And the place is littered with defunct projects and closed hotels.

“We have a history of being taken for fools,” says Pauline Sillinger, a

sustainable-development specialist at Te Ora Naho, a federation of environmental groups in French Polynesia, who took a job with Blue Frontiers this year, and also teaches Tahitian dance. “Nuclear testing, big hotels, nice, smiling, white, intelligent people telling us it'll be good for us.”

But their wariness vies against their desperation for new revenue streams, Sage says. After winding down nuclear testing, France began paying French Polynesia more than US$100 million per year in compensation for lost income from military activity. But in 2016, that amount was reduced. Meanwhile, tourism revenues have never recovered from the 2008 recession. Thanks to increased political stability and other factors, things have improved since 2014, when the collectivity was so broke that it risked not being able to pay its civil servants, according to Sage. But it is still dangerously reliant on a small number of income sources — tourism, pearls, coconut oil. Unemployment stands at nearly 18%. “We are looking for new ideas,” Sage says. “We are really open to any ideas, any investors.”

If Sage is sceptical but willing to give it a shot, there are others who have had enough of grandiose project ideas. Among them is a religious leader in Tahiti, Frère Maxime Chan, who heads Association 193, which advocates on behalf of those harmed by nuclear testing. Chan is also vice-president of Te Ora Naho. (Sage, incidentally, is the organization's president.) Chan says that his old friend Sage and the rest of the government are “dazzled” by the flash and money of the Seasteaders. He talks about recent projects — including a tourist resort, an aquaculture scheme and an eco-resort — that were all announced with fanfare and optimistic job projections, only to be cancelled, scaled back or put on indefinite hold. Chan wishes the government would admit that the standard of living for the average Tahitian has been artificially inflated by nuclear-test payments and must come down. This can be done without suffering, Chan contends, by gracefully returning to a version of the pre-1960s subsistence economy. “Small is beautiful,” he says.

Convincing French Polynesia to support the project will fall mainly to Marc Collins, another managing director of Blue Frontiers. Collins is Tahitian and lives there now, but in the early 1990s he lived in Silicon Valley, and fell in love with its fast-paced culture of big ideas and endless possibility. Ever since, he's kept his toe in those waters in part by maintaining a subscription to

Wired magazine. In May 2015, the digital lifestyle glossy ran a story[3] about how the seasteading movement planned to scale back its grand, high-seas concept, reorienting towards safer, shallower waters and looking for “cost-reducing solutions within the territorial waters of a host nation”.

Collins, a serial entrepreneur who has dabbled in every major French Polynesian industry, from hotels to black pearls and telecommunications, saw an opportunity to, as he puts it, “bring some of the DNA of Silicon Valley to Tahiti”. Tahiti joined the world of high-speed Internet in 2010, with the completion of an undersea fibre-optic cable linking it to Hawaii. It has calm lagoons aplenty and daily flights from Los Angeles, California, and, as a minor bonus, is widely regarded as paradise on Earth. Collins fired off a LinkedIn request to the Seasteading Institute's executive director, Randolph Hencken.

The Seasteaders were interested in Collins's pitch, but they wanted a more official gesture of support. So Collins, who served as French Polynesia's minister of tourism in 2007 and 2008, began working his government contacts. By August, the president of French Polynesia, Édouard Fritch, signed a letter formally inviting the Seasteaders to present their ideas. A delegation of nine took him up on the offer the next month, and by January, a memorandum of understanding with pledges of cooperation was signed.

The next step in making the island a reality will be the passage of a law defining the 'special economic zone' that will cover the synthetic island. Blue Frontiers isn't asking French Polynesia for any subsidies to build the island, but it is asking for a 0% tax rate, among other regulatory exceptions. It has hired French firm GB2A, based in Paris, to prepare legal research and a set of requests, which Blue Frontiers presented to the government at the end of September. The team hopes to see a bill emerge before the end of the year.

In the meantime, the Seasteading Institute is building excitement and courting potential investors with a series of gatherings. In May, it held talks, networking events and tours in Tahiti. Speakers included Fritch; Tony Hsieh, chief executive of online retailer Zappos in Las Vegas, Nevada; Tua Pittman, a master canoe navigator from the Cook Islands; and engineers, nanotechnologists and a 'blockchain strategist', a specialist in the distributed information systems behind cryptocurrencies. The seasteaders hope to use

such systems to handle their financials, as well as any scientific data that they generate. But the event wasn't all work. An announcement for a party on outrigger canoes cheerfully suggested: “Do not wear heels. Bring a swimsuit for an optional moonlight swim.”

On 22–29 October, Blue Frontiers will hold an Insiders Access Week for supporters and potential investors, a mix of tours, discussion and morning yoga with Hencken. Always ambitious, the team hopes to have draft legislation from the Polynesian government by then, and some detailed architectural plans. The goal is to break ground — or rather, sea — in 2018.

While all this work goes on behind the scenes, the lagoon remains fairly quiet. On a day in July, locals compete in a stand-up paddle-board race while families play on the shore and young women drink beer with their feet in the waves. By the roadside, freshly caught tuna are for sale. On one level, it is hard to imagine this place being improved upon.

Time will tell whether the Seasteaders' island becomes a refuge for Polynesians facing rising seas and an incubator for Polynesian science and business, or merely a playground for wealthy foreigners who want to dodge bothersome regulations. That is, if it materializes at all.

Journal name:
Nature
Volume:
550,
Pages:
22–24
Date published:
(05 October 2017)
DOI:
doi:10.1038/550022a

Comments

Comments

There are currently no comments.

How fracking is upending the chemical industry

As shale-gas compounds flood the market, chemists are working out the best ways to convert them into the ingredients of modern life.

04 October 2017

Jeff J Mitchell/Getty

A ship carrying US shale gas, the *Ineos Insight*, approaches port in Scotland in September 2016.

As the *Ineos Intrepid* cruised slowly through the sapphire waters of Norway's Frierfjord, chaperone tugboats sprayed jets into the sky to herald her arrival. In giant refrigerated tanks below decks, the ship carried 27,500 cubic metres

of liquid ethane — enough to fill 11 Olympic swimming pools. *Intrepid* also brought a message, painted in giant capital letters along her side: “SHALE GAS FOR PROGRESS”.

The vessel's arrival in March 2016 brought the first ever shipment of shale gas from the United States to Europe — and marked the start of a burgeoning business. More of these 180-metre-long 'Dragon'-class vessels have followed in her wake, forming a 'virtual pipeline' for ethane across the Atlantic Ocean. This gas, which is extracted from the ground through the hydraulic fracturing of shale deposits, isn't destined to fuel power stations or domestic stoves. Instead, it will be transformed into the chemical building blocks needed to make a panoply of products, including plastics, clothes, adhesives and medicines.

Intrepid's voyage is a striking demonstration of how cheap US shale gas is reshaping the chemical industry and changing the origin of countless manufactured objects. For decades, the industry's raw ingredients have mostly come from crude oil. Chemical plants break down long hydrocarbon molecules in crude to produce a smorgasbord of smaller molecules, such as ethene, propene and benzene — all important precursors to polymers.

But shale gas, which is composed mainly of methane, ethane and propane, is turning that pathway on its head. The abundance of the gas has slashed the costs of these molecules. As a result, some are now usurping large hydrocarbons as the preferred starting point for industrial synthesis.

This shift from oil to gas brings enormous opportunities. According to the American Chemistry Council, a trade group based in Washington DC, the shale boom has attracted about US$160 billion in investment from the US chemical industry since 2011, and will help to create half a million jobs in plastics manufacturing over the coming decade[1]. But it also poses huge challenges. Some of the main techniques that are used to turn the components of shale gas into more valuable compounds — processes generally known as upgrading — are decades-old, dirty and energy-intensive. And they rarely produce the same mix of chemicals as conventional oil-based routes, which means that some relatively minor, yet valuable, chemicals such as butadiene, an ingredient of synthetic rubber, are becoming scarcer.

These challenges are driving an intensive research effort, spanning industry and academia, to develop catalysts and reactors that can transmute small hydrocarbons in cleaner, cheaper and more efficient ways.

Translating that research into commercial production will depend on the finely balanced economics of a changeable market. It will also require a reliable supply of gas. The US Energy Information Administration predicts that natural-gas extraction in the United States will continue to grow until at least 2040, but that might be too optimistic (see Nature 516, 28–30; 2014). Meanwhile, concerns that fracking can contaminate groundwater — along with the broader climate implications of extracting fossil fuels — continue to dog the technology. If the glut does persist, however, it could usher in technologies that would form the foundations of a much more sustainable chemical industry. “We could totally redesign our chemical plants,” says Bert Weckhuysen, a chemist at Utrecht University in the Netherlands.

The ethane revolution

Shale gas is extracted from kilometres below ground, and typically contains about 70–95% methane, less than 15% ethane and less than 5% propane. After traces of oil, water and other impurities are cleaned out, the gas is chilled so that ethane and propane can be separated in liquid form, leaving methane behind.

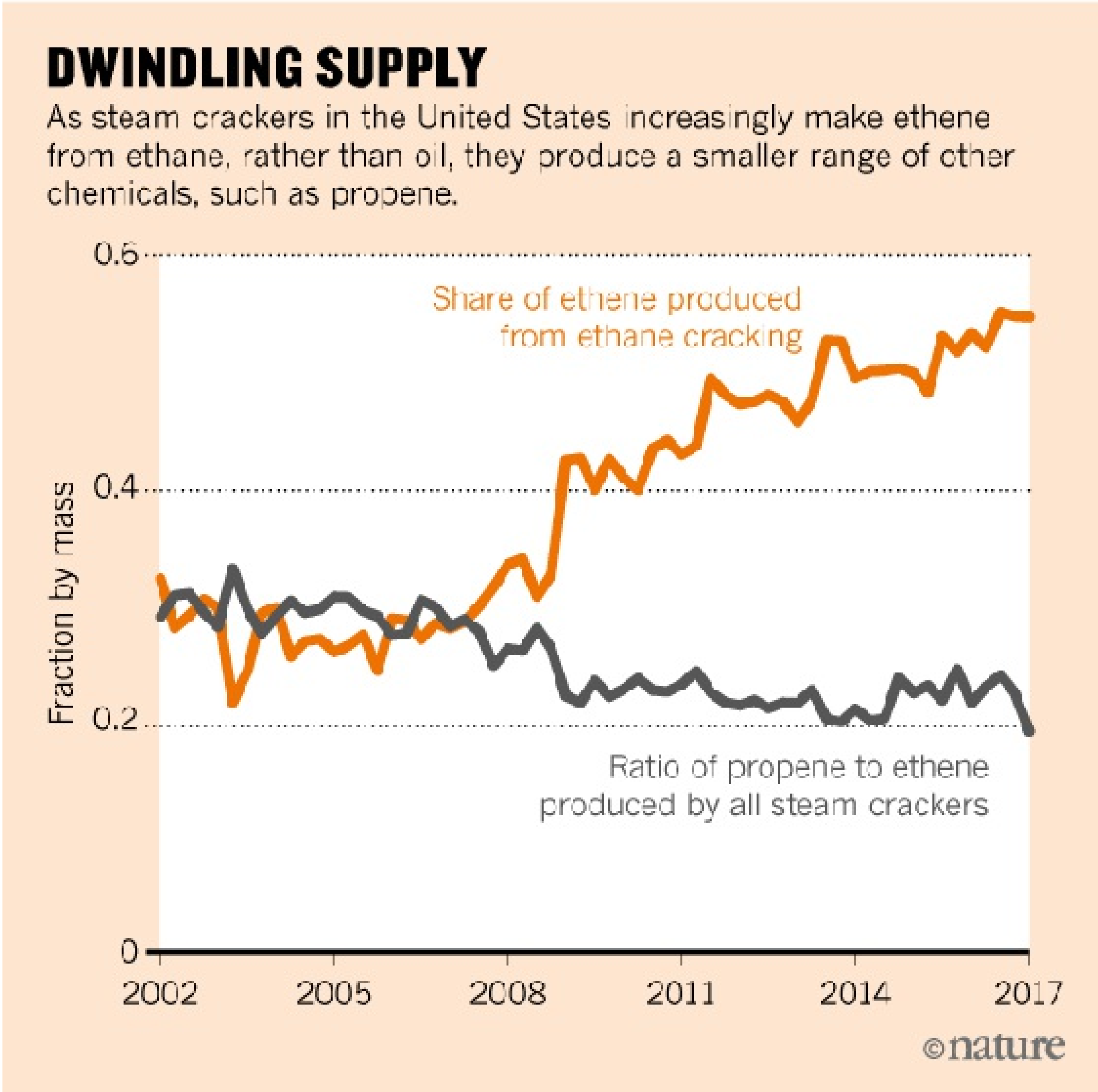
Although ethane makes up a small proportion of shale gas, it has so far had the biggest impact on the chemical industry. That's because chemists can easily use it to make ethene, also known as ethylene. Ethene is used to make various types of polyethylene and the precursors to other plastics, such as polyvinyl chloride (PVC) and polystyrene. So voracious is the world's appetite for these plastics that the chemical industry produces roughly 150 million tonnes of ethene every year, more than any other chemical building block.

Most processes in the chemical industry use catalysts. But ethene can be produced simply by steam cracking ethane or larger hydrocarbons. First developed in the 1920s, steam cracking is a blunt, energy-intensive process

that requires little more than water and 850 °C temperatures. “You basically just heat the snot out of it,” says Jeffrey Plotkin, an industry analyst at IHS Markit in New York City. “The heart and soul of the thing is this gigantic furnace, that's where all the chemistry happens.”

The boom in shale-gas-derived ethane has driven the chemical industry to invest nearly $45 billion in extra steam-cracking capacity[2]. But the transition to this feedstock is also creating a headache. When steam crackers are fed with mixtures of long hydrocarbons from crude oil, they make an array of useful by-products. But when they are supplied with ethane, the output is almost entirely ethene. “So there is a shortage of other building blocks,” says Weckhuysen.

One of those building blocks is propene, arguably the second most important product of the chemical industry after ethene. Propene is turned into polypropylene, a plastic used in packaging and textiles, along with other polymer ingredients such as acrylic acid. But by one estimate, propene production by US steam crackers dropped by almost half between 2005 and 2014, even as global demand rose (see 'Dwindling supply').



Source: S&P; Global Platts

To combat the shortfall, the industry is rolling out alternative ways to make propene. One of the leading routes starts with the shale-gas component propane. A combination of heat and a catalyst to remove two hydrogen atoms can be used to turn it into propene.

The conversion is becoming more profitable: more than 20 of these propane-dehydrogenation units are already operating worldwide, and at least 40 more have been ordered since 2011. But Weckhuysen says that there is much scope to improve the process, which tends to chew up catalysts quickly, requires a

time-consuming and costly catalyst-regeneration step, and can use harsh reagents.

The methane question

Although ethane and propane are already making waves as commercial feedstocks, the big prize for chemists is to upgrade the most abundant component of shale gas: methane.

Most of the world's methane is currently burnt as fuel, its lowest-value application. The gas can also be used as a chemical feedstock, but it contains strong carbon–hydrogen bonds that are difficult to break in a controlled way. When methane is converted into other molecules, it is done mainly through an inefficient sledgehammer of a process called steam reforming. First commercialized in the 1930s, this involves smashing methane and water together at up to 1,100 °C, over a metal catalyst. It produces an extremely useful mixture of carbon monoxide and hydrogen called syngas — and also emits several hundred million tonnes of carbon dioxide per year, accounting for roughly 3% of all industrial emissions[3].

Syngas is the world's principal source of hydrogen, much of which goes to make the ammonia in fertilizer. Syngas can also be used to produce longer hydrocarbons, such as basic components of diesel and waxes.

Such upgrading is typically done through a technique called the Fisher–Tropsch (FT) process, which uses cobalt or iron catalysts and heat to create daisy-chains of carbon atoms. FT was developed in Germany in the 1920s to make petrol and a wide range of other hydrocarbons from syngas derived from coal.

Producing transport fuels in this way is generally more expensive than refining oil. There are just six large-scale FT plants in the world, made economical only thanks to their proximity to huge coal or gas fields and the mind-boggling scale of the plants themselves: the world's largest, in Qatar, cost $19 billion to build and munches through 45 million cubic metres of methane every day, on a par with the natural-gas consumption of Belgium.

Courtesy Velocys

A plant in Oklahoma City owned by ENVIA Energy uses compact reactors developed by Velocys to turn methane-derived gas into products such as diesel.

But the shale boom has prompted chemical engineers to take a fresh look at the FT process. Shale-gas wells typically don't produce enough gas to support a conventional FT plant, so research teams and companies have been developing smaller reactors that can process modest gas flows. One of those is Velocys, based in Houston, Texas, which developed a 5-metre-long reactor that can convert syngas into substances such as naphtha, diesel and wax. Its reactor technology is being used in Oklahoma City in the first commercial mini-FT plant in the United States. The plant, which is owned by ENVIA Energy, started production earlier this year.

Temperature control is a big challenge for the FT process: the reaction kicks in at about 180 °C, then generates huge amounts of heat. If not carefully controlled, it will run away with itself, turning carbon atoms into useless soot. To address this, Velocys's reactor contains corrugated layers of channels that

are alternately stuffed with catalyst or filled with water. This keeps the reaction running at a steady 200 °C, so that the reactor can use an efficient catalyst without risking a runaway reaction. “It allows you to pack a lot of reaction in a very small space,” says Neville Hargreaves, business-development director for Velocys in Oxford, UK.

The reactor in Oklahoma City pulls methane from a landfill site, an activity that comes with renewable-energy credits. But Hargreaves thinks companies could ultimately profit by tapping remote and relatively small natural-gas reserves that are unlikely to get a pipeline. Another potential target is unwanted gas from oil wells, which is often simply burnt off. Such 'flaring' puts about 350 million tonnes of CO_2 into the atmosphere every year. According to the World Bank, it carries enough energy to meet Africa's entire current electricity requirements.

The direct route

The high temperatures involved in producing syngas will always make it a costly way to create complex chemicals — as well as a major source of CO_2 emissions. Researchers have spent decades looking for ways to convert methane directly to methanol or other products, cutting syngas out of the route altogether. The shale boom has given this effort fresh urgency, along with a burst of investment in research and development in both academia and industry.

Turning methane into methanol — itself a key precursor to a wide range of other compounds — involves adding only a single oxygen atom. But first, one of methane's strong carbon–hydrogen bonds must be broken, and the high temperatures or strong oxidants needed to do that can set the molecule on a one-way journey down a thermodynamic roller coaster with a messy end. Methanol sits on a brief crest about halfway down, but it is all too easy to race downhill as the reaction goes too far, producing a mixture of other molecules, including formaldehyde, formic acid or carbon monoxide.

In 2005, however, a team led by Robert Schoonheydt at the University of Leuven in Belgium, found[4] that copper seeded onto a porous material called a

zeolite could unite oxygen and methane to make methanol at less than 200 °C. Crucially, the methanol became trapped in the zeolite's pores, preventing further reactions. But extracting methanol from the pores and reactivating the catalyst would have proved expensive and impracticable in a commercial setting.

Since then, research groups have developed a range of copper–zeolyte catalysts that are more industry-friendly. Others have focused on completely redesigning chemical reactors. The European Union-funded project Adaptable Reactors for Resource- and Energy-Efficient Methane Valorisation, for example, aims to build small reactors that use renewable electricity, rather than heat generated from fossil fuels, to turn methane into compounds such as ethene and methanol. One approach uses microwaves to generate intense hotspots in the catalyst, lowering the heating requirements for the incoming gas.

Another approach to direct methane upgrading aims to couple pairs of the molecule together to make ethene. Since 2015, Siluria Technologies, a start-up in San Francisco, California, has been running a demonstration plant for this process in La Porte, Texas. It relies on a catalyst made of metal-oxide nanowires that collectively offer a surface area of about 200 square metres per gram of catalyst, hundreds of times more than a bulk catalyst could offer.

The company builds its catalysts in a unique way, based on a technique[5] developed by co-founder Angela Belcher, a materials scientist at the Massachusetts Institute of Technology in Cambridge. First, viruses are genetically engineered to express proteins that bind to dissolved metal ions. The ions form orderly arrangements as they stick to the surface of the virus. When the biological template is burned away, it leaves behind a highly stable, crystalline nanowire.

Rahul Iyer, Siluria's vice-president of corporate development, says that the process is cost-competitive with steam cracking ethane, and produces far fewer CO_2 emissions than steam reforming methane. Siluria has already licensed the technology to some chemical companies, and expects the first commercial facilities to be operating in 2019.

Plotkin says that Siluria is currently in the lead in the race to commercialize direct methane upgrading, and is backed by multimillion-dollar investments from big players in the industry. “People are keeping a watchful eye on it,” he says.

Gas that's greener

The shale-gas boom is credited with spurring a major renaissance in the US chemical industry, which has invested heavily in chemical plants and other infrastructure, as well as research and development. Enthusiasm for shale-gas upgrading has fostered major collaborations between academia and industry.

Translating laboratory results into commercial production is an ongoing challenge, although the trend towards small, modular reactors is helping to make it less daunting. The chemical industry is notoriously conservative: if a process succeeds in the lab but fails at commercial scale, tonnes of catalyst can be wasted and a plant shut down for months. “Industry will not take the risk unless they are sure it will work,” says Weckhuysen.

Despite these challenges, he is optimistic that gas upgrading could have a huge impact — not only on the chemical industry's processes, but also on its environmental footprint. Some of the reactor technologies being developed to feed on shale gas could be adapted to use bio-based feedstocks, such as methane from landfills, as Velocys has found. Meanwhile, shortages in some compounds caused by the shift to shale gas could improve the economic case for starting with ethanol from crops, or lignin from wood[6]. There has already been movement along these lines. In 2013, for example, French tyre-maker Michelin and partners launched a €52-million (US$61-million) project to make butadiene from bioethanol.

But for now, US shale ethane continues its relentless march around the world. More chemical companies are commissioning ships to transport the gas to destinations in Europe, Brazil and India. By 2022, according to one estimate, about 8 million tonnes of ethane will flow through these virtual pipelines each year. They will carry this revolution in the US chemical industry to the rest of the globe — both its challenges and its opportunities.

Journal name:
Nature
Volume:
550,
Pages:
26–28
Date published:
(05 October 2017)
DOI:
doi:10.1038/550026a

Comments

Commenting is currently unavailable.

Scientists have most impact when they're free to move

04 October 2017

An analysis of researchers' global mobility reveals that limiting the circulation of scholars will damage the scientific system, say Cassidy R. Sugimoto and colleagues.

Spencer Platt/Getty Images

Measuring the global movements of researchers will help to assess the effects of political actions on science.

Recent political upheavals portend an era of increased isolationism in

science, with a chilling effect on collaboration and mobility. Last month, US President Donald Trump issued his third travel ban in a year, suspending entry of individuals from several countries into the United States, and placing restrictions on many more for visa renewals. These orders have stranded scholars abroad and prevented those who were in the country from engaging in international work. In March, UK Prime Minister Theresa May began the process of formally severing ties with the European Union. As a result, British institutions face a potential exodus of non-resident EU researchers and will have to overcome barriers to participating in and receiving funding for European collaborative projects. The list of countries engaging in these isolationist actions, and the list of actions themselves, grows longer.

To assess the impacts of such political actions, we need better ways to measure researcher mobility. Although the size and composition of the scientific workforce is fairly well established through national surveys and registries[1], less is known about how often researchers move, where they go, what networks they form, and how important their movement is to the scientific impact of their work[2].

We present here a new analysis based on the records of 14 million papers from nearly 16 million unique individuals who published between 2008 and 2015. In our study, some 96% of researchers had only one country of affiliation; we classed these as non-mobile. About 4% (more than 595,000 researchers) were mobile — meaning that they had more than one affiliation during that period. Our analysis revealed surprising trends.

Chain reaction

Over the study period, Europe and Asia saw a dramatic net loss of researchers, whereas North America saw large gains. Many commentators have anguished about 'brain drain' or 'brain gain', assuming that receiving countries get the lion's share of scientific capital at the expense of the nations from which researchers originate. The reality is more complicated (see 'Brain circulation').

We found that the majority of scientists didn't cut ties with their country of

origin but instead built a chain of affiliations that linked nations together. Many researchers returned to their home country. Brain circulation may be a more apt term for the movement of contemporary scholars[3].

Different nations have different roles in the circulation of elite scholars (for which our proxy is highly cited researchers). But wherever they are, wherever they stop off and wherever they come from, mobile scholars have about 40% higher citation rates, on average, than non-mobile ones (see Supplementary Information; Table S7). Closing borders takes these elite scholars out of circulation.

Origin stories

Our study looks at the country stated in a researcher's affiliation when they published their first paper, and uses this as their country of scientific origin (this should not be confused with where they were born). We then track whether they moved or gained new affiliations in other countries over the eight years of this study.

The conventional idea of mobility focuses on migrant researchers — those who begin publishing in one country and then move to another, at some point discontinuing their attachment to the previous country. This group made up less than one-third of the mobile researchers in our study (27.3%, or 162,519 researchers). By far the largest proportion were those we call travellers: scholars who retain a footing in their country (or countries) of scientific origin throughout their career, while gathering up more international affiliations to add to their name (72.7%, or 433,375 researchers). Nearly half of the travellers are 'non-directional': they have more than one affiliation in their first year of publication, and they retain all these affiliations in each publication year.

Circulation networks that map the number and flow of researchers reveal the importance of the United States, United Kingdom, France, Canada and Germany as prominent nodes in the global scientific network (see Supplementary Figure S2). Isolation of these countries would have dramatic consequences. Although the United Kingdom is not particularly central to researcher migration in the European Union, it serves a crucial function in providing a bridge for European scientists to other areas of the world (see Supplementary Figure S2). Isolationist policies in the United Kingdom could deconstruct this network, redirecting scholars through other countries.

More patterns emerge if we look only at migrants and directional travellers who moved between and within continents, who first published in 2008, and who published at least eight papers during the study period. Admittedly, our short time window means that we focus on junior scholars. But it avoids conflating them with senior scholars whose movement and networking are likely to differ.

This group comprised 12,046 researchers. Europe provides the largest share (35%) followed by about one-quarter each from Asia and North America (see 'Making tracks'). The relationship between these latter continents is strong:

the majority of mobile scholars associated with an Asian address in their first publication in 2008 have a North American address by 2015, and more than one-third of mobile North American scientists end up in Asia. Both of these trends can probably be explained by the same underlying phenomenon — the influx of Asian students into the United States (some of whom publish before their arrival, and others of whom do so afterwards), and their subsequent moves back to Asia.

We see a 22% net loss of researchers from Europe, a 20% loss from Asia, and a nearly 50% gain for North America (see Supplementary Table S4). European scholars make up the largest population of mobile scholars in nearly every country, with the exception of Asian countries, where most scholars are drawn from North America (see 'Scientist shuffle').

It is also of interest to know the degree to which certain countries are responsible for the production and cultivation of high-impact scholars. We assess this by looking at citation scores for mobile researchers before and after their moves (see 'Trip adviser').

Countries in North America and Northern Europe act as strong producers: they put into circulation scholars who are well-cited before they move. The same countries are also strong cultivators, identifying talent early and providing fertile ground for scholars to achieve high impact once they arrive. Asian regions are strong recruiters, gaining affiliations with established scholars who were well-cited before their arrival. Oceania is a notable incubator, affiliated with scholars who realize high potential once they move on.

Some migratory routes tend to be associated with highly cited scholars. Those from North America with the highest impact tend to land in Northern and Western Europe and, to a lesser extent, in Southeastern Asia. Mobile, high-impact Northern Europeans are recruited to Southern Europe; mobile, high-impact Western Europeans are recruited to Oceania and Eastern Asia.

Mobile scholars from Oceania produce particularly high-impact work when they arrive in North America and Southern Europe. Central and Western Asian scholars (including those from countries implicated in the US immigration ban) realized their highest citation rates for work done in North

America and Europe. Barring scholars from these countries is likely to displace high-impact ones to other nations.

Regardless of region, mobility pays in terms of citations. Across all regions, mobile scholars are more highly cited than their non-mobile counterparts. The advantage varies by region. Mobile North Americans see only a 10.8% boost in citations over their non-mobile colleagues. For Eastern European scholars, the gulf is 172.8%.

Mobility measures

Of course, our method has limitations. We cannot tell if our 'country of academic origin' represents country of birth, of academic training or of academic employment — it reveals solely where an individual began publishing. If researchers from some countries tend not to publish first in a journal indexed in the Web of Science, then our measures would underestimate mobility from these places. Those we have counted as 'non-mobile' might really be 'pre-mobile' — meaning that they have not yet moved. Furthermore, examining less than a decade of papers, focusing on journal articles and adding restrictions for number of publications may privilege certain disciplines in the analysis. And our study does not look at mobility rates within each country: for large nations such as the United States, these might be significant and interesting.

Internationally comparable mobility indicators for the scientific workforce are particularly necessary in an era in which mobility is growing, complicated and increasingly threatened. We need indicators that provide more nuanced and dynamic assessments of the exchange of human capital and the effect of this exchange on the knowledge economy, particularly given that the 'travellers' in our analysis account for the majority of mobile scholars. This study provides a start.

It might be argued that collaboration can continue, even when mobility is restricted. However, despite advances in computing, collaboration tends to be initiated and sustained through interactions that happen in person[4]. Limiting mobility is likely to have adverse effects on the scientific system, which is

increasingly dependent on international collaboration[5].

Disruption of the existing network would have serious effects on many nations, including large science producers and cultivators such as the United States. The country benefits significantly both from its centrality in the global knowledge network, and from the educational investments of other countries. Its exceptional contributions are disproportionately made by researchers who are both foreign-born and foreign-educated[6]. Disconnection would also seriously affect those nations that benefit from the United States' role as a cultivator — it invests in researchers who come from Asia and elsewhere and later return home.

Some countries may see benefits, however: isolationism among central countries can lead to advantages for other competitive nations. For example, the number of graduate-student applicants to Canada has risen since the change in the US administration (see go.nature.com/2fjc4i). However, if adequate scientific capacity does not exist in these other countries, global talent will not be cultivated to the extent it is today. With good bibliometric standards to measure the impact of mobility, we can test the effects of these political changes in the decades to come.

One thing is already clear. Internationally mobile scholars are in the minority, yet show the highest impact across the globe. Limiting the circulation of scholars will damage the entire scientific system.

Journal name:
Nature
Volume:
550,
Pages:
29–31
Date published:
(05 October 2017)
DOI:
doi:10.1038/550029a

Supplementary information

PDF files

1. Supplementary information (1.6M)

Comments

Comments

There are currently no comments.

Open countries have strong science

04 October 2017

Caroline S. Wagner and Koen Jonkers find a clear correlation between a nation's scientific influence and the links it fosters with foreign researchers.

Spencer Platt/Getty

Nations that welcome international researchers and encourage cross-border collaboration tend to produce papers with high scientific impact.

International projects account for at least 20% of national government spending on scientific research. Some countries spend as much as 50% of these funds on international collaborations[1, 2]. The number of internationally co-authored papers is growing rapidly[2]. For countries at the forefront of

research, the fraction of papers that are entirely 'home grown' is falling[3].

Is there a connection? We analysed publication and citation data for 36 nations, along with government expenditures on science. We found that although government spending on research and development (R&D;) does correlate with the number of publications produced, it does not correlate with scientific impact — at least as assessed by citations, one of the few practical metrics available. What does correlate with impact is a country's openness, which we approximated by combining metrics of international co-authorship and the mobility of each nation's research workforce.

In 2016, we partnered with Jeroen Baas, head data scientist at Elsevier, the publication house that also runs the citation database Scopus, to examine nearly 2.5 million publications that were published in 2013 across all scholarly fields and that had three years' worth of citation data available. Publications and a field-weighted citation index were apportioned to countries according to authors' locations. (So if two-thirds of the authors on a publication were in the United Kingdom and one-third in Singapore, those fractions were applied to determine the publication count and citations assigned to those countries for that paper.)

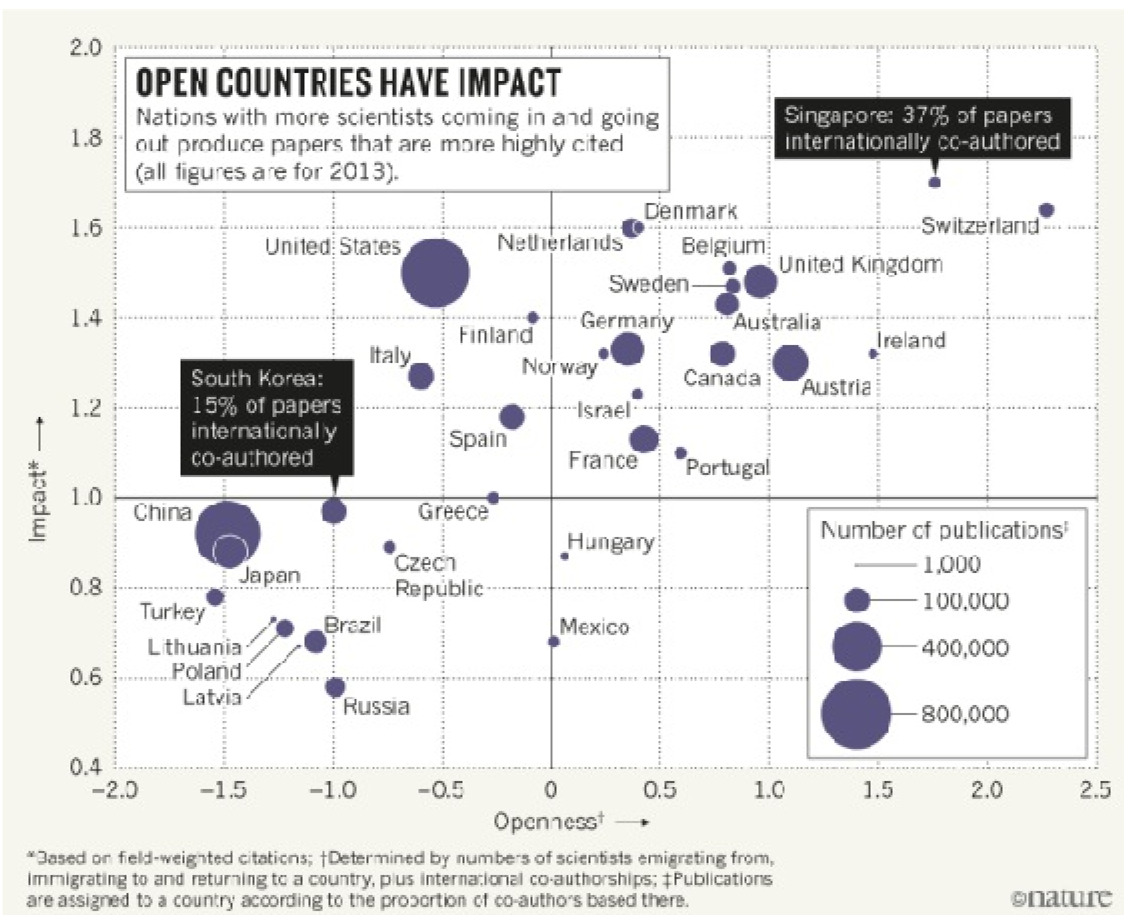
In terms of papers published, the United States and China dominate. For 'international papers' (those with authors from more than one country), the United States still leads, followed by the United Kingdom, China, Germany, France and Canada. When international papers are considered as a percentage of all of a country's papers, Switzerland (42%) appears as the most connected country, followed by Belgium (38%), Singapore (37%), Austria (36%) and Denmark, the Netherlands and Sweden (all 34%). In terms of impact for international papers, Singapore tops our list, followed by the United States, and then Sweden, Belgium, Switzerland and the Netherlands.

We looked for factors that could explain this. In addition to international collaboration, scientific mobility was expected to contribute to impact[4]. So we also considered new researchers coming in, returnees and emigrating researchers, all of which are tracked by the Organisation for Economic Co-operation and Development (OECD). These variables, together with collaboration, proved to be highly correlated as measures of international

engagement; so we used them to create an index of openness and were able to assign values to 33 of the countries that we looked at (data available at go.nature.com/2fzrnt3).

To assess whether government R&D; spending (as tracked by the OECD and Eurostat, the statistical office of the European Union) and our openness measure explained the relatively higher impact for smaller countries, we used a Pearson correlation analysis, which allows comparisons to be made across a large quantitative range, such as the publication output of the United States versus that of Singapore.

Public R&D; funding is tied to publication output: the more money spent, the more articles produced (counting sole-authored, co-authored and internationally co-authored). But we found only a weak correlation between spending and impact. In other words, more government funds spent does not necessarily result in more citations.



Countries that are highly 'open' and that produce high-impact research seem to benefit from participating in international collaboration. This is seen in the higher impact of smaller nations, which cluster in the top-right quadrant of the graphic (see 'Open countries have impact'). Singapore, the United Kingdom, the Netherlands, Switzerland, Sweden and Denmark all scored highly on this measure as well as on citations. The correlation between openness and citation impact was tight ($r^2 = 0.7$ according to a regression analysis) regardless of R&D; spending or numbers of articles published.

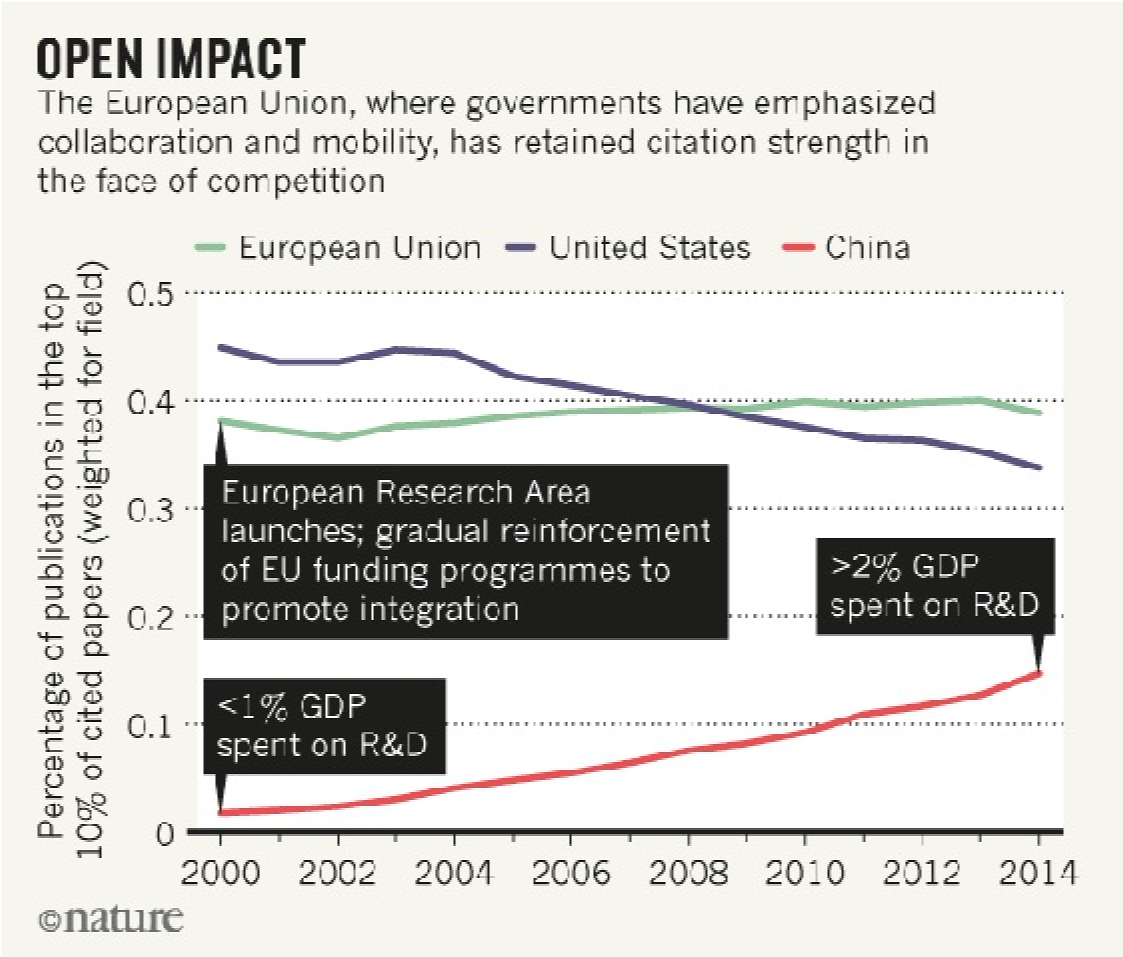
Countries with low openness and low impact include Russia, Turkey and Poland, China, Japan, Latvia, Lithuania, the Czech Republic and, against expectations, South Korea (which spends a higher percentage of its GDP on R&D; than almost every country, including the United States) These countries are shown in the lower-left quadrant.

The United States scores highly on impact, but less so on openness — perhaps because of the magnitude of its scientific enterprise and its geographic distance from possible collaborators. Of our 33 countries, only 4 (the United States, Italy, Spain and Finland) have low openness and high impact, and only 2 (Hungary and Mexico) have high openness and low impact.

Our analysis suggests that openness is related to impact, although we recognize that correlation is not causation. Nevertheless, we note that many of the countries whose scholarship has high impact, and whose policies encourage international engagement, are from Europe. The EU has established the European Research Area (ERA). Its governments have been implementing measures to strengthen domestic research systems while also promoting both international collaboration and mobility. The EU's Framework programmes have similar aims — one of the current stated objectives of EU research policy is to be more “open to the world”.

Analysis of citation strength for countries in Europe shows that they have greatly enhanced their impact compared with the United States (see 'Open impact'). As a bloc, the EU now outperforms the United States. Both far exceed China in impact, although China's share of high-impact papers is growing rapidly[5]. Other countries that promote openness also perform well in

terms of impact: examples include Singapore and Australia.



EU Joint Research Centre Tools for Innovation Monitoring, based on Scopus data release August 2016

Some will argue that citation is not synonymous with quality or importance, but it does signal engagement and recognition. Studies dating as far back as 1992 show that international papers are, on average, more highly cited[6]. The countries that are engaging internationally are seeing a dividend in terms of attention to their research.

It may be that the exchange of ideas encourages greater creativity, or that a virtuous cycle of quality work attracts others to work with those in higher-impact countries. In fact, we had very similar results when we considered each component in our openness metric separately, although most of the

effect of the mobility variables is mediated by international collaboration. Analytically, it makes sense to combine these into a single variable. However, other factors — such as the ease of obtaining visas or support to study in a country — are not explicitly incorporated.

In Japan, especially, output and citation impacts have remained flat since 2000. Japan is also among the least internationalized of leading nations, and this could be dragging on its performance. Lack of professional mobility, as well as language barriers, may be hindering engagement.

Our analysis suggests that national funding programmes should, whenever possible, move away from policies that fund only national researchers. In the longer term, countries could benefit more by funding the best science, wherever it is, and ensuring that domestically based scientists are linked with it. Restricting the movement of researchers — by limiting exchange opportunities or imposing visa restrictions, for example — could be counterproductive.

Just as industries make 'build or buy' decisions, so governments must make 'link or sink' decisions about research investment. Our data add to a growing body of work about the changing science system, indicating that science policymakers who seek to enhance impact should prioritize international exchange.

Journal name:
Nature
Volume:
550,
Pages:
32–33
Date published:
(05 October 2017)
DOI:
doi:10.1038/550032a

Comments

Commenting is currently unavailable.

| 章节菜单 | 主菜单 |

Collaborative software development made easy

Save time and protect critical code with 'continuous integration' services.

04 October 2017

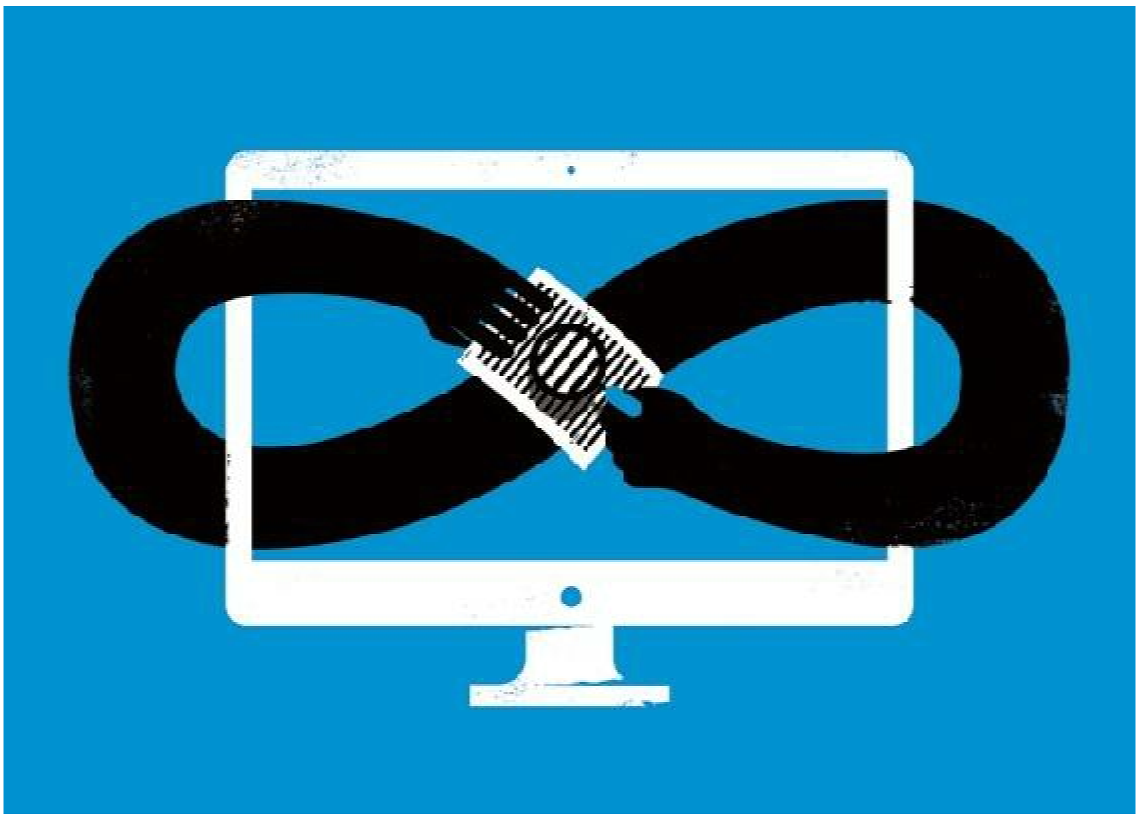


Illustration by the Project Twins

Sebastian Neubert, a particle physicist at Heidelberg University in Germany, leads a group studying subatomic particles called pentaquarks. The six team members all have access to the software code used to run their multi-step analyses, and the programmers update it daily with new features and bug fixes. With each code change, however, they run the risk of introducing

inadvertent errors that foul the underlying algorithms.

To prevent that, the team checks and rechecks the analyses, and uses error-checking algorithms, functions they can call whenever a change is proposed, to ensure that their software works as intended. One test, for example, verifies that a noise-cancelling algorithm gives the correct output when it is run on practice data.

In 2015, in an effort to save time and resources, the team took inspiration from the technology industry, automating their testing using a process called 'continuous integration'.

In continuous integration, changes to software code automatically trigger repetitive tasks, such as error-checking. Fundamentally, the process simplifies a task that diligent coders already perform. Programmers usually write lists of tests that they will run periodically to ensure that their code still works, just as Neubert's team do. But a busy team might forget or lack the time to run them, allowing errors to creep in. Continuous integration automates that process so those checks run whenever a change is proposed, saving team members the time they would spend hunting down an error. A team running genomic analyses could spend more time at the bench, while a group developing climate-prediction software could better refine its models. That said, the resulting peace of mind is only as good as the tests themselves: a poorly designed test can still allow mistakes to pass undetected.

The process is common in the commercial and open-source sectors. A study presented at the 2016 IEEE/ACM International Conference on Automated Software Engineering in Singapore found that about 40% of the 34,544 most-popular open-source projects hosted on the coding collaboration site GitHub used continuous integration in some form.

Only a few of those open-source projects might be considered scientific software, but an increasing number of scientists are looking to continuous integration to automate all sorts of time-consuming tasks, from testing code to updating documents with the latest data.

Researchers at institutions such as CERN, Europe's particle-accelerator laboratory near Geneva, Switzerland; the Pacific Northwest National

Laboratory in Richland, Washington; and the Ontario Institute for Cancer Research in Toronto, Canada, have embraced the practice, but adoption in the scientific sector remains relatively sparse.

For Neubert, continuous integration ensures that the pipeline's behaviour remains correct and consistent as his team refines its code, providing an “incredibly valuable” safeguard. “There is a real danger of just missing something or making a slight mistake,” he says.

Exceptions

A variety of continuous integration services exist. These include the open-source Drone, and commercial options such as CircleCI, Codeship, GitLab, Shippable and Travis CI, all of which offer pricing tiers based on the desired testing behaviour, number of users and whether the project is public or private. Travis CI, for instance, is free for open-source projects; private projects cost from US$69 per month. Shippable offers a free basic service for public projects, but charges $25–150 per month for support for private projects and greater computing power, among other features.

Researchers should consider what is a suitable and worthwhile investment, however. Not every project needs continuous integration and setting up and configuring a service can be challenging. Further difficulties can arise if the services need to interact with software or data with legal restrictions on its use, says Daniel Himmelstein, a data-science postdoc at the University of Pennsylvania in Philadelphia.

Also, code is often used only once, making the cost even less worthwhile. “For day-to-day research coding, the amount of code is not large enough to make continuous integration valuable,” says Andrea Zonca, a specialist in high-performance computing at the University of California, San Diego. He uses Travis CI when publishing code, but most that he writes is for his own one-time use and is not executed again.

Computing costs can also mount if code is being constantly updated and requires repeated testing, which is why Neubert's lab only tests its most

critical data analyses after code changes.

Despite these challenges, continuous integration services tend to improve code quality, says Björn Grüning, a bioinformatician at the University of Freiburg in Germany, especially on large projects such as Galaxy, a bioinformatics toolkit that Grüning, along with about 160 others, contributes to.

According to Grüning, continuous integration has shortened the turnaround time for approving contributions to the Galaxy project and given programmers more confidence when submitting new features and fixes. Before these services were available, it was often impractical for researchers in such projects to test every new feature collaborators proposed because they didn't have the time, he says.

Some researchers use continuous integration to automate non-programming tasks. In April, as part of a project studying how ecosystems change over time, Ethan White, an ecologist at the University of Florida in Gainesville, helped to configure Travis CI to update tables and plots automatically with new field or weather-station data, saving the research team up to 5 hours a month.

Continuous integration helps Himmelstein automate revisions to scientific papers, citations and web pages following text or code updates. Without continuous integration, he says, human maintainers would probably “get lazy and update the manuscript less frequently than every change”.

Initializing

Whether hosted externally by a third party or on a user's own machine, the continuous integration service is controlled with a custom set of instructions. This configuration file defines the tasks to be run and sets up the server with the correct environment — the operating system and software libraries — required to run them. The service then executes those instructions at set times or on receipt of a code or data update.

University of Pennsylvania bioinformatician Casey Greene, who uses

continuous integration to rerun his data analyses, has tested many of today's most popular services. “The good news about all of these services is that they're quite similar,” he says.

Subtle differences do exist, for instance in the number of concurrent jobs users can run, or the amount of computing power available to run them. “I'd encourage people to dig into the limits of each service to make sure they are compatible with their workflows,” advises Greene.

Although continuous integration adoption in science right now is small, it is growing, and more researchers should get on board, Greene says. Getting up to speed takes time, he acknowledges, but often, the effort is worth the reward. “Scientists analysing data should have it in their toolbox.”

Journal name:
: Nature

Volume:
: 550,

Pages:
: 143–144

Date published:
: (05 October 2017)

DOI:
: doi:10.1038/550143a

Comments

Comments

There are currently no comments.

A taste of Toolbox

Nature's technology editor, Jeffrey Perkel, started blogging about workplace technology in science in 2016. Here are some highlights.

04 October 2017

From stadiums to genomes

Most bioinformaticians are either biologists skilled in programming or programmers with an interest in biology. Mike Goodstadt, the programmer behind the 3D genome-visualization tool TADkit, took a different approach. In the early-to-mid 1990s, Goodstadt was a student at the University of Bath, UK. His course of study? Architecture, with an emphasis on 3D modelling. After graduation, he helped to design and build a 61,500-seat stadium. But a faltering economy and newly acquired programming skills helped to steer him towards biology.

Lorena Barba, reproducibility champion

Lorena Barba, a mechanical and aerospace engineer at George Washington University in Washington DC, has long championed research reproducibility. “I've always believed that the open-source model is ideal for science, as it exposes the complete sequence of steps that produces a given result,” she says. In January, she travelled to Chile to run a week-long course on reproducible research computing. The month before, she had been awarded a 2016 Leamer-Rosenthal Prize, which celebrates those “working to forward the values of openness and transparency in research”. In this Q&A;, she talks flying snakes, 'repro-packs' and copyright.

The sound of DNA

With an alphabet comprising just four letters, a DNA sequence isn't much to look at. So when sequence-analysis tools want to highlight key elements, they typically do so using colour or font, or by overlaying other types of information. In the not-too-distant future, there may be another option. Molecular biologist and part-time drummer Mark Temple at Western Sydney University, Australia, describes DNA sonification, "an auditory display tool" for DNA: sequence in, audio out. "I'm not saying audio by itself is the bees' knees for interpreting DNA sequence," Temple says, "but surely audio can contribute to your visual interpretation."

Journal name:
Nature
Volume:
550,
Pages:
144
Date published:
(05 October 2017)
DOI:
doi:10.1038/550144a

Comments

Comments

There are currently no comments.

South Korea cracks down on dirty air

Despite huge clean-up effort, scientists say country’s pollution problem could get worse over next five years.

03 October 2017

Ed Jones/AFP/Getty

South Korea's capital, Seoul, ranks among the world's most polluted cities.

In a major attempt to clean its increasingly dirty air, South Korea’s government last week unveiled a five-year, 7.2 trillion won ($6.3 billion) plan to close down old coal plants, get diesel vehicles off the road and curb polluting emissions from industrial plants, construction sites and ships.

Although much of the spending had already been pledged, researchers say that the new strategy, announced on 26 September, is the country's most ambitious attempt yet to scrub its air. But because it omits controls on a class of chemicals called volatile organic compounds (VOCs), the initiative might make air quality worse before it improves.

The plan fulfils a key campaign pledge by President Moon Jae-in, who was elected in May by a Korean public increasingly concerned about their country's worsening air quality. At times this year, Seoul ranked among the world's top three most polluted cities. And the Organisation for Economic Co-operation and Development (OECD), based in Paris, reports that in 2015 South Korea's average exposure to fine-dust particles under 2.5 micrometres in size was the highest of all OECD member nations. This particulate matter, known as PM2.5, is small enough to enter the lungs and can cause respiratory illnesses.

The government hopes to cut domestic emissions of PM2.5 by 30% before 2022. Moon's administration has already focused on shutting down coal plants, temporarily closing eight of them in June and beginning the permanent shutdown of three in July. And the previous administration of Park Gyun-Hye had pledged 5 trillion won by 2020 to speed the adoption of electric cars to replace diesels.

NOx-ious crackdown

But the new strategy also aims to crack down on emissions of nitrogen oxides (NOx), which can react with other atmospheric compounds, including VOCs, sulfides and ammonia, to form ozone and fine-dust particles. Large industrial facilities such as steel plants and petroleum refineries will be fitted with monitoring equipment and held to a cap on their NOx emissions starting in 2019, the environment ministry's deputy director JaeHyun Kim says.

That approach has been informed in part by data released in July from a joint US–South Korean study called KORUS-AQ[1], says Kim. The most comprehensive examination of air quality in the region, it involved more than 580 researchers from the United States and South Korea, as well as several

research aircraft, including a NASA DC-8 jet that flew across the Korean peninsula and the Yellow Sea. Researchers found that South Korea was emitting more NOx and VOCs than its own ministry estimated, and recommended reductions in these chemicals. This highlighted the importance of addressing South Korea's domestic pollution, says Kim, at a time when many in the country were more concerned about pollution blowing over from China.

The focus on NOx means the new plan is "a lot better than before", says Kyung-Eun Min, an atmospheric chemist at the Gwangju Institute of Science and Technology. But she and other scientists point out that it says little about curbing VOCs. These are typically aromatic molecules produced for activities such as painting, printing and dry cleaning. A compound called toluene, used to manufacture solvents, is particularly instrumental in producing fine dust and ozone, the KORUS-AQ study found. The VOCs often leak during production, or while being stored or used by small businesses.

Ozone up?

Paradoxically, Min says, reducing NOx without reducing VOCs is likely to increase ozone across much of South Korea. That is because, according to the KORUS-AQ results and Min's own work, relative levels of NOx are so high in Korea — especially in car-filled Seoul — that they restrict the efficiency of ozone production, much as an over-rich fuel mixture makes an engine sputter. The quickest way to cut ozone is to starve it of both NOx and VOCs, "but the VOC part is not really there," Min says. However, regions downwind of Seoul may benefit more quickly from NOx reductions, says Rokjin Park, an air chemist at Seoul National University.

Tracking VOC emissions is particularly difficult, because there is no clear way to monitor or regulate small businesses such as painters and dry cleaners. A first step would be to collect data to nail down where South Korea's VOCs are coming from, Min says. In the longer term, she suggests developing technology that can capture dirty air from such emissions sites so that it can be purified at treatment facilities — in a process analogous to sewage treatment.

Yong Pyo Kim, an environmental scientist at Ewha Womans University in Seoul and an author of the KORUS-AQ report, says he thinks that both ozone and fine dust could get worse for the next five years. “In my opinion, the environment ministry did not learn from the KORUS-AQ results seriously,” he says. The South Korean environment ministry has not responded to requests for comment from *Nature* about the criticisms.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22448

Comments

Comments

There are currently no comments.

Xenon view, butterfly wings and a strange squid

September's sharpest science shots, selected by *Nature*'s photo team.

03 October 2017

CRISPR catches

Richard Wallbank/Smithsonian Institution and University of Cambridge

The beauty of butterfly wings owes much to just two genes, researchers revealed this month. They used the CRISPR gene-editing system to turn off the genes, called *WntA* and *optix*, to show how their absence dulls the colours

of these fleeting flyers. Left are the wings of an unmodified Sara longwing (*Heliconius sara sara*) from the study; right is a gene-edited version.

Inside Xenon

Image Slideshow

1. 

   Winner of a gold award in the 2017 International Images for Science competition, this picture by Enrico Sacchetti shows the interior of the Xenon1T experiment at Italy's Gran Sasso Laboratory, which hunts for dark matter.

   Enrico Sacchetti/Royal Photographic Society

2. 

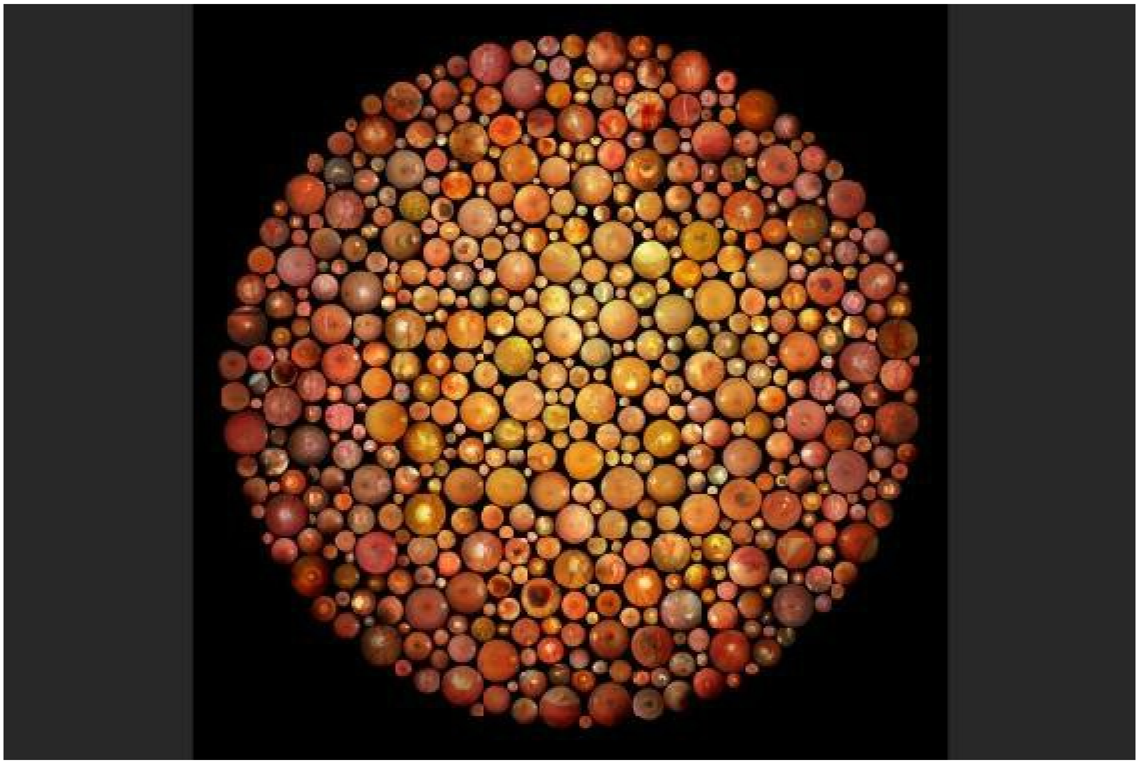
Another gold-award winner, this one taken by Teresa Zgoda. What looks like a frightening visage is actually a close-up of a pork tapeworm (*Taenia solium*), showing in detail the suckers that allow it to stick to the inside of humans and grow — and grow, and grow.

Teresa Zgoda /Royal Photographic Society

3. 

These legs belong to impalas (*Aepyceros melampus*); the black patches are glands used for scent marking. This image from Morgan Trimble won a bronze award in this year’s competition.

Morgan Trimble/Royal Photographic Society

4. 

This shot is a combination of hundreds of images of retinas shot by Jonathan Brett, and assembled to mimic a colour-vision test chart. The eyes took a silver award.

Jonathan Brett/Royal Photographic Society

Coming down…

Bill Ingalls/NASA

At the start of the month, this Soyuz capsule brought back three astronauts to Earth, landing near Zhezkazgan in Kazakhstan. Among them was Peggy Whitson, who spent 288 days in space aboard the International Space Station.

… and going up

Bill Ingalls/NASA

Ten days after Whitson and her colleagues returned to this planet, another three people left it when this Soyuz left for the space station from Baikonur Cosmodrome.

A complex cloud

Artem Mironov

This nebula — called the Rho Ophiuchi cloud complex — is 140 parsecs (460 light years) from Earth. Photographer Artem Mironov took three nights to capture this image of it, which went on to win this year's Insight Astronomy Photographer of the Year award.

Seamount squid

NOAA Office of Ocean Exploration and Research

On 17 September, the crew of the US National Oceanic and Atmospheric Administration's ship *Okeanos Explorer* were exploring the Musicians Seamounts, a formation of undersea mountains in the Pacific Ocean, with remotely operated submersibles when they spotted this cranchiid squid. You can see more pictures of weird and wonderful deep-sea denizens on their diary site.

Bee bounty

Image Slideshow

1. 

The USGS Bee Inventory and Monitoring Lab in Laurel, Maryland has long been among our favourite purveyors of online insect images. Among the latest additions to its catalogue is this *Hoplitis fulgida*.

Anders Croft/USGS Bee Inventory and Monitoring Lab

2. 

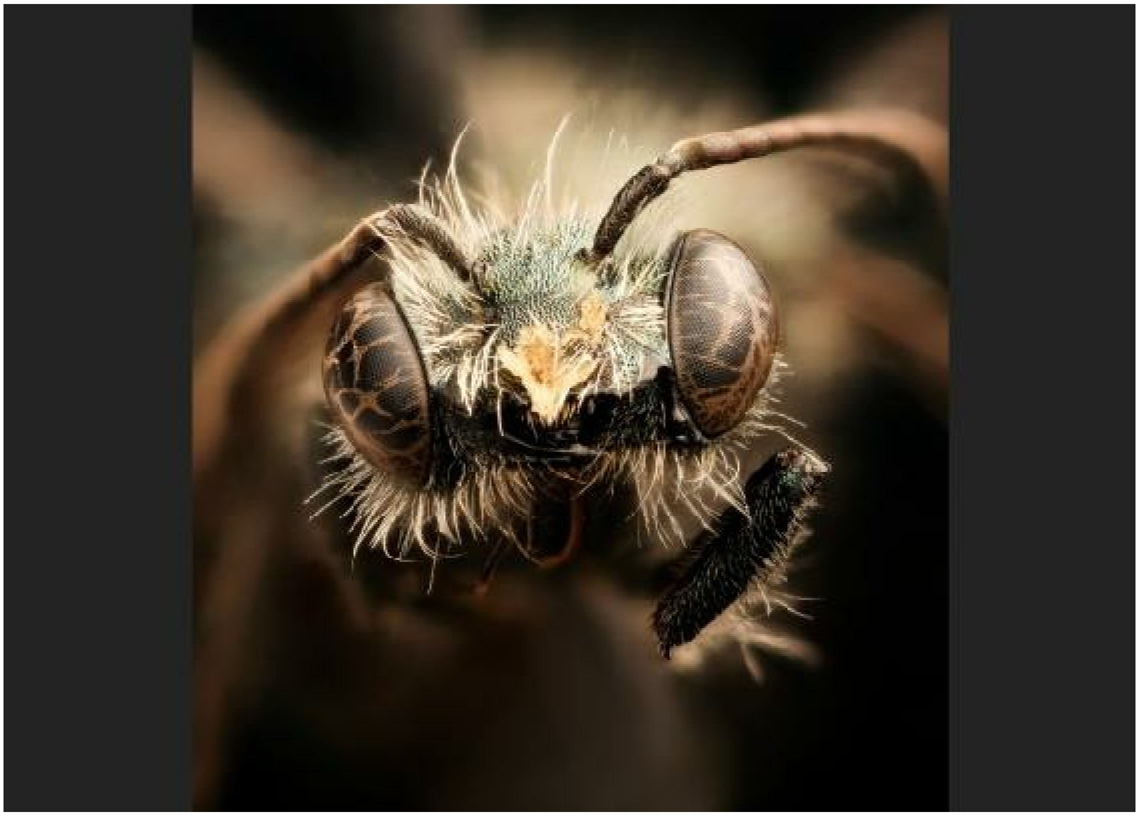
Another shot of *H. fulgida*, collected in Yosemite National Park, California.

USGS Bee Inventory and Monitoring Lab

3. 

Dianthidium singulare glues rocks together to make little houses for its eggs. The lab calls it a “boss looking bee”, and it’s hard to disagree.

USGS Bee Inventory and Monitoring Lab

4. 

The lab says this mason bee *Osmia subarctica* is a terrible specimen, but it has photographed beautifully.

USGS Bee Inventory and Monitoring Lab

Cassini comedown

NASA/Joel Kowsky

It is finally over. The Cassini mission this month dived into Saturn’s atmosphere, destroying itself. In this photo, Cassini programme manager Earl Maize packs up his workspace at mission control in the Jet Propulsion Laboratory in Pasadena, California. on 15 September.

They grow up so fast

Online Tracking of Arabidopsis Root

Arabidopsis thaliana, or thale cress, is widely used as a model organism in labs. Daniel von Wangenheim of the Institute of Science and Technology Austria in Klosterneuburg won first place in the Nikon Small World in Motion Photomicrography Competition for this remarkable time-lapse video of the root tip of one *A. thaliana* plant growing.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22741

Comments

Comments

There are currently no comments.

Europe’s Joint Research Centre, although improving, must think bigger

External report criticizes lack of exploratory research.

03 October 2017

Sean Gallup/Getty

Europe’s Joint Research Centre first raised awkward questions about diesel car emissions.

The European Union’s Joint Research Centre (JRC) uses the label EU Science Hub now. Whether the rebranding will increase its profile is one

question. What science gets done inside this hub is another. In response to that query, there is some positive news. It is doing what it should be, and doing it well: collecting scientific and technical evidence in support of EU policies. That's according to the report of an external evaluation released this week. Furthermore, EU research commissioner Carlos Moedas praised the JRC at its annual public meeting on 26 September for contributing to the interminable struggle to counter false information and communicate science effectively to a sceptical public.

The JRC employs more than 2,000 scientists, who generate or collate a constant feed of information for authorities and politicians. In theory, this helps to support evidence-based policies — from the old chestnuts of genetically modified (GM) crops and nuclear safety to the ongoing refugee crisis, for which it holds a repository of relevant information and reliable statistics. Yet most of this work fails to reach public attention. For example, staff in the JRC transport section had worked out and published evidence that car makers were manipulating diesel-emission data years before the public scandal over Volkswagen finally broke in 2015.

The JRC celebrates its 60th anniversary this year. It has become a complex beast, operating at six sites in five EU countries, with a budget this year of €372 million (US$437 million). It was originally set up as a nuclear research organization, but widened its remit over the decades, adding institutes. Twenty years ago, it morphed into a centre with an explicit mission to provide support for a wide range of EU policies. But by that time it had lost its way, and tough reforms were introduced. A 2009 evaluation led by former UK government science adviser David King concluded that it was carrying out its new remit well, but criticized it for doing too little independent research of the type required to attract and keep the best scientists.

The new report, headed by the former Irish government science adviser Patrick Cunningham, echoes this call. It acknowledges how rapidly the centre has broken out of its much-criticized institute-based silos to restructure thematically into cross-site departments, such as energy and health, which more directly mirror policy areas. It also notes that the JRC has significantly increased its presence in the world's top-cited literature. But it says that the centre still does too little exploratory research — such research engages only

3.5% of JRC staff, well below the target of 10% that it set itself in 2015.

Why has it struggled? Although it has established partnerships with European universities and research institutes, and aided the exchange of scientists, many JRC researchers have different motivations from those of colleagues in universities. There is much satisfaction in contributing to policies that influence the lives of people in the EU. But officials and staff must look again at their priorities. As well as keeping the JRC relevant, a wider focus on the cutting edge would allow it to flag up hot topics to policymakers earlier.

But what policymakers do with the information they receive from their science service is another matter entirely. EU policy on GM crops is notoriously weak — scientific evidence for their safety has failed to convince some countries, whose citizens viscerally reject the technology. And sometimes the EU's intrinsic political weakness can block the implementation of its science-based policies. After all, the European Commission and EU member states ignored the findings on diesel emissions, and acted only after regulators in the United States cracked down.

Journal name:
Nature
Volume:
550,
Pages:
8
Date published:
(05 October 2017)
DOI:
doi:10.1038/550008a

Comments

Comments

There are currently no comments.

Bill & Melinda Gates Foundation

Make plans to eliminate cholera outbreaks

Governments must stop denying the occurrence of cholera and unite in long-term prevention strategies, says Anita Zaidi[1].

03 October 2017

As a medical student in Karachi in the 1980s, I saw cholera all the time. We had a dedicated diarrhoea ward in the hospital, and if there was an increase in diarrhoea cases in children aged over 3, we knew we had a cholera outbreak. Over the past decades, the world has become much better equipped to fight cholera, yet the disease continues to spread across sub-Saharan Africa, Asia and the Caribbean.

In Yemen, cholera has killed more than 2,000 people and infected nearly 700,000 in the past 5 months alone, eclipsing the post-earthquake outbreak in Haiti. Haiti still battles with the disease 7 years after its reintroduction. Meanwhile, Somalia is experiencing its worst outbreak in five years. South Sudan continues to fight its worst outbreak since it gained independence in

2011. If nothing changes, cholera will continue to claim some 100,000 lives a year and afflict around 3 million people, many of them children.

This week, the World Health Organization (WHO) launches a campaign to eliminate cholera outbreaks by 2030. The plan could move countries beyond ad hoc reactions, to sustainable prevention.

The disease is caused by the bacterium *Vibrio cholerae* and spreads mainly through contaminated water. Infection usually causes no or mild symptoms, but in approximately one-tenth of cases it swiftly leads to watery diarrhoea, vomiting and cramps. Rapid loss of fluid can result in dehydration and death within hours. An oral rehydration solution that costs cents can reduce fatality from a high of 50% to under 1%. Every year, it still fails to reach tens of thousands of victims in time.

Clean water, improved sanitation and better access to treatment have been game-changing for much of the world, but cholera is still thought to be endemic in 69 countries, including most of sub-Saharan Africa.

In the twenty-first century, no one should die from this disease. We have treatments and prevention strategies that work, including sufficient cholera-vaccine stocks. We know where outbreaks are most likely to start. To spread, cholera needs estuaries, rivers or coastal waters that are contaminated with faeces, and susceptible people living nearby; it has clear patterns of recurrence. What we need to do is get there first.

What's stopping us? One barrier is stigma. Many national and regional governments don't want to admit that their territory harbours cholera. Rather than controlling it, they hide it. The stigma goes back hundreds of years, to when ships with sick passengers were not allowed to dock and people feared being put in quarantine. Now the fears are public anger and loss of economic opportunities. Many countries with known endemic cholera in Asia and Africa report to the WHO that they have no cases, and in the face of an outbreak do not request cholera vaccines. In 2010, during the massive floods in Pakistan, my colleagues and I saw hundreds of cases of acute watery diarrhoea in Sindh that we confirmed to be cholera in our laboratory, but national health officials told us to keep it quiet.

Too many countries act only after a crisis has emerged: then they request vaccine campaigns, set up makeshift cholera clinics and urgently mobilize supplies.

These tactics can quell an outbreak and dampen transmission in the short term, but they don't stop outbreaks from happening again. For that, governments must intervene preemptively to control cholera in places where it recurs frequently. Since the WHO cholera-vaccine stockpile was established in 2013, almost 13 million doses have been delivered. Millions more doses should have been requested.

To truly stop cholera outbreaks, countries must do two things: deploy vaccines where cholera is endemic and strengthen the infrastructure that provides clean water and good sanitation.

Events in Malawi give reason for optimism. In April this year, the country adopted a national plan to control and prevent cholera that directs vaccines to affected communities identified by geo-spatial mapping. More than 2 million citizens have been vaccinated ad hoc since 2015. The new plan, made possible by strong political commitment at the Ministry of Health, collates two decades' worth of information to better estimate cholera burden, identify hotspots and support early intervention. At the same time, Malawi is planning to strengthen water and sanitation infrastructure. Experts are hopeful that this will reduce the country's cholera burden to its lowest level in years.

Similarly, the WHO Global Task Force on Cholera Control is launching a renewed strategy to eliminate cholera outbreaks worldwide. Unlike past efforts, this plan goes beyond responding to cholera flare-ups: it encourages countries to invest in protecting people from cholera over the short and long term.

The success of the WHO's plan ultimately depends on the commitment of governments worldwide. All governments, whether or not they are directly affected by cholera, must unite and increase their political and financial investment in cholera prevention and control.

The first cholera pandemic, in 1817, swept across South Asia, East Africa, the Middle East and Europe, claiming hundreds of thousands of lives. Back

then, we had no vaccine and a limited understanding of transmission. It is unacceptable that, now, in that pandemic's 200th anniversary year, a disease we know how to fight remains out of control.

Journal name:
Nature
Volume:
550,
Pages:
9
Date published:
(05 October 2017)
DOI:
doi:10.1038/550009a

Comments

Comments

There are currently no comments.

| 章节菜单 | 主菜单 |

Ethics of Internet research trigger scrutiny

Concern over the use of public data spurs guideline update.

03 October 2017

Matt Cardy/Getty

A Banksy artwork in Cheltenham, UK. Scientists tried to find the artist’s true identity using public data.

British graffiti artist Banksy is renowned for his anonymity. But that status was dented last year when researchers published a paper that cross-referenced the locations of Banksy’s street art with public information about people’s

addresses and likely movements (M. V. Hauge *et al. J. Spatial Sci.* **61,** 185–190; 2016). The team, led by academics at Queen Mary University of London, concluded that someone previously suspected to be Banksy probably was the secretive artist.

Because the study used public data, a university ethics committee said that the work was exempt from formal review — and informally advised academics that it would do no harm because a UK national newspaper had already identified the person in question as Banksy. But for some ethicists, the paper highlights growing concerns about the potential hazards of research that uses public data. “I think this study should never have been done,” says Jake Metcalf, a technology ethicist at the think tank Data & Society in New York City.

Metcalf is one of several academics calling for new guidelines to steer scientists through ethical quandaries in Internet research. The unprecedented availability of online data — together with tools to draw patterns from it, such as machine learning — is opening up research possibilities that outpace existing ethics frameworks around privacy, consent and harm, says Charles Ess, a research ethicist at the University of Oslo and a member of the Association of Internet Researchers. The association will discuss how to update its guidelines at its annual meeting on 19 October in Tartu, Estonia.

A flurry of similar initiatives is under way. Earlier this year, the SATORI project, funded by the European Commission, published recommendations on Internet research as part of an effort to standardize and update research-ethics guidelines. In September, the US National Science Foundation funded a US$3-million, 4-year study called PERVADE — of which Metcalf is a part — that aims to chart attitudes to data-research ethics, produce best-practice guidelines and create tools to assess the potential harms of such work. And some British universities are preparing their first guidelines on the ethics of Internet research, after the UK Research Integrity Office, a national advisory body, published non-binding recommendations about it last December.

Common themes among these efforts include rethinking what counts as ‘public’ data, the ethical use of social media and the need to consider a study’s potential harm to wider society, as well as to individuals. Many

countries have long-standing ethical checks for research that intervenes in human lives. But those principles, set up for medical and psychological studies, apply to research on human subjects, the definition of which often excludes Internet research, says Metcalf.

In the United States, for instance, studies using public data (which includes that purchased from a third party) generally do not count as human-subjects research because they don't access private, identifiable information about people. They don't need to be checked by an institutional review board (IRB) or require informed consent. Guidelines issued in 2013 add that researchers should sometimes consider seeking review — if a person incorrectly assumed that access to his or her public information was restricted, for example. But IRBs have no obligation to adopt these proposals, and different committees may come to different verdicts, says Metcalf.

Peter Hedges, head of the research-operations office at the University of Cambridge, UK, argues that even researchers who use information that is undeniably public, such as Twitter data, should review the ethics of their work. The SATORI guidelines advise that regulators and researchers should carefully consider whether publicly available information is actually private, and not fall back on simple classifications.

If someone's data are considered private and identifiable, that would usually mean obtaining their informed consent. But, in practice, such consent is often impossible to acquire for large-scale data studies, says Ess. And anonymizing data is difficult, because search engines can easily identify individuals from even small snippets of anonymized text or by cross-referencing them in multiple data sources. The SATORI guidelines recommend that researchers take precautions to ensure the anonymity of study participants, and Ess suggests that scientists can still, without too much effort, seek consent from anyone they explicitly quote in research papers.

When ethics committees do assess data studies, their viewpoint might be too narrow, says Ansgar Koene, an engineer and ethicist at the University of Nottingham, UK. They tend to consider the direct damage to an individual involved in research, rather than a project's potential to do widespread harm to society. That debate flared up in September when artificial-intelligence researchers at Stanford University in California posted a preprint of research

that predicted whether someone is gay from their photo; it used pictures sourced from an online dating site (see https://osf.io/zn79k). The study was approved by Stanford's IRB, but provoked condemnation from some advocacy groups for lesbian, gay, bisexual, transgender and queer (LGBTQ) people, which branded it dangerous. The study's lead author, Michal Kosinski, said the work aimed to protect people by exposing an existing threat from widely used technology. Kosinski and his colleague, Yilun Wang, discussed their results afterwards with representatives of the LGBTQ community, but Koene says that the discussion should have happened beforehand and the paper should have addressed their comments.

Computer science is a flashpoint for Internet-research ethics. Researchers in this field are not used to working with human study participants and often don't consider the ethical impact of their work, says Koene, who has surveyed approaches to ethics in different disciplines. A major concern, academics agree, is how companies use online data for research — much of which they have proprietary access to. In 2014, for example, Facebook altered users' newsfeeds without telling them, to study how this affected their emotions. A public backlash prompted Facebook to publish some details of its internal review process (M. Jackman and L. Kanerva *Wash. Lee Law Rev. Online* **72,** 442; 2016) — but there is little transparency overall about how this works, says Koene.

Researchers may not want to see their science slowed by formal ethical review, which can be time-consuming and opaque. Better ethics training is one solution, says Koene. But a failure to align data science with public perceptions of what is acceptable could generate a severe reaction, he warns. "The public will see us as no different from corporate or other special-interest groups pursuing a hidden agenda," he says.

Journal name:
Nature
Volume:
550,
Pages:
16–17
Date published:

(05 October 2017)
DOI:
doi:10.1038/550016a

Comments

Commenting is currently unavailable.

Gravitational wave detection wins physics Nobel

Rainer Weiss, Barry Barish and Kip Thorne share the 2017 prize for their work at LIGO to detect ripples in space-time.

03 October 2017

Left: Bryce Vickmark/MIT. Centre: Caltech. Right: Caltech Alumni Assoc.

Rainer Weiss (left), Barry Barish (centre), and Kip Thorne (right), who led work to detect gravitational waves.

Three physicists who had leading roles in the first direct detection of gravitational waves have won the 2017 Nobel Prize in Physics.

Rainer Weiss, at the Massachusetts Institute of Technology (MIT) in Cambridge and Barry Barish and Kip Thorne, both at the California Institute

of Technology in Pasadena, share the 9 million Swedish krona (US$1.1-million) award for their work at the US-based Laser Interferometer Gravitational-Wave Observatory (LIGO). In September 2015, LIGO picked up the deformations in space-time caused by the collision of two distant black holes.

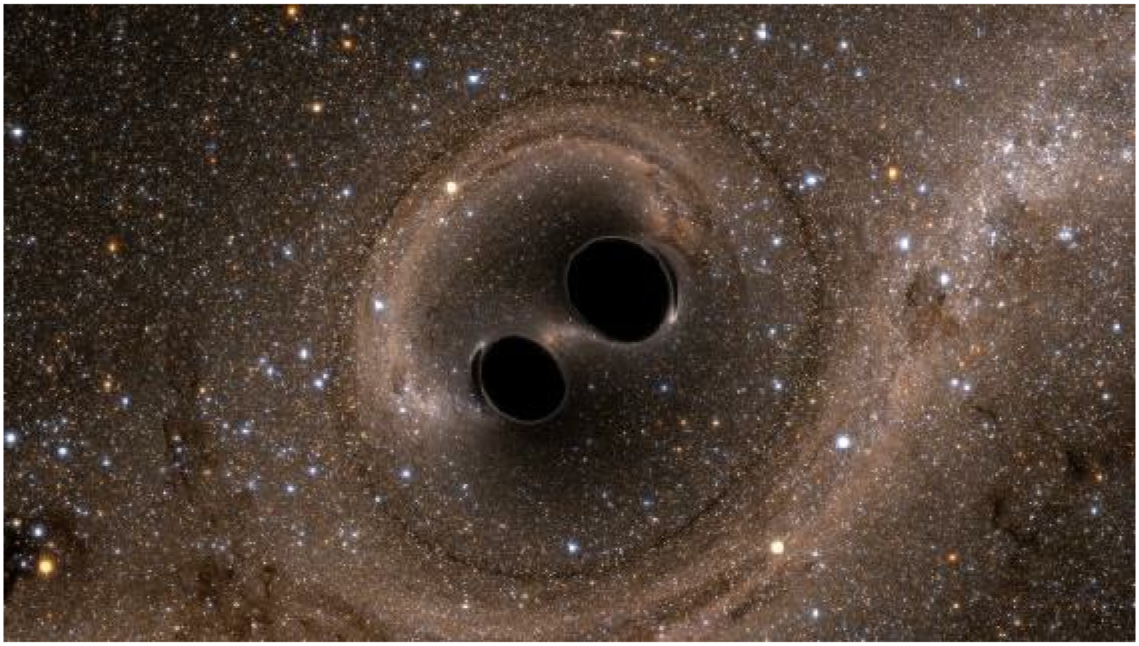
That discovery, which was announced in February 2016, opened up a new field of astronomy, in which scientists listen to the space-time vibrations emitted by some of the Universe’s most cataclysmic events. And it confirmed the existence of gravitational waves, which Albert Einstein had predicted a century before.

Weiss and Thorne are two of three physicists known as the Troika — the founders of LIGO’s giant twin detectors in Livingston, Louisiana, and in Hanford, Washington. The third troika member, Ronald Drever, died on 7 March this year. And Barish, who was LIGO director from 1997 to 2005, is widely credited with having transformed the collaboration from a chaotic endeavour to a well-oiled machine.

"I view this more as a thing that recognizes the work of about 1,000 people, a really dedicated effort that’s been going on for — I hate to tell you — as long as 40 years," said Weiss in an interview with the Nobel Committee just after winning the prize.

"We were all very happy for them to be recognized. They worked on this for decades," says Gabriela Gonzalez, a physicist at Louisiana State University in Baton Rouge, and a LIGO team member and former spokesperson for the collaboration. The Nobel prize can be awarded only to a maximum of three people, but the Nobel Committee noted the huge numbers of people who worked on LIGO in its press release.

Researchers had been widely expecting the committee to reward the team since last year's detection announcement. "I'm very happy that they got the right people," says Charles Misner, a general relativity theorist at the University of Maryland in College Park. Half of the Nobel prize has been awarded to Weiss, with the other half split between Barish and Thorne.



The SXS Project

A computer simulation of two black holes colliding, which generates gravitational waves.

Unimpeded motion

Few physicists doubted the existence of gravitational waves before the LIGO discovery. The distortions in space-time are an inevitable consequence of Einstein’s general theory of relativity, and propagate across the Universe almost unimpeded. In 1974, they were confirmed indirectly when researchers examined the radio flashes emitted by a pair of merging neutron stars; the shifts in the flashes' timing matched predictions of how gravitational waves would carry energy away from the event. That discovery was rewarded with the 1993 Nobel Prize in Physics.

But sensing the waves themselves was a monumental task. Even the most powerful deformations — those produced by collapsing stars or colliding black holes — would typically be tiny by the time they reached Earth. The waves detected in 2015 stretched and squeezed LIGO’s perpendicular 4-kilometre vacuum pipes by a fraction of a proton’s width, but that was

enough to noticeably shift out of sync the laser beams bouncing inside the pipes.

Physicists in the United States and the then-Soviet Union first proposed using laser interferometers to detect gravitational waves in the 1960s. Weiss made the first detailed calculations for how an interferometer would work in 1972. The idea seemed so far-fetched that even he was not sure it would work. “It might come to a junction in a year or so when we will decide it ain’t worth it,” he told science sociologist Harry Collins at the time[1].

Weiss, who was born in Germany in 1932, emigrated with his family to the United States in 1938 to escape from Nazism. He built his first prototype interferometer in the mid-1970s, soon followed by researchers in Europe — among them, Drever and his collaborators at the University of Glasgow, UK, and another group in Munich, Germany.

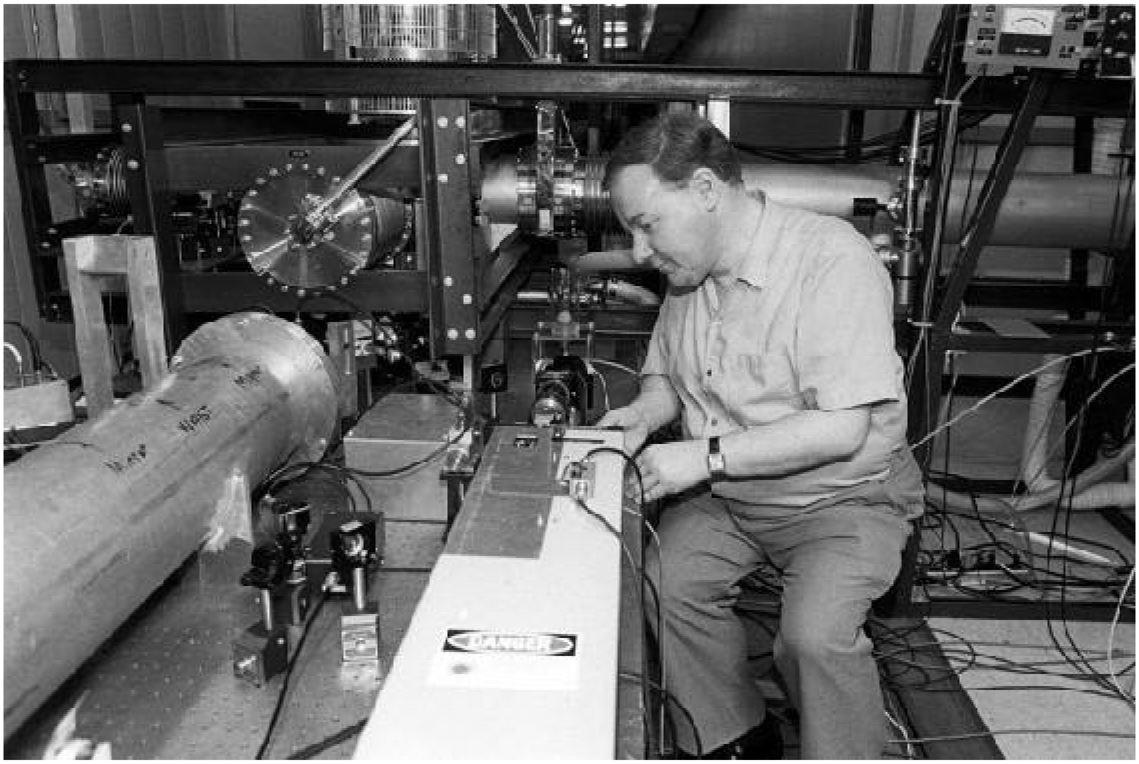
Thorne, born in Utah in 1940 to Mormon parents, specialized in general relativity and had also been developing ideas on the waves. At a conference in Washington DC in 1975, Thorne and Weiss shared a room in an over-booked hotel. During their conversations, Weiss convinced Thorne that interferometers were the right approach. Thorne, Weiss and Drever joined forces in the early 1980s, when it became clear that the US National Science Foundation would not fund two separate efforts, and the LIGO collaboration was born.

Dramatic turn-around

The troika did not always work smoothly and, at their own admission, did not possess the right skills for managing what was quickly becoming a vast operation. Things improved dramatically after Barish, who had been LIGO’s principal investigator since 1994, became director in 1997. Collins, who has closely studied the collaboration for decades, says that Barish turned LIGO into a ‘big science’ organization. “Without Barish turning things around, it would have collapsed,” he says.

LIGO initially struggled to get funded, but ended up being the largest and

most expensive experiment in the history of the US National Science Foundation. Its two nearly identical detectors first opened in 2002, with an admittedly scant chance of detecting anything during their first phase of data collection. The observatory shut down in 2010 for a major overhaul, and restarted in September 2015, three times more sensitive than before.



Bob Paz/Caltech Archives

Ronald Drever was one of the original co-founders of the LIGO project; he died in March 2017.

Researchers were cautiously optimistic of a discovery within a few years. But the Universe was kind to LIGO, providing a dramatic event for it to record on 14 September, while the interferometers were still being calibrated, days before their official science run was due to start. Since then, LIGO has detected at least three other gravitational-wave events — the most recent also spotted by Virgo, a similar interferometer near Pisa, Italy.

The LIGO team benefited from significant research efforts in other countries.

Germany and the United Kingdom have contributed funding and research, and GEO600, a smaller interferometer near Hannover, Germany, is the main test-bed for technologies that are implemented on its larger cousins in the United States.

The three winners have other strings to their bows: as well as working on LIGO, Weiss was a leading scientist in the Cosmic Background Explorer (COBE), a NASA probe that in the 1990s produced the first map of the cosmic microwave background, the 'afterglow' of the Big Bang. (Two other COBE researchers shared the physics Nobel in 2006.)

Thorne, who has spearheaded theoretical studies of gravitational waves, also helped to conceive the original idea for the plot of the 2014 film *Interstellar*, on which he was an executive producer. And before joining LIGO, Barish worked on neutrino experiments at the Fermi National Laboratory in Batavia, Illinois and elsewhere. He has also led the design of a proposed International Linear Collider.

Thorne and Weiss were generally considered shoo-ins for the Nobel. Before Drever's passing last March, the troika raked up almost every prize there was for them to win, including the $3-million Special Breakthrough Prize in Fundamental Physics; the $500,000 Gruber Foundation Cosmology Prize; the $1.2-million Shaw Prize in Astronomy; and the $1-million Kavli Prize in Astrophysics.

Journal name:
Nature
Volume:
550,
Pages:
19
Date published:
(05 October 2017)
DOI:
doi:10.1038/nature.2017.22737

Comments

Commenting is currently unavailable.

Risk of human-triggered earthquakes laid out in biggest-ever database

Geologists track hundreds of quakes caused by people and the projects that set them off.

02 October 2017

Chris McGrath/Getty

A 7.8-magnitude earthquake that hit Nepal on April 30, 2015, has been linked by some to groundwater pumping.

From mining projects to oil and gas operations, human activity has set off

earthquakes around the world and in many geological settings. Research now highlights how big these quakes can get — and how little scientists agree on which ones are caused by people.

The Human-Induced Earthquake Database, or HiQuake, contains 728 examples of earthquakes (or sequences of earthquakes) that may have been set off by humans over the past 149 years. Most of them were small, between magnitudes 3 and 4. But the list also includes several large, destructive earthquakes, such as the magnitude-7.8 quake in Nepal in April 2015, which one paper linked to groundwater pumping[1].

Miles Wilson, a hydrogeologist at Durham University, UK, and his colleagues describe the database in a paper set to be published on October 4 in *Seismological Research Letters*[2]. The scientists say that HiQuake is the biggest, most up-to-date public listing of human-caused quakes ever made. By bringing the data together in this way, they hope to highlight how diverse induced quakes can be — and help society to understand and manage the future risk.

Earth-shaking activity

HiQuake began in 2016, when the Dutch Petroleum Society (NAM), an oil and gas company based in Assen, funded a team of researchers at Durham and at Newcastle University, UK, to collect examples of induced earthquakes. NAM drills in the Groningen gas field in the Netherlands, where it has set off many small earthquakes.

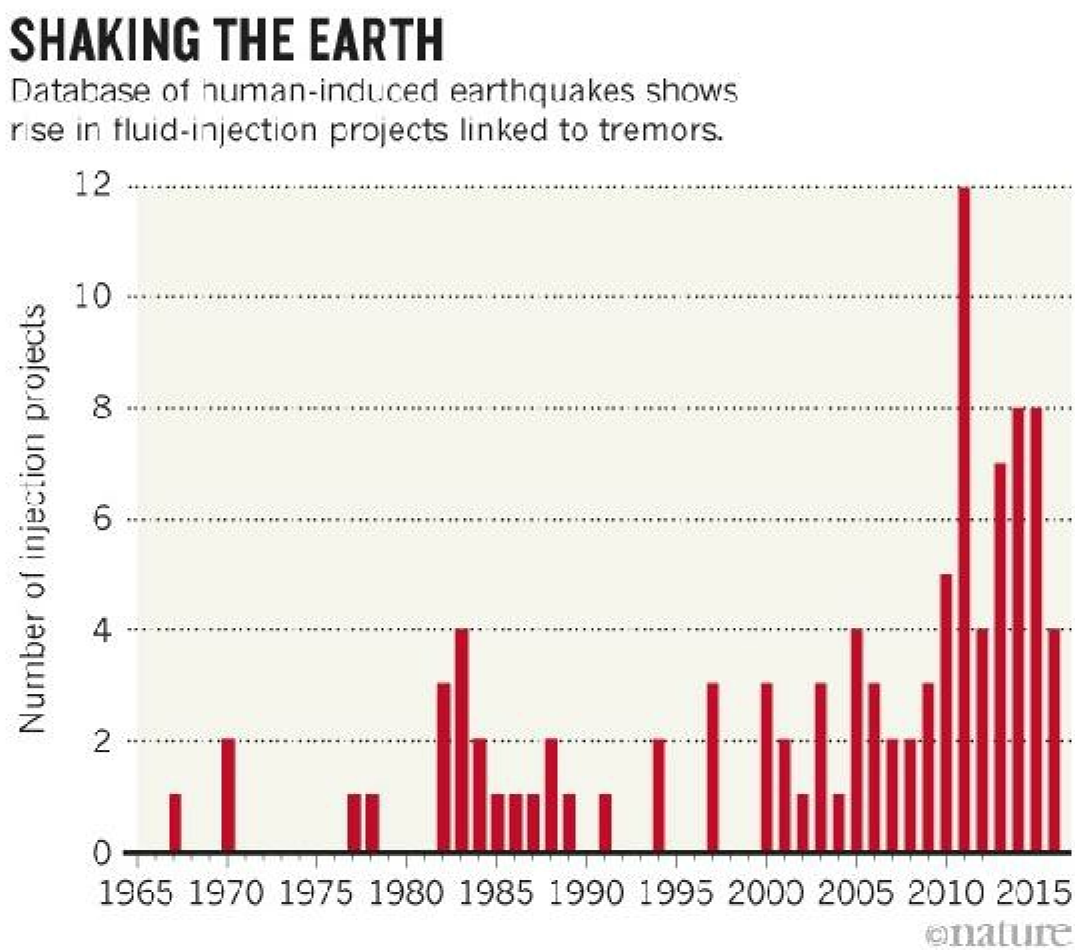
Wilson’s team trawled through sources including scientific papers and media accounts to come up with its 728 events. When a single project, such as a wastewater-injection well, set off more than one quake, the researchers counted those as a single event. Further details appear in *Earth-Science Reviews*[3].

The result is a database in which the earliest entry dates to 1868, with a quake triggered by an Australian coal-mining operation. Of the 728 events, 271 (37%) are linked to mining — often from tunnel collapses. About 23% are

linked to water piling up behind a dam and 15% to conventional oil and gas development. Just 4% are linked to hydraulic fracturing, or fracking, for oil and gas. Some of the more unusual cases involve quakes triggered by the building of heavy skyscrapers or by an underground nuclear-bomb test.

Mass movement

In HiQuake, the fastest-growing quake-inducing activity in the database is the injection of wastewater back into the ground by oil and gas operations (see 'Shaking the earth'). The process that can increase stress on buried geological faults and cause them to generate small earthquakes. The number of these projects spiked in the early 2010s, at the height of wastewater-injection in Oklahoma and other parts of the central United States.



The largest event in the database is the magnitude-7.9 earthquake that struck in Sichuan, China, in 2008, which some have linked with the filling of a nearby reservoir[4]. Wilson says his team was initially startled to see quakes that large proposed as human-induced. But in retrospect, he says, “we probably shouldn’t be surprised by any anthropogenic cause”. All the projects linked to earthquakes — whether blasting a mining tunnel, injecting wastewater or pumping groundwater — involve moving mass around on Earth’s surface in ways that can nudge already-stressed faults.

The scientists found a relationship between the volume of material moved — such as the size of the reservoir filled before the Chinese quake — and the magnitude of the largest linked earthquake that followed. No such relationship was seen with factors such as dam height or reservoir area. The researchers suggest that limiting the amount of material moved in a construction project could help to minimize any quakes triggered.

Judgement calls

All possible instances of induced quakes were included “without regard to plausibility”, writes the team, because of the difficulty involved in deciding what constitutes absolute proof that an earthquake was caused by human activity. But that could mislead people about the real hazard from induced quakes, says Raphaël Grandin, a geophysicist at the Institute of Earth Physics in Paris. “When you put a dot in the database, and a scientific reference behind it, then you may lead the non-expert to think that the earthquake was caused by humans,” he says. Such a listing might hide scientific uncertainty, as with the Chinese quake: despite the paper linking it to reservoir filling, many seismologists do not believe it was triggered by human activity[5].

Susan Hough, a seismologist at the US Geological Survey in Pasadena, California, says she understands why the HiQuake team included all possible instances of induced quakes. “I suspect the authors were unwilling to pass judgement on published studies, which I consider a reasonable decision,” she says. “If you start down the road, where do you stop?”

Wilson agrees. “Any judgement calls we leave to users,” he says.

Over time, HiQuake should become more useful as researchers add examples and references to its entries, says Gail Atkinson, a seismologist at the University of Western Ontario in London, Canada, who leads a Canadian collaboration to study induced seismicity.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22693

Comments

Comments

There are currently no comments.

Discoveries have awkward first dates

Fuzzy timings over a plate-tectonics anniversary highlight the rolling nature of scientific discovery.

02 October 2017

Archive of Alfred Wegener Institute

Alfred Wegener first suggested the idea of continental drift which led to the theory of plate tectonics.

This week, the Geological Society in London will mark the 50th anniversary

of plate tectonics — the theory that describes the workings of Earth, how earthquakes strike, and why volcanoes happen. Or will it?

The timing of the anniversary is disputed. After all, this journal published its own 50th anniversary commemoration of plate tectonics 4 years ago (*Nature* **501,** 27–29; 2013). Columbia University's Lamont–Doherty Earth Observatory in New York celebrated last May. Confused? Blame the rolling nature of scientific discovery. Plate tectonics did not spring into existence fully formed, Athena-like, on a particular day in a particular year.

No doubt aware of this, the London conference, although billing itself as "Plate Tectonics at 50", pins next week more cautiously: as a commemoration of the "advent of the paradigm" — the arrival of the model of the theory.

Coming up with the modern theory of Earth involved sparks of insight from many different researchers, working in different laboratories on different continents. Most of the resulting papers were published in the 1960s, many of them in *Nature*.

In September 1963, Frederick Vine and Drummond Matthews described how stripes of changing magnetism on the sea floor represented the spreading of new oceanic crust away from the ridge where it was born (F. J. Vine and D. H. Matthews *Nature* **199,** 947–949; 1963). This was the crucial insight that nailed the concept of sea-floor spreading, which had been hinted at in the 1950s, when oceanic mapping by Marie Tharp and Bruce Heezen revealed a mountainous rift, and so this is the paper that *Nature* editors choose to commemorate in plate-tectonics anniversaries. Fast-forward four years, and Dan McKenzie and Robert Parker publish the first complete description of how crustal plates move around on the surface of the sphere (D. McKenzie and R. L. Parker *Nature* **216,** 1276–1280; 1967), the paper that the Geological Society is now celebrating.

Of course, Vine, Matthews, McKenzie and Parker were far from alone. In the 1960s, plate tectonics was such a fecund, fast-moving field that it involved several instances of simultaneous discovery. In early 1967, as McKenzie was developing his ideas of rigid-plate motions, he looked at a conference abstract by colleague Jason Morgan and decided not to attend the talk. As it

turns out, Morgan veered from the text of his abstract and instead described ideas of plate motions that were eerily like McKenzie's. Later that year, McKenzie sent off his manuscript to *Nature* — and, when he realized that Morgan was about to publish similar ideas, he asked the journal to delay his own paper in order to give Morgan the credit. *Nature*'s editor, John Maddox, sent a telegram back saying that the issue had already been typeset, so there would be no delay. Who has not skipped an event, only to have that affect their careers for years to come?

But back to the question of anniversaries. Popular interpretations of scientific history are biased towards the single great discovery by a single great person — and they are more easily commemorated in an anniversary. But most discoveries are much more nuanced and communal. Charles Darwin would not have published his ideas of evolution by natural selection when he did, had he not been prompted into it by the similar thoughts of Alfred Russel Wallace. Albert Einstein relied on the work of friends and colleagues to develop his general theory of relativity.

Similar broad revolutions are unfolding today. Despite all the bitterness and infighting over who invented the CRISPR–Cas9 gene-editing technique, the fact remains that a large number of very bright scientists made enormous advances quickly by playing off one another. Just as in the heyday of plate tectonics, one gene-editing breakthrough inspired the next, until biologists were brimming with publications. Historians may one day bicker about which CRISPR paper to celebrate on the 50th anniversary of the technique, but science as a whole is much better off than it was before.

And so, we could celebrate a 1963 publication on the magnetism of the sea floor, or a 1967 paper on the geometry of spherical rotations, or even the entirety of the dawning of plate tectonics. But when was that? Was it in 1912, when Alfred Wegener came up with the idea of continental drift? Or was it decades later, when his ideas were finally transformed into the concept we now know as tectonics? Much of that delay might trace to US researchers viciously opposing his ideas, as historian Naomi Oreskes described in *Plate Tectonics* (Westview Press, 2001). But after the slow start, Earth scientists in the 1960s were quick to embrace the data and theories that redrew almost every aspect of their field.

Such is the nature of discovery — incremental at times, fast-paced at others, occasionally derailing into pettiness. But it does nearly always move in the right direction. In these times of political uncertainty and global unrest, that is an accomplishment worth noting.

Journal name:
Nature
Volume:
550,
Pages:
7
Date published:
(05 October 2017)
DOI:
doi:10.1038/550007a

Comments

Commenting is currently unavailable.

Chinese scientists fix genetic disorder in cloned human embryos

A method for precisely editing genes in human embryos hints at a cure for a blood disease.

02 October 2017

Mauro Fermariello/SPL

Fixing the genetic mutation linked to β-thalassaemia would save affected individuals from having to get life-sustaining blood transfusions.

A team in China has taken a new approach to fixing disease genes in human embryos. The researchers created cloned embryos with a genetic mutation for a potentially fatal blood disorder, and then precisely corrected the DNA to

show how the condition might be prevented at the earliest stages of development.

The report, published on 23 September in *Protein & Cell*[1], is the latest in a series of experiments to edit genes in human embryos. And it employs an impressive series of innovations, scientists say. Rather than replacing entire sections of genes, the team, led by Junjiu Huang at Sun Yat-sen University in Guangzhou, China, tweaked individual DNA letters, or bases, using a precision gene-editing technology developed in the United States[2].

Huang's team is also the first to edit out the mutation responsible for a 'recessive' disease: one caused by having two faulty copies of a gene. Because it would be difficult for researchers to find dozens of embryos that all have this rare double mutation, the team worked around this roadblock by developing embryonic clones from their patient's skin cells.

"I thought, 'Why would they do cloning?' Then I read the paper, and thought, 'Wow, that's fascinating,'" says Shoukhrat Mitalipov, a reproductive-biology specialist at the Oregon Health and Science University in Portland who pioneered human cloning and also works on gene editing in embryos. "I would not have thought to do this."

Scientists around the world have now published eight studies reporting gene editing in human embryos, five in the past two months. None have permitted the embryos to grow beyond 14 days, and the research has had different purposes: some to test gene-editing technologies; others to edit various disease-related genes; and some to unravel the mechanisms behind early embryonic development. Huang's team led the first report, published in April 2015, in which they used the CRISPR–Cas9 enzyme complex to snip chromosomes at specific locations, excise DNA and replace it with other genetic material[3].

Precision editing

In the latest study[1], Huang's team used 'base editing', a modification of CRISPR–Cas9. It guides an enzyme to specific gene sequences, but does not

cut the DNA. Instead, the Cas9 enzyme is disabled and tethered to another enzyme that can swap out individual DNA base pairs. So far, this technique can convert guanine (‘G’) to adenine (‘A’), and cytosine (‘C’) to thymine (‘T’). Hundreds of genetic diseases are caused by single-base changes, or ‘point mutations’, and so editing of this sort at the embryonic stage could potentially stave off such conditions.

Huang’s team chose one mutation common in the Chinese population: a switch from an A to a G at a certain spot in the *HBB* gene, which can lead to β-thalassaemia, a recessive blood disorder associated with severe or fatal anaemia. Researchers generally source embryos from *in vitro* fertilization (IVF) clinics, but it’s rare for these facilities to have embryos with two copies of the same rare mutation. So Huang’s team found a person with the blood disorder, extracted their skin cells and used cloning techniques to develop embryos with the same genetic makeup.

The researchers reported that in 8 of 20 cloned embryos, they were able to convert the errant G back into an A in one or both copies of the gene. (Repairing only one copy might be enough to cure a recessive disease.) That rate is too low for the technique to be considered for clinical use, but the efficiency was high relative to that achieved in other gene-editing studies. “The repair rate is pretty good, and certainly promising,” says Gaetan Burgio, a geneticist at the Australian National University in Canberra. “Our study opens new avenues for therapy of β-thalassaemia and other inherited diseases,” says Huang.

But scientists caution that not all cells in the eight embryos were fixed. Such embryos are ‘mosaic’, meaning that they have a patchwork of cells with different genetic make-ups, which is potentially dangerous. “It looks like solid work, but highlights that the problem of mosaicism remains a challenge for any form of gene editing in the human embryo,” says Dieter Egli, a stem-cell biologist at Columbia University in New York City.

Unintended consequences

Some scientists also question whether Huang’s team looked thoroughly

enough for unintended genetic changes, called off-target effects, that might have been caused by the base-editing procedure, although the authors reported that none were found.

Huang says future experiments will be more comprehensive, but that this first study was a successful proof of principle that the base-editing technique can be used to correct a disease mutation in a human embryo. It may be that conventional CRISPR–Cas9 cannot fix embryos when both copies are faulty, although this isn't yet clear. In August, for instance, Mitalipov's team reported using CRISPR–Cas9 to repair a mutation in a gene that can cause a potentially deadly heart disorder, by using the other, healthy copy of the gene as a template[4].

In the future, Huang says, he plans to ask for oocytes and sperm from donors who have one mutated copy of the gene — and so are unaffected by the condition, but are carriers of the disease — and use these to produce embryos. Some of those embryos would have two mutated copies, and some one, but Huang wants to edit both types. That raises the contentious idea that gene editing might be used not only to prevent severe disease, but also to eliminate the chance of people becoming carriers of the disorder. "Base editing can repair the mutant site and block it from being passed on to the next generation," he says.

Journal name:
    Nature
Volume:
    550,
Pages:
    15–16
Date published:
    (05 October 2017)
DOI:
    doi:10.1038/nature.2017.22694

Comments

Comments

There are currently no comments.

| 章节菜单 | 主菜单 |

Medicine Nobel awarded for work on circadian clocks

Jeffrey Hall, Michael Rosbash and Michael Young unpicked molecular workings of cells' daily rhythms.

02 October 2017

Nora Tam/SCMP

Michael Rosbash (left), Jeffrey Hall (centre) and Michael Young (right) have been recognized for their work on circadian clocks.

Three scientists who studied the workings of organisms' inner circadian clocks have won the 2017 Nobel Prize in Physiology or Medicine. Jeffrey Hall and Michael Rosbash, both at Brandeis University in Waltham, Massachusetts, will split the award of 9 million Swedish kronor (US$1.1

million) with Michael Young at Rockefeller University in New York City.

Beginning in the 1980s, the three researchers isolated and characterized a gene in fruit flies, *period*, that encodes a protein that builds up each night, only to be broken down the following day. In subsequent work, the trio, as well as other scientists, unpicked the molecular regulation of the *period* gene (and the protein that it encodes, called PER) and identified additional components of the circadian clock.

All multicellular organisms possess circadian clocks, and human versions of the genes that comprise their clocks have been implicated in sleeping disorders and other medical conditions.

Rosbash, Hall and Young have been collecting awards together for the past five years. In 2013, for example, they shared the Shaw Prize in life science and medicine, then worth US$1 million. That has set the expectation that a Nobel might be around the corner, says Herman Wijnen, who studies circadian clocks at the University of Southampton, UK and was a postdoc in Young's lab. "This has been one that people have been looking out for," he says. "It's been settled in the scientific community that this is the trio."

But Young says he was so stunned by the news that he could barely get his shoes on the morning he found out. "I'd go and I'd pick up the shoes, and then I'd realize I need the socks," he said during a press conference. "And then I realized I needed to put my pants on first." The award took Rosbash by surprise too, says Thomas Perlmann, secretary of the Nobel Assembly, which selects the prizewinners. "I first got hold of Michael Rosbash, and he was silent," says Perlmann. "And then he said, 'you are kidding me'."

The work has its roots in genetic screens performed by physicist and molecular biologist Seymour Benzer and geneticist Ronald Konopka, who together found fruit-fly mutants with abnormal hatching rhythms. (Benzer died in 2007; Konopka in 2015.) At the time, the idea that behaviour could have a genetic basis was controversial, says Wijnen. Years later, two teams — Young leading one, Hall and Rosbash working together to lead another — would clone the genes responsible. "That really changed the situation," says Wijnen. "Since then, it has become clear how conserved this system is and how conceptually it could work."

The competition between the two teams — each with ambitions to be first to identify the gene — was initially intense, says Charalambos Kyriacou, a behavioural geneticist at the University of Leicester, UK, who worked with Hall in the late 1970s. “As they got older they mellowed,” he says. “They’re all good buddies now.”

Subsequent work detailed how abundance of the PER protein peaks at night and then declines during the day. Researchers gradually pieced together a model in which the accumulation of PER serves as a signal that represses expression of the gene that encodes it. This type of negative feedback loop would become a prevailing theme in the study of circadian rhythms, as researchers identified additional loops and clock proteins over the years.

Joseph Takahashi at the University of Texas Southwestern Medical Center in Dallas and others extended the work from fruit flies to mammals, and showed that the system is remarkably conserved across species. Researchers have since tied the circadian clock to many aspects of mental and physical well-being. “We expose ourselves to inappropriate light, we travel across time zones, we do shift work,” says Wijnen. “And all of that is negatively impacting our health.”

The links between the circadian clock and human health are so pervasive that medical schools should increase their focus on chronobiology, says Martha Merrow, chair of medical psychology at Ludwig Maximilian University of Munich in Germany. This could be either as a speciality in its own right, or incorporated into medical training in other specialities such as endocrinology or rheumatology, she adds. A Nobel prize may give Merrow and her colleagues added force to make that case. Merrow learnt of the news before heading into an administrative meeting. “I was so breathless, I could hardly go into my meeting,” she says. “It’s just a fantastic choice. It will be great for our field.”

Journal name:
Nature
Volume:
550,
Pages:
18

Date published:
(05 October 2017)
DOI:
doi:10.1038/nature.2017.22736

Comments

Commenting is currently unavailable.

Nature News

周二, 17 10月 2017

Nature News

[周二, 17 10月 2017]

- **Nature News**

Nature News

Nature is a weekly international journal publishing the finest peer-reviewed research in all fields of science and technology on the basis of its originality, importance, interdisciplinary interest, timeliness, accessibility, elegance and surprising conclusions. Nature also provides rapid, authoritative, insightful and arresting news and interpretation of topical and coming trends affecting science, scientists and the wider public.

- ## Colliding stars spark rush to solve cosmic mysteries [周一, 16 10月 08:00]
  Stellar collision confirms theoretical predictions about the periodic table.
- ## Eye in the sky offers clearest vision of Earth [周一, 16 10月 08:00]
  The world’s latest carbon-monitoring satellite has advanced our understanding of how the planet functions. US politicians should take note.
- ## Prepare for larger, longer wildfires [周五, 13 10月 08:00]
  Climate change makes land management more urgent than ever, says Kathie Dello.
- ## Global networks of small telescopes will chase companion signals of gravitational waves [周五, 13 10月 08:00]
  Seeing cosmic events is one thing, but what if you could hear them and taste them, too?
- ## Weather-company chief is Trump's pick to lead climate agency [周四, 12 10月 08:00]
  Barry Myers would bring private weather-forecasting experience to the National Oceanic and Atmospheric Administration.
- ## European drug regulation at risk of stalling as agency prepares to leave London [周四, 12 10月 08:00]
  Post-Brexit plans to relocate the European Medicines Agency could trigger severe staff losses, its head has warned.
- ## European Medicines Agency chief raises alarm at forced relocation [周四, 12 10月 08:00]
  Guido Rasi says that ensuring the safety of drugs could be compromised.
- ## FDA advisers back gene therapy for rare form of blindness [周四, 12 10月 08:00]
  Therapy that targets disease-causing mutations could become the first of its kind approved for use in the United States.
- ## Male scientists share more — but only with other men [周四, 12 10月 08:00]
  Evolutionary differences blamed for squeezing out female researchers.
- ## South African researchers bemoan slashed funds [周三, 11 10月 08:00]

Plans to cut funding to a programme that recognizes and rewards excellence in research have met with criticism.

- **[A more personal view of human-gene regulation]** [周三, 11 10月 08:00]
  A long-planned effort to examine gene expression and gene regulation in all the major tissues in the human body across many people comes to fruition.
- **[Marine snow falls heaviest at the Equator]** [周三, 11 10月 08:00]
  Organic matter drifts down to the equatorial ocean floor in distinct patterns.
- **[ResearchGate lawsuit, walrus spat and a Second World War shipwreck]** [周三, 11 10月 08:00]
  The week in science: 6–12 October 2017.
- **[The ambitious effort to document California's changing deserts]** [周三, 11 10月 08:00]
  Ecologists catalogue bird and mammal populations as warming transforms Death Valley.
- **[Gene-expression study raises thorny ethical issues]** [周三, 11 10月 08:00]
  Project obtains tissues from recently deceased individuals to look for the origins of disease.
- **[The rise and fall and rise again of 23andMe]** [周三, 11 10月 08:00]
  How Anne Wojcicki led her company from the brink of failure to scientific pre-eminence.
- **[The future of DNA sequencing]** [周三, 11 10月 08:00]
  Eric D. Green, Edward M. Rubin and Maynard V. Olson speculate on the next forty years of the applications, from policing to data storage.
- **[Physics: A classical toolkit]** [周三, 11 10月 08:00]
  Malcolm Longair extols a long-heralded tome by Roger Blandford and 2017 Nobel laureate Kip Thorne.
- **[Chemistry: Explosive moments in the laboratory]** [周三, 11 10月 08:00]
  Mark Peplow surveys a gorgeous gala of reactions in Theodore Gray's new book.
- **[Books in brief]** [周三, 11 10月 08:00]
  Barbara Kiser reviews five of the week's best science picks.
- **[Cancer care: Tap latent source of frugal cancer ideas]** [周三, 11 10月 08:00]
- **[Natural hazards: Risk assessments face legal scrutiny]** [周三, 11 10月 08:00]
- **[Countries: Avoid glib terms of development status]** [周三, 11 10月 08:00]
- **[Brain modelling: Does the brain control foraging?]** [周三, 11 10月 08:00]
- **[Predatory journals: Research that isn't read doesn't exist]** [周三, 11 10月 08:00]
- **[Runes transcribed from Dig Site 401A in Ladysmith,**

Wisconsin [周三, 11 10月 08:00]

Postcards from the past.

- ## Publishers threaten to remove millions of papers from ResearchGate [周二, 10 10月 08:00]

  Take-down notices “imminent” as lawsuit is filed alleging widespread copyright infringement.
- ## Trump EPA begins push to overturn Obama-era climate regulation [周二, 10 10月 08:00]

  The agency's plan to reverse limits on greenhouse-gas emissions is likely to draw legal challenges.
- ## Climate meetings pose serious test in the Trump era [周二, 10 10月 08:00]

  Annual jamborees fail to ignite public passion but are crucial to progress on global-warming.
- ## Developing nations need more than just money [周二, 10 10月 08:00]

  Grants from big science funders can be hard to use without better administration and mutual understanding, says Rana Dajani.
- ## How the United States plans to trap its biggest stash of nuclear-weapons waste in glass [周二, 10 10月 08:00]

  After decades of delays, a challenging clean-up project is gaining ground.
- ## Cancer-genome study challenges mouse 'avatars' [周一, 09 10月 08:00]

  Grafting human cancer cells into mice alters tumour evolution.
- ## LIGO's unsung heroes [周一, 09 10月 08:00]

  Nature highlights just a few of the people who played a crucial part in the discovery of gravitational waves — but didn’t win the Nobel Prize.
- ## Water-repellent coatings could make de-icing a breeze [周一, 09 10月 08:00]

  Coatings that force ice to grow upwards from the surface could make it easier to remove.
- ## Build on the outer space treaty [周一, 09 10月 08:00]

  Fifty years on, the agreement is being pushed to its limits by changing geopolitics, technology and commercial interests, warns Joan Johnson-Freese.

Colliding stars spark rush to solve cosmic mysteries

Stellar collision confirms theoretical predictions about the periodic table.

16 October 2017

Cosmic furnace

A simulation of the merger of two neutron stars, leading to the formation of a black hole. About 2% of the stars' mass gets ejected at high speed, producing radioactive, heavy atoms.

W. Kastaun/T. Kawamura/B. Giacomazzo/R. Ciolfi/A. Endrizzi

Gold, platinum, uranium and many of the rare-earth elements that are crucial to today's high-tech gadgets are generated during the formation of black holes, astronomers have said. The collision of two small but dense stars simultaneously solved several cosmic mysteries, researchers announced at a press conference in Washington DC on 16 October. More than 30 papers have been published so far in five journals — *Physical Review Letters, Science, Nature, Nature Astronomy* and *Astrophysical Journal Letters.*

Astronomers watched as two neutron stars — small but very dense objects formed after the collapse of stars bigger than the Sun — collided and merged, forming a black hole, in a galaxy 40 million parsecs (130 million light years) away, according to two dozen researchers interviewed by *Nature*'s News team.

The collision generated the strongest and longest-lasting gravitational-wave signal ever seen on Earth. And the visible-light signal generated during the collision closely matches predictions made in recent years by theoretical astrophysicists, who hold that many elements of the periodic table that are heavier than iron are formed as a result of such stellar collisions.

Neutron-star mergers are also thought to trigger previously mysterious short γ-ray bursts, a hypothesis that now also seems to have been confirmed.

Astronomers have good reasons to believe that they are looking at the same source of both the gravitational waves and the short γ-ray bursts, says Cole Miller, an astronomer at the University of Maryland in College Park, who was not involved in the research but who has seen some of the papers ahead of their publication.

Bright object

The event was detected on Earth on 17 August, and triggered weeks of febrile, round-the-clock activity on all 7 continents, as more than 70 teams of researchers scrambled to observe the aftermath.

The collision was felt first as a space-time tremor by the Laser Interferometer Gravitational-wave Observatory (LIGO) in the United States and by its Italy-based counterpart Virgo, and seen seconds afterwards as a smattering of high-energy photons by NASA's Fermi Gamma-ray Space Telescope.

Alerted by the LIGO–Virgo team, astronomers then raced to find and study what was seen as a bright object in the sky using telescopes big and small, famous and obscure, on land and in orbit, and spanning the spectrum of electromagnetic radiation, from radio waves to X-rays.

Cody Messick was at his home at 08:41 local time (12:41 UT) on 17 August when he first found out about the event. "I remember standing on my stairs and looking at my phone, thinking: 'Wow!" he says. Messick, who is a physicist at Pennsylvania State University in University Park, belongs to a small team of LIGO first-responders who receive frequent automated alerts from the two interferometers, which are based in Livingston, Louisiana, and Hanford, Washington. Normally, LIGO's algorithms flag a potential signal in real time only if both interferometers detect it. Messick was surprised, because the message on his smartphone mentioned a strong signal — but one seen only at the Hanford site.

Messick quickly got on a conference call with his team leader, Chad Hanna, also at Pennsylvania State, and other colleagues. Together, they examined the data online. The Hanford signal looked like a textbook example of the waveform of the gravitational waves emitted by two compact objects, each slightly more massive than the Sun, as they spiral into each other, he says. In particular, the waves lasted much longer — about 100 seconds — and had a higher pitch than the signals from the much more massive black-hole mergers that LIGO had previously detected.

When they looked at the data stream coming from Livingston, the LIGO researchers found a similar signal there as well, but one with a loud, spurious glitch towards the end. It was that anomaly that had caused the real-time-analysis software to ignore the signal, says David Shoemaker, a physicist at the Massachusetts Institute of Technology in Cambridge who is LIGO's spokesperson.

Meanwhile, researchers received another alert: Fermi had detected a short γ-ray burst that had occurred 1.7 seconds after the gravitational waves had ended. Called GRB170817A, it was unusually faint for such a burst.

Second signal

In Italy, another technical glitch had suspended the continuous stream of data normally sent out by Virgo. So it took another 40 minutes for researchers to realize that they, too, had a signal — albeit a faint one. It transpired that the waves had travelled close to one of the interferometer's four blind spots, says Jo van den Brand, a physicist at the Vrije Universiteit Amsterdam and spokesperson for the Virgo Collaboration.

By 13:21 UT, 40 minutes after the event, the LIGO–Virgo team had decided to notify its roughly 70 follow-up partners — teams of astronomers on standby to look for related events using conventional telescopes.

Four and a half hours later, the team sent a second, much more useful alert. The timing of Virgo's feeble signal had been sufficient for the LIGO-Virgo team to identify the source of the waves. It pointed to a region of the sky spanning an angle of just a few degrees, in the southern sky. They called the event GW170817, after the date it was detected.

Virgo had joined LIGO's observation campaign only on 1 August, after a five-year shutdown for upgrades. And just three days before the event's detection, on 14 August, LIGO and Virgo had made their first joint detection. It enabled them to rehearse the more precise identification of the patch of sky of interest. The event on 17 August enabled them to narrow it down even further. And the estimated distance was ten times closer to Earth than in the previous events. They could tell this because of how loud and persistent the waves were: it was the strongest signal LIGO had ever sensed. After the fact, Hanna's team was able to extract a signal that lasted a full six minutes.

Together, the alerts from LIGO–Virgo and Fermi sent astronomers into a frenzied rush. Each team wanted to be first to spot the fireworks produced by a neutron-star merger. It was daytime on most of the world's land mass, so teams began to formulate strategies for their nocturnal observations. They knew that, at that time of the year, the region to search was not far from the Sun. That left a window of observation of a couple of hours after dusk, before the region of sky would set below the horizon.

"We had a complicated, choreographed dance of telescopes that night," says Iair Arcavi, an astrophysicist at the University of California, Santa Barbara, whose team made non-stop observations using the Las Cumbres Observatory, a worldwide network of robotic telescopes. It began by activating a number of telescopes in Chile.

Three messengers

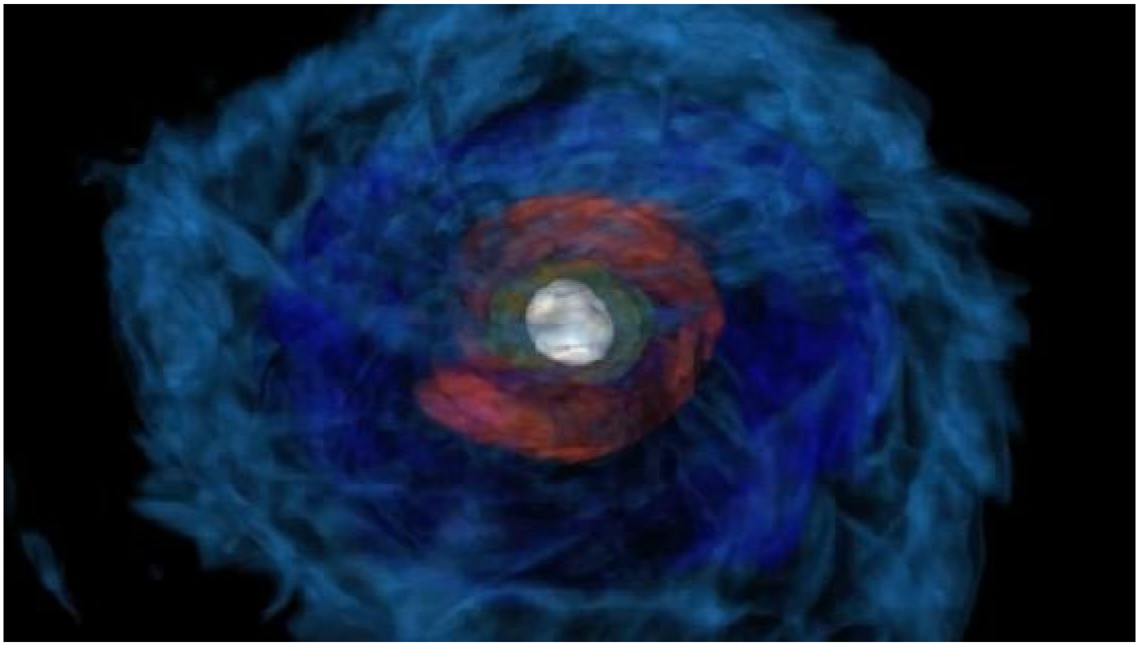
The first person to see the event may have been Charles Kilpatrick, an astronomer at the University of California, Santa Cruz. He was part of a team that was scanning the sky with the more modest means of the single one-metre Swope Telescope in Chile. Like his competitors, Kilpatrick was closely watching the exposures one by one as they came out, comparing them with archival images of the same patch of sky. By the ninth exposure, he saw something very conspicuous in a galaxy called NGC 4993. “It looked exactly like a point source in this image that wasn’t in the reference image,” Kilpatrick says. The team named it SSS17a.

At least two other groups say they spotted the bright dot independently. They and other teams also made sure that there were no other plausible candidates within the search region. GW170817, GRB170817A and SSS17a really seemed to be three different messengers from the same source.

LIGO and Virgo lacked a sufficiently detailed signal of the final instants of the collision to be certain that the objects were neutron stars, Shoemaker says. From gravitational-wave data alone, they could have been two unusually small black holes. But the presence of visible light strongly suggested that at least one of the objects in the merger was a neutron star, he and other researchers say.

The group at the University of California, Santa Cruz, was also the first to measure the optical spectrum of SSS17a. On the first night, the dot was bright blue, says astronomer Ryan Foley, who led that effort. NASA’s Swift telescope also detected blue, as well as ultraviolet, light. But during the next few nights of observation, those colours faded away, and the object became more red, according to multiple teams.

Colliding neutron stars should spread debris — a mix of neutrons, but also some protons — in three ways, says Brian Metzger, a theoretical astrophysicist at Columbia University in New York City. First, they fling matter out from their outer layers during the final orbits. Then some matter gets squeezed out in the actual collision. Finally, as the two stars begin to collapse into a black hole, it forms an accretion disk of matter, some of which flies out instead of falling in.



W. Kastaun/T. Kawamura/B. Giacomazzo/R. Ciolfi/A. Endrizzi

Over the past decade or so, astrophysicists had come to believe that this was the most plausible mechanism to explain the abundance of the heavier elements of the periodic table[1]. The theory held that, overall, about 2% of the combined mass of the stars would escape the fate of the rest. Within one second of the collision, this material would have expanded to become a cloud tens of thousands of kilometres across, but still about as dense as the Sun. In this cauldron, protons and neutrons would immediately clump together to form neutron-heavy nuclei, which would then begin to decay radioactively. This radioactivity would keep the cloud glowing hot for several days, even as it reached the size of the Solar System. Within a million years, it would spread across an entire galaxy.

As predicted

Metzger says that the switch from blue to red was just what he expected to see. His models suggest that nuclei in this early cloud would reach the masses of many of the elements beyond iron, although not the heaviest ones. This chemical composition would cause the cloud to glow blue.

But the real smoking gun for this model, the signatures of the formation of the heaviest elements, would be a cloud that glowed in the red and infrared. These would be elements forged in a separate wave of the explosion, probably the one coming from the accretion disk, says Metzger.

“We had predicted exactly what kind of red,” says Daniel Kasen, a theoretical astrophysicist at the University of California in Berkeley. Jennifer Barnes, another theorist then in Kasen’s team who is now at Columbia University, had run the supercomputer simulations that predicted the experimental signatures in 2013[2]. “I had just finished my PhD thesis predicting what these things would look like,” she says.

Eleonora Troja, an astronomer at NASA Goddard Space Flight Center in Greenbelt, Maryland, was part of one of the first teams to use the Hubble Space Telescope to view the event. “The spectra were phenomenal,” she adds, and almost indistinguishable from the theoretical predictions. “You could clearly see the fingerprints of the metals that had formed.”

But Troja and other observers were also puzzled, because they couldn't find any signal in the X-ray and radio regions of the spectrum. These would be expected during the formation of a black hole, which is thought to shoot jets of out of its poles at close to the speed of light. Nine days later, Troja’s team was the first to find the X-rays.

Alessandra Corsi, an astronomer at Texas Tech University in Lubbock, and her collaborators kept looking for radio emissions using the Very Large Array in New Mexico. Day after day, the dishes recorded nothing. “It turned out we had to wait 16 very long days in order to see the first radio glow,” she says.

The late onset of the radio and X-ray signals, together with the weakness of the initial γ-rays, suggest that the jets were pointed away from the line of sight to Earth. Gamma-ray bursts that happen to be pointed in the right direction can look very bright even from billions of parsecs away.

After a few weeks, most observatories had to stop looking at the object, because that part of the sky had got too close to the Sun. But radio telescopes are still tracking it to this day, Corsi says. More discoveries might yet be made.

“The idea that all this stuff has happened, it’s too much. It is just hard to process,” says Daniel Holz at the University of Chicago in Illinois. “It’s unreasonable that we have done so much with just one event of its kind.”

“All our hopes and dreams have basically come true,” says Jocelyn Read, an astrophysicist at California State University, Fullerton. “All this time we have been saying, look at this amazing thing we are going to be able to see. And it is still hard to believe when it actually happens.”

Journal name:
Nature
DOI:
doi:10.1038/550309a

Comments

2 comments

1. *Pentcho Valev* • 2017-10-16 04:53 PM
   Synopsis of the spacetime story. Here is a schematic presentation of Einstein's initial argument: Postulate 1: The principle of relativity is correct. Postulate 2: The speed of light is independent of the speed of the source (emitter). Conclusion: The speed of light is independent of the speed of the observer. Actually that was a reductio ad absurdum argument - the conclusion was nonsense: John Stachel: "But this seems to be nonsense. How can it happen that the speed of light relative to an observer cannot be increased or decreased if that observer moves towards or away from a light beam? Einstein states that he wrestled with this problem over a lengthy period of time, to the point of despair." http://www.aip.org/history/exhibits/einstein/essay-einstein-relativity.htm The reductio-ad-absurdum procedure should have forced Einstein to abandon the false Postulate 2. Instead, he camouflaged the nonsense by introducing more nonsense now known as "spacetime": Peter Galison: "Only by criticizing the

foundational notions of time and space could one bring the pieces of the theory - that the laws of physics were the same in all constantly moving frames; that light traveled at the same speed regardless of its source - into harmony." https://www.aip.org/history/exhibits/einstein/essay-einsteins-time.htm "Special relativity is based on the observation that the speed of light is always the same, independently of who measures it, or how fast the source of the light is moving with respect to the observer. Einstein demonstrated that as an immediate consequence, space and time can no longer be independent, but should rather be considered a new joint entity called "spacetime." http://community.bowdoin.edu/news/2015/04/professor-baumgarte-describes-100-years-of-gravity/ The false Postulate 2, like a typical malignancy, quickly overwhelmed the body of physics and killed this branch of science: "The speaker Joao Magueijo, is a Reader in Theoretical Physics at Imperial College, London and author of Faster Than the Speed of Light: The Story of a Scientific Speculation. He opened by explaining how Einstein's theory of relativity is the foundation of every other theory in modern physics and that the assumption that the speed of light is constant is the foundation of that theory. Thus a constant speed of light is embedded in all of modern physics and to propose a varying speed of light (VSL) is worse than swearing! It is like proposing a language without vowels." http://www.thegreatdebate.org.uk/VSLRevPrnt.html "...Dr. Magueijo said. "We need to drop a postulate, perhaps the constancy of the speed of light." http://www.nytimes.com/2002/12/31/science/e-and-mc2-equality-it-seems-is-relative.html "But the researchers said they spent a lot of time working on a theory that wouldn't destabilise our understanding of physics. "The whole of physics is predicated on the constancy of the speed of light," Joao Magueijo told Motherboard. "So we had to find ways to change the speed of light without wrecking the whole thing too much." http://www.telegraph.co.uk/technology/2016/12/06/speed-light-discovered/ Joao Magueijo, Faster Than the Speed of Light, p. 250: "Lee [Smolin] and I discussed these paradoxes at great length for many months, starting in January 2001. We would meet in cafés in South Kensington or Holland Park to mull over the problem. THE ROOT OF ALL THE EVIL WAS CLEARLY SPECIAL RELATIVITY. All these paradoxes resulted from well known effects such as length contraction, time dilation, or E=mc^2, all basic predictions of special relativity. And all denied the possibility of establishing a well-defined border, common to all observers, capable of containing new quantum gravitational effects." http://www.amazon.com/Faster-Than-Speed-Light-Speculation/dp/0738205257 Pentcho Valev

2. *Pentcho Valev* • 2017-10-16 03:14 PM

   LIGO and Fermi already tried this particular hoax - optical confirmation of LIGO's "discovery" - but then Integral exposed the fraud: "Integral is sensitive to transient sources of high-energy emission over the whole sky, and thus a team of scientists searched through its data, seeking signs of a sudden burst of hard X-rays or gamma rays that might have been recorded at the same time as the gravitational waves were detected. "We searched through all the available Integral data, but did not find any indication of high-energy emission associated with the LIGO detection," says Volodymyr Savchenko of the François Arago Centre in Paris, France. Volodymyr is the lead author of a paper reporting the results, published today in Astrophysical Journal Letters. [...] Subsequent analysis of the LIGO data has shown that the gravitational waves were produced by a pair of coalescing black holes, each with a mass roughly 30 times that of our Sun, located about 1.3 billion light years away. Scientists do not expect to see any significant emission of light at any wavelength from such events, and thus Integral's null detection is consistent with this scenario. [...] The only exception was the Gamma-Ray Burst Monitor on NASA's Fermi Gamma-Ray Space Telescope, which observed what appears to be a sudden burst of gamma rays about 0.4 seconds after the gravitational waves were detected. The burst lasted about one second and came from a region of the sky that overlaps with the strip identified by LIGO. This detection sparked a bounty of theoretical investigations, proposing possible scenarios in which two merging black holes of stellar mass could indeed have released gamma rays along with the gravitational waves. However, if this gamma-ray flare had had a cosmic origin, either linked to the LIGO gravitational wave source or to any other astrophysical phenomenon in the Universe, it should have been detected by Integral as well. The absence of any such detection by both instruments on Integral suggests that the measurement from Fermi could be unrelated to the gravitational wave detection." http://www.esa.int/Our_Activities/Space_Science/Integral_sets_limi Now Integral is neutralized but still LIGO conspiracy is doomed. Theoreticians know that spacetime doesn't exist (LIGO's "ripples in spacetime" are like the Cheshire cat smile): Nima Arkani-Hamed (06:09): "Almost all of us believe that space-time doesn't really exist, space-time is doomed and has to be replaced by some more primitive building blocks." https://www.youtube.com/watch?v=U47kyV4TMnE Nobel Laureate David Gross observed, "Everyone in string theory is convinced...that spacetime is doomed. But we don't know what it's replaced by." https://www.edge.org/response-detail/26563 What scientific idea is ready for retirement? Steve Giddings: "Spacetime. Physics has always been regarded as playing out on an underlying stage of space and time. Special relativity joined these into spacetime... [...] The apparent need to retire classical spacetime as a fundamental concept is profound..." https://www.edge.org/response-detail/25477 "Splitting Time from Space - New Quantum Theory Topples Einstein's Spacetime. Buzz about a quantum gravity theory that sends space and time back to their Newtonian roots." https://www.scientificamerican.com/article/splitting-time-from-space/ Joao Magueijo, Faster Than the Speed of Light, p. 250: "Lee [Smolin] and I discussed these paradoxes at great length for many months, starting in January 2001. We would meet in cafés in South Kensington or Holland Park to mull over the problem. THE ROOT OF ALL THE EVIL WAS CLEARLY SPECIAL RELATIVITY. All these paradoxes resulted from well known effects such as length contraction, time dilation, or E=mc^2, all basic predictions of special relativity. And all denied the possibility of establishing a well-defined border, common to all observers, capable of containing new quantum gravitational effects."

http://www.amazon.com/Faster-Than-Speed-Light-Speculation/dp/0738205257 "And by making the clock's tick relative - what happens simultaneously for one observer might seem sequential to another - Einstein's theory of special relativity not only destroyed any notion of absolute time but made time equivalent to a dimension in space: the future is already out there waiting for us; we just can't see it until we get there. This view is a logical and metaphysical dead end, says Smolin." http://www.guardian.co.uk/books/2013/jun/10/time-reborn-farewell-reality-review "Was Einstein wrong? At least in his understanding of time, Smolin argues, the great theorist of relativity was dead wrong. What is worse, by firmly enshrining his error in scientific orthodoxy, Einstein trapped his successors in insoluble dilemmas..." https://www.amazon.com/Time-Reborn-Crisis-Physics-Universe-ebook/dp/B00AEGQPFE "[George] Ellis is up against one of the most successful theories in physics: special relativity. It revealed that there's no such thing as objective simultaneity. [...] Rescuing an objective "now" is a daunting task." https://www.newscientist.com/article/mg22730370-600-why-do-we-move-forwards-in-time/ "...says John Norton, a philosopher based at the University of Pittsburgh, Pennsylvania. Norton is hesitant to express it, but his instinct - and the consensus in physics - seems to be that space and time exist on their own. The trouble with this idea, though, is that it doesn't sit well with relativity, which describes space-time as a malleable fabric whose geometry can be changed by the gravity of stars, planets and matter." https://www.newscientist.com/article/mg20026831.500-what-makes-the-universe-tick Perimeter Institute: "Quantum mechanics has one thing, time, which is absolute. But general relativity tells us that space and time are both dynamical so there is a big contradiction there. So the question is, can quantum gravity be formulated in a context where quantum mechanics still has absolute time?" https://www.perimeterinstitute.ca/research/conferences/convergence discussion-questions/what-are-lessons-quantum Pentcho Valev

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http://www.nature.com/doifinder/10.1038/550309a

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Eye in the sky offers clearest vision of Earth

The world’s latest carbon-monitoring satellite has advanced our understanding of how the planet functions. US politicians should take note.

16 October 2017

Bill Ingalls/NASA

Launched in 2014, the OCO-2 satellite has offered unprecedented views of carbon flow on Earth.

When a rocket failure saw NASA’s first carbon-monitoring satellite plunge

into the ocean in 2009, it was a major blow for climate scientists. Space-based greenhouse-gas monitoring was a promising new frontier — and perhaps an eventual tool for monitoring international climate commitments. It took several years to get a replacement into space, but the Orbiting Carbon Observatory-2 (OCO-2) began taking measurements in 2014. The first major scientific results were published last week in *Science*[1–5], and there can be no doubt that the mission is delivering. No doubts, either, that the US government should launch a successor.

The results give an unprecedented insight into one of the most important planetary phenomena: El Niño, the subtle but massively influential gathering of warm waters in the tropical Pacific Ocean. The 2015–16 El Niño was a monster, changing weather patterns and driving the largest and longest coral-reef-bleaching event on record. Through it all, scientists used OCO-2 to watch carbon move through oceans and ecosystems.

The overall trend came as little surprise — a massive increase in global atmospheric carbon levels. Scientists have measured similar rises in carbon dioxide during past El Niños. But the precise mechanism was elusive. OCO-2 helped clarify the matter by producing detailed maps. Researchers saw an initial decrease in the amount of CO_2 coming out of the tropical Pacific Ocean, a dip later swamped by CO_2 originating from Africa, South America and southeast Asia as the event wore on.

Tracking carbon is just the first step. Those data feed into atmospheric models that can provide a more comprehensive explanation for the origin — and destination — of any given CO_2 molecule. Fortunately, sensors on board OCO-2 can assess the amount of photosynthesis using methods other than measuring carbon flux. They detect a photosynthesis-linked signal called solar-induced chlorophyll fluorescence, which gives an independent measure of how much CO_2 plants are taking up.

With this suite of tools, scientists have managed to paint a finer picture of how the 2015–16 El Niño affected individual regions. Heat and drought set the stage for the massive wildfires that ravaged Indonesia during the event, whereas drought-stricken trees in the Amazon rainforest took up less carbon than usual. In Africa, the higher temperatures probably boosted plant

respiration. All three mechanisms for increasing atmospheric CO_2 have been proposed in the past, but it was a surprise to see all play out on different continents simultaneously.

Plenty of questions remain. The satellite measurements are not as precise as scientists would like, and they don't always align perfectly with data from the ground. And getting the models right is a never-ending challenge. It will be some time before satellites are able to provide the precision needed to quantify the natural carbon cycle, let alone to separate out human emissions with enough confidence to verify whether countries are meeting their obligations to cut greenhouse-gas emissions. But OCO-2 is further validation that the effort is worth pursuing.

US politicians should take note. President Donald Trump has proposed scrapping a follow-on mission, OCO-3, presumably because it falls under the rubric of climate — a topic that is anathema to this administration. That would be a self-defeating and damaging move. The bulk of the budget for OCO-3 — which was built from the spare parts of its predecessor — has already been spent; all that's left is the expense of launch and operation. Killing the mission now would waste time and money. But more importantly, as these latest studies show, humanity can learn from the measurements that it will make.

OCO-2 is an affirmation of climate science that everybody should be able to appreciate, regardless of political leanings. Trump might not like talking about climate. But surely his administration — and the lawmakers on Capitol Hill who will decide whether OCO-3 survives — cares about the weather.

El Niño has an impact on weather systems around the world. It raises the likelihood of heavy rainfall from California to the Gulf of Mexico, while increasing the chances of drought and extreme heat in areas farther north. El Niño and its opposite sister system La Niña factor heavily in longer-term seasonal forecasts, which can help governments prepare for fires like those tearing through California at the moment. The more we understand this system, the better we will be at forecasting changes in the weather, the climate — and the economy. A 2014 report from the International Monetary Fund argued that effects of El Niño should be taken into account when

nations plan their finances. This has nothing to do with politics, and everything to do with understanding the world in which we live.

Journal name:
Nature
Volume:
550,
Pages:
301
Date published:
(19 October 2017)
DOI:
doi:10.1038/550301a

Comments

Comments

There are currently no comments.

Prepare for larger, longer wildfires

Climate change makes land management more urgent than ever, says Kathie Dello[1].

13 October 2017

Neighbourhoods burned this week in northern California, with more than 30 people reported dead and 2,000 buildings destroyed. Downtown San Francisco is hazy with smoke from wildfires covering 465 square kilometres, more than 30 kilometres north of the Golden Gate Bridge.

Whatever the proximate cause, these should serve as reminders that climate change is not a future problem, nor a hazard just for tiny island nations. It is a problem now, and our land-management plans need to do a better job of incorporating it.

Scientists must walk a careful line when attributing specific events to climate change. Wildfires are part of a healthy ecosystem and a fact of life in the western United States. Many aspects of a landscape affect them, including past fire suppression, land use and human carelessness.

But climate change increases the threat: fires that do start are larger and last longer. Warmer summer temperatures mean more evaporation. Overall, that means drier forests during the fire season. Ironically, California's past wet winter ended a long drought, but meant that there was more vegetation to become tinder. A 2016 study showed that the fire area attributed to human-

caused climate change has doubled since 1984, largely because vegetation has dried out more. Another 2016 study found that the average area of burnt forest in the northwest United States each year from 2003 to 2012 was almost 5,000% larger than in the years 1972 to 1983, and that the fire season grew from an average of 23 days to 116 days over the same periods. Four other forest areas studied — the Northern Rockies, Southern Rockies, Sierra Nevada and Southwest — also saw increases in both the area burnt and the length of the fire seasons.

Talk about climate change can focus exclusively on avoiding temperature increases in the vague future. The US government's moves to pull out of the Paris climate accord and the home-grown Clean Power Plan are short-sighted, and states' and municipalities' efforts to cut their own emissions are laudable. But it's not enough. We have to manage the effects of climate change that are already here. That means recognizing that threats are increasing.

The cost of fighting US wildfires this year exceeded a staggering US$2 billion, more than half the US Forest Service's budget. The agency has to use funds to fight fires that would otherwise go towards prevention and forest management. It needs more resources so that plans for prevention can become bolder and more expansive.

In fact, the Forest Service is incorporating some climatic adaptation into its regional plans. These include planting seedlings less densely, for instance. But we need many more plans in place, and we need to make sure that goals are met.

What does adaptation mean for wildfires? We have to manage risk even more aggressively than we have done, and incorporate greater uncertainty. We are likely to need an expansion of the areas considered to be at risk. We should avoid building in the urban–wildland interface and mandate the use of materials that are less likely to catch fire. We can boost attempts to thin woody growth and remove brush.

A public-education component is needed as well. At the end of August, a wildfire ravaged the breathtakingly beautiful Columbia River Gorge near Corvallis, Oregon, where I live. It was probably caused by a teenager

throwing a firework off a cliff during one of the hottest summers on record in the Pacific Northwest. Everyone has to realize that the consequences of foolish behaviour or bad luck (many wildfires are started by lightning) are getting worse, so prevention and mitigation are even more important.

Let’s face it — adapting to a changing climate makes the already difficult task of land management even tougher. The aspects we need to manage aren’t isolated — for instance, the burn scars left by the fires will be prone to landslides in the rainy season and dust storms in the summer.

Those living far from fire hazards also need to adapt. The 2014 US National Climate Assessment counts only 15 states with climate-adaptation plans, mainly concerned with flooding and saltwater hazards. The Georgetown Climate Center in Washington DC, which has been tracking progress, says that most states have completed only a few of their goals, many set nearly a decade ago, although work on others is in progress.

The irony is that catastrophes can make for better planning. We should not be afraid to talk about them. Recent events — such as the fires this summer, and the crippling five-year drought that ended in 2015 — motivate us to account for more of these events in the future. Part of my job is talking to policymakers, natural-resource managers and the general public about climate change. Contrary to stereotypes, people in rural areas in the US West are ready to discuss it.

Approaches to climate change that start off in an atmosphere of blame and aggressive policy proposals rarely stick. Instead, discussions about the land that people know provide a common ground that images of lonely polar bears on ice floes do not. There’s always an entry point, and it’s around shared values and solutions. That’s as true in Pocatello, Idaho, as it is in Portland, Oregon.

The wildfires in northern California are horrendous. There is much to mourn. And we can bet that these and other disasters will get worse. Our planning needs to take that into account. We need to protect our livelihoods now, to help ensure better prospects for future generations.

Journal name:

Nature
DOI:
doi:10.1038/nature.2017.22821

Comments

Commenting is currently unavailable.

Global networks of small telescopes will chase companion signals of gravitational waves

Seeing cosmic events is one thing, but what if you could hear them and taste them, too?

13 October 2017

Krzysztof Ulaczyk/University of Warwick

The Gravitational-wave Optical Transient Observer (GOTO) in La Palma, Spain, will look for flares of light coming from the same spot as any gravitational waves.

A cottage industry of small observatories is springing up around the globe to take advantage of astronomers' new ability to capture the gravitational waves from major cosmic events. These new facilities will enable researchers to match up those gravitational waves with electromagnetic signals and perhaps one day even particles of matter from some of the cataclysms that send measurable ripples through space-time.

The main goal is to look for flares of light originating from the same spot as any gravitational waves detected by the US-based Advanced Laser Interferometer Gravitational-Wave Observatory (LIGO), or the Virgo observatory near Pisa, Italy. These smaller telescopes, often built on a shoestring budget, will serve as first-line responders, filling the gap between gravitational-wave detectors and the major facilities of conventional astronomy. “Once you know where to look, you can swing the whole world’s telescopes at it,” says Danny Steeghs, an astronomer at the University of Warwick, UK.

Moving quickly is key. It’s tricky to pinpoint the source of gravitational waves — astronomers can typically narrow it down to a region of the Universe that could contain thousands of galaxies — and observatories may have only a few days before any promising flares of light dissipate. “You need to look at a lot of sky,” says Steeghs, “and you don’t have a lot of time for it.”

Robots of the sky

Steeghs leads a small UK–Australian collaboration that built the Gravitational wave Optical Transient Observer (GOTO) in La Palma, Spain. It is an array of four small robotic telescopes that will eventually grow to 8 telescopes, and perhaps 16. So far, it has cost just £800,000 (around US$1 million).

Alan Watson of the National Autonomous University of Mexico (UNAM) in Mexico City and his collaborators spent even less. They built the Deca-Degree Optical Transient Imager (DDOTI), currently consisting of a pair of robotic telescopes at Sierra San Pedro Martir, Mexico, for a mere

US$350,000, largely by using off-the-shelf components, he says. They plan eventually to have six telescopes, perhaps followed by more facilities in France and Australia.

Some of the facilities, including GOTO, are being designed and built specifically to follow up on gravitational-wave signals. Most of these will be robotic, using machine-learning algorithms to alert each other to point at particular regions of sky and search for interesting flares without the need for human intervention.

Other projects have grown out of existing collaborations that are familiar with looking for visible-light counterparts to the γ-ray bursts spotted by space observatories, or tracking other transient phenomena, such as supernovae explosions or asteroids that are potentially Earth-bound. And some venerable telescopes, including one of those once used by Edwin Hubble in Palomar, California, have been retrofitted. The 1.2-metre telescope is now part of GROWTH (Global Relay of Observatories Watching Transients Happen), a network of 17 facilities around the globe that can track an object seamlessly as the Earth spins. “The idea is, basically, to beat sunrise,” says Mansi Kasliwal, an astronomer at the California Institute of Technology in Pasadena, who is part of GROWTH.

Twan Bekkers

Engineers install a prototype of the BlackGEM telescopes at the South African Astronomical Observatory in Sutherland.

Astrophysicist Paul Groot of Radboud University in Nijmegen, the Netherlands, whose group is part of the Virgo collaboration itself, is leading a Dutch-funded project called BlackGEM. It will initially consist of three telescopes in La Silla, Chile, costing about €6 million (US$7.1 million), that will continuously map the southern sky to build up a database of archived images. If news of a gravitational-wave detection arrives, BlackGEM will scan the relevant patch of sky within hours, and automatically compare that to its archived images to search for anything new.

Neutrino chasers

Similar efforts are already following up on detections of notable particles from space, such as unusually energetic neutrinos or cosmic rays. The

Astrophysical Multimessenger Observatory Network (AMON), started in 2016, got its first interesting hint on 22 September, when it responded to a high-energy neutrino detected by IceCube, the world's largest neutrino observatory, at the South Pole.

When AMON researchers looked towards the source of the neutrino, they saw that a known quasar — an entity consisting of heated matter orbiting a supermassive black hole at the centre of a distant galaxy — was flaring up. This is the type of heightened activity that theorists think could produce an excess of neutrinos, but so far, no high-energy neutrinos have been traced conclusively back to their sources.

In the future, researchers hope that they might detect all three types of emission together: electromagnetic radiation, gravitational waves and particles of matter. Some compare that to seeing, hearing and tasting an astrophysical event at once.

Journal name:
    Nature
DOI:
    doi:10.1038/nature.2017.22828

Comments

Commenting is currently unavailable.

Weather-company chief is Trump's pick to lead climate agency

Barry Myers would bring private weather-forecasting experience to the National Oceanic and Atmospheric Administration.

12 October 2017 Updated:

1. 12 October 2017

Mandel Ngan/AFP/Getty

Barry Myers has been nominated to lead the US National Oceanic and Atmospheric Administration.

Barry Myers, the chief executive of weather-forecasting firm AccuWeather, is US President Donald Trump’s pick to head the National Oceanic and Atmospheric Administration (NOAA), the White House said on 11 October.

Myers, an attorney by training, has led AccuWeather — based in State College, Pennsylvania — since 2007. This experience could prove useful if the US Senate confirms Myers as NOAA’s chief, given that the agency includes the US National Weather Service. But some scientists worry that Myers’s ties to AccuWeather could present conflicts of interest, and note that Myers has no direct experience with the agency’s broader research portfolio, which includes the climate, oceans and fisheries.

“I think the science community has real cause for concern,” says Andrew Rosenberg, head of the Center for Science and Democracy at the Union of Concerned Scientists in Cambridge, Massachusetts.

Rosenberg notes that Myers was an early proponent of carving out a larger role for the private sector in providing weather services. And in 2005, while Myers served as executive vice-president and general counsel, AccuWeather lobbied for legislation to prevent the National Weather Service from competing with private firms in providing products including basic weather forecasting. “Is he going to recuse himself from decisions which might potentially be of interest to his company down the road?” asks Rosenberg.

A different perspective

Myers will probably advance efforts to bring commercial weather data into the national weather-forecasting system, says Bill Gail, chief technology officer for the Global Weather Corporation in Boulder, Colorado. Still, Gail says, Myers respects the importance of the public sector in such activities. “I’ve got a lot of respect for him, and I think he could do a pretty good job,” adds Gail, the co-chair of a decadal survey of US Earth-science satellites being conducted by the National Academies of Sciences, Engineering, and Medicine.

The chief executive's views on climate change are a little harder to parse,

because Myers hasn't taken any strong public positions on global warming. But in a position statement on the Accuweather website, the company says there is "little doubt" that human activities influence the planet's climate. "At the same time, our knowledge of the extent, progress, mechanisms and results of global climate change is still incomplete," the statement says. The company says it encourages its scientists to express their own views, and it publishes a blog featuring posts about climate research.

If Myers ascends to NOAA's top job, he will lead an agency facing an uncertain financial future. Trump has proposed slashing NOAA's budget by 17% in fiscal year 2018, compared to the 2017 level of US$5.7 billion. Although Congress has so far rebuffed Trump's attempts to cut funding for several key science agencies, funding for the 2018 budget year — which began on 1 October — is still up the air. The government is currently running on a stopgap spending bill that will expire on 8 December, prompting another round of budget negotiations.

Ultimately, Myers will need to build a solid team to handle the full NOAA portfolio, says Antonio Busalacchi, president of the University Corporation for Atmospheric Research in Boulder. "He's going to face a lot of challenges, but the bottom line is that Barry does bring a lot of relevant experience to the table."

Whoever ends up leading the agency will have help. On 5 October, the Senate confirmed oceanographer Timothy Gallaudet as assistant secretary of commerce for oceans and atmosphere, the number-two position at NOAA. Gallaudet, a 32-year veteran of the US Navy, has experience ranging from weather and ocean forecasting to developing policies to counter illegal fishing and assessing the national-security implications of global warming, according to the White House.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22311

Updates

Updated:

> This story has been updated with information about Myers' views on climate change and the recently confirmed assistant secretary of commerce for oceans and atmosphere, Timothy Gallaudet.

Comments

Comments

There are currently no comments.

European drug regulation at risk of stalling as agency prepares to leave London

Post-Brexit plans to relocate the European Medicines Agency could trigger severe staff losses, its head has warned.

12 October 2017

Chris Ratcliffe/Bloomberg via Getty Images

The European Medicines Agency in London

Drug regulation in Europe could temporarily freeze if the European Medicines Agency (EMA) loses staff during its post-Brexit move from

London. Up to 70 per cent of its 900 staff have said they would quit if the agency relocated to some of the cities bidding to host the organisation.

According to a battle plan drawn up by agency management, failure to retain enough staff would result in a shutdown of essential operations until more people could be hired. If fewer than 30% of the staff move with the agency to its new destination — to be decided next month — it would cease operation, Guido Rasi, the agency's executive director, told *Nature*.

The EMA, an agency of the European Union, needs to leave London — where it has been headquartered since 1995 — as a result of Brexit. In addition to its permanent staff, the agency hires many other experts on a short-term basis. Following an internal staff survey undertaken in September, the agency urged European heads of state to pick a location to which at least 65% of staff would relocate.

Bids for a home

Some 19 cities across Europe have applied to host the prestigious organization. Last week, the EMA released its own assessment of the applications, and warned that several locations are entirely unsuitable for the agency's location. Proposals for Sofia, Malta and Warsaw met almost none of the requirements put forward by the agency and could result in huge staff losses, Rasi warned. Amsterdam was the most popular alternative to London.

"The best case is, of course, a continuum of our activities, with only about 20% staff loss," he says. "The worst case scenario we have come up with is 94% staff loss. For our business-continuity plan, we found three levels of activities we can delay, put on hold or stop completely."

According to Rasi, the agency's core mission — the regulation and monitoring of innovative drugs across Europe — would be the last thing to stop. But even with 50% staff loss, the agency would have to reduce advisory support to new research projects, which could stall work on innovative medicines, he says (see 'European Medicines Agency chief raises alarm at forced relocation').

The agency assesses all medicines, including veterinary products, to be sold on the European market, and passes on recommendations to the European Commission for authorization. It evaluates reports of adverse reactions and, if necessary, works with national agencies to ban medicines that are suspected of being dangerous. The EMA also has in-house scientists who provide advice to drug developers on which criteria they need to fulfil to get a product passed.

In 2016, the agency recommended 81 new medicines for authorization and answered more than 450 requests for scientific advice.

Medication mediation

The European Federation of Pharmaceutical Industries and Associations, headquartered in Brussels, has called on member states to put the agency's well-being first when choosing a location. "There are many cities that could have the right criteria for the agency to settle," said a spokesman. "There is a potential for disruption, but also a potential for harmony. It all depends on what you choose."

In the United Kingdom, pharmaceutical companies worry about how they will get their medicines approved after Brexit. The BioIndustry Association, a group of British life-sciences companies, has backed a UK government proposal to maintain authorizations for medicines granted before Brexit and the continuation of work with the agency during a transition period.

"The alternative — organizing and delivering a wholesale change — would be a gargantuan task for companies and regulators across the UK and Europe," says Steve Bates, the association's chief executive officer. "It would be extremely challenging to successfully deliver in the short amount of time left until Brexit in March 2019."

Meanwhile, the uncertainty about the agency's future is already causing problems. The agency has been unable to fill a position as head of veterinary medicine; all three potential candidates said that they would wait for the final location to be announced before deciding whether or not to take the job, according to Rasi.

Europe’s heads of state will meet on 18–20 October to begin hammering out an agreement. A decision is due to be announced on 20 November, at the next EU General Affairs Council meeting.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22817

Comments

Comments

There are currently no comments.

European Medicines Agency chief raises alarm at forced relocation

Guido Rasi says that ensuring the safety of drugs could be compromised.

12 October 2017

Finbarr O'Reilly/REUTERS

The European Medicines Agency (EMA), which oversees drug safety in the 28 countries that are members of the European Union, must move out of London because the United Kingdom is leaving the EU. Nineteen cities have bid to host it and a decision on its new home is expected in November. But EMA staff – and its executive director, Guido Rasi – are worried that the move could severely disrupt the agency's functions. On 26 September, the agency revealed an internal staff survey which suggested that more than 70%

of current staff would quit, rather than move country, in the case of eight candidate cities. Rasi says he fears that the EMA – which licenses drugs for use in the EU, monitors adverse reactions to medicines and sets standards – could find itself hobbled by the wrong choice of city. *Nature* talked to him about how this might affect European researchers and public health. The interview has been edited for length and clarity.

What kind of activities would stop first if you lost staff?

Initiatives for the elderly, initiatives for tailoring medicine to male and female patients, engagement with patients, efforts to increase transparency, our communication — all these are for the improvement of our work, but they can be stopped if we need to focus on more essential activities. We must ring-fence the approval process, monitoring and inspections. So the second layer would be to decrease our engagement with scientists. The third layer would be to stop scientific advice and abandon early engagement during the research process.

What is the worst-case scenario?

If we retained less than 30% of our staff, we simply could not operate. We could see the collapse of entire services. For example, think of clinical-trials assessment. If we lose all the statisticians, all the experts, we'll sink. We might maintain some activities that are not so relevant, because we have people there, but might have to cancel core activities because those people are gone. In other words, we cannot replace plumbers with blacksmiths. The best case is, of course, a continuum of our activities, with only about 20% staff loss.

How would this affect the average European?

In the worst-case scenario, there would be no approval of medicines and no management of adverse reactions at the central level. Member states would urgently have to make provisions to approve new medicines and decide what standards they want to see. Many innovative medicines would be delayed or simply not be known, because there are no assessors. Innovation would be available only at the cost of uncertainty. Monitoring would rely on local efficiency, and there would be 28, sorry, 27 different approaches and standards.

And what does it mean for researchers?

We would cease the many activities we are doing to support research and development. For example, we get involved at the EU level to define strategy, such as planning for big EU funding programmes or its Innovative Medicines Initiative. We also provide scientific advice, innovation passports for drugs, protocol assistance and advice around clinical trials. For example, we are working with the commission to reduce the regulatory pool around clinical trials while maintaining the standards. This would stop completely for about two years or so. The impact would be huge, because without staff, we cannot engage with researchers and listen to their needs.

How did you react to the results of the staff survey?

We were surprised by the possible severity of staff loss. This is the worst thing that has happened during my experience here. Now, we feel the imperative responsibility to highlight the consequences of the choice of location. What is at stake now is not where to put the agency; it’s about where you can maintain its activities.

How likely is it that people will leave the agency?

You have to consider that people made a choice to come to London. They competed hard to get here. It’s not their choice to go away. In 14 months, from November 2017 to April 2019, they will have to recast their lives, give up their houses, their mortgages, the plans they had for the future of their children, the jobs of their partners, their cultural lives. These people are the crème de la crème of Europe. It will not be difficult for most of them to find a job elsewhere, and the headhunters are already around.

But wherever the agency goes, can’t you find experts there?

I am sure there are smart people in each country. But to train someone into an expert takes five or six years. It is unlikely that the local environment in any single member state can give us back the knowledge that we are losing.

Would you consider leaving the agency?

You know, the captain is the last to abandon his ship. I will go along with the agency, and I will do whatever will be in my capacity and power to retain as many people as I can.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22818

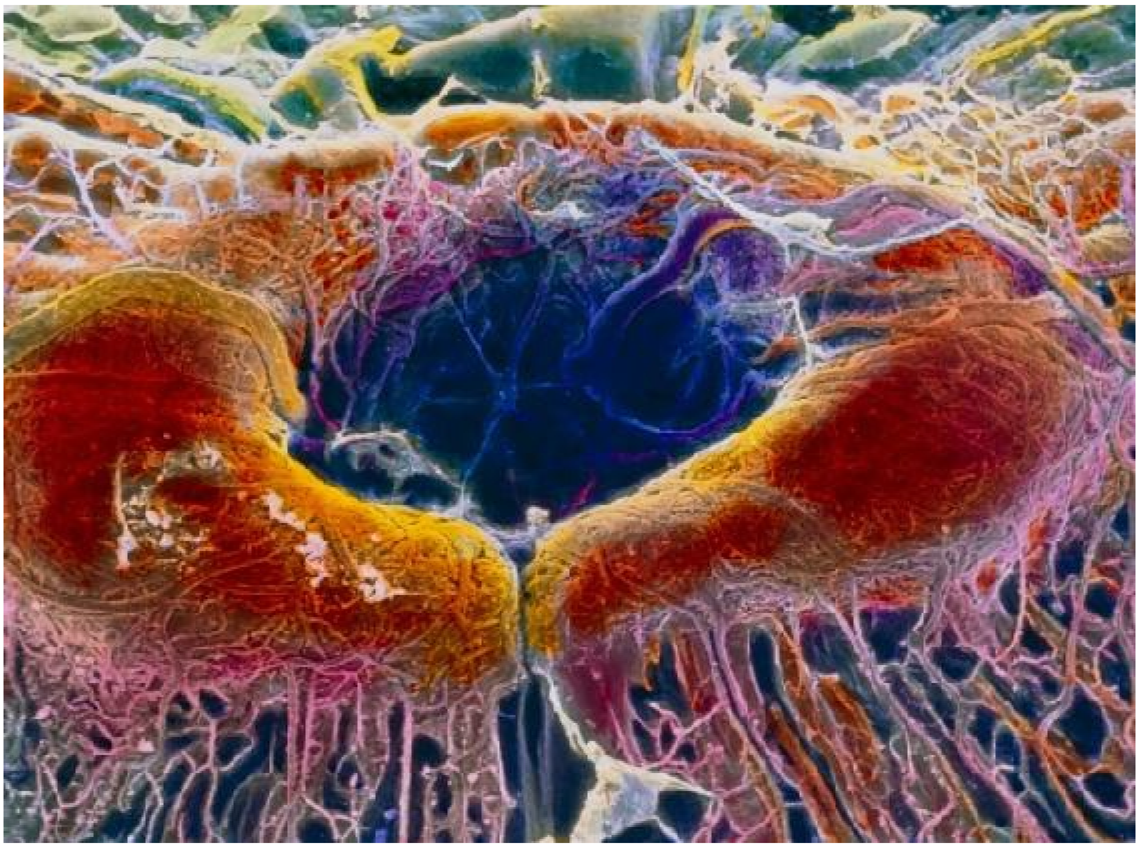
Comments

Commenting is currently unavailable.

FDA advisers back gene therapy for rare form of blindness

Therapy that targets disease-causing mutations could become the first of its kind approved for use in the United States.

12 October 2017



P. Motta/Dept. of Anatomy/University “La Sapienza”, Rome/SPL

The US government is considering whether to approve a gene therapy to prevent the degradation of cells in the retina (shown here in an image from a scanning electron microscope).

Advisers to the US Food and Drug Administration (FDA) have paved the way for the agency's first approval of a gene therapy to treat a disease caused by a genetic mutation.

On 12 October, a panel of external experts unanimously voted that the benefits of the therapy, which treats a form of hereditary blindness, outweigh its risks. The FDA is not required to follow the guidance of its advisers, but it often does. A final decision on the treatment, called voretigene neparvovec (Luxturna), is expected by 12 January.

An approval in the lucrative US drug market would be a validation that gene-therapy researchers have awaited for decades. "It's the first of its kind," says geneticist Mark Kay of Stanford University in California, of the treatment. "Things are beginning to look more promising for gene therapy."

Gene replacement

Luxturna is made by Spark Therapeutics of Philadelphia, Pennsylvania, and is designed to treat individuals who have two mutated copies of a gene called *RPE65*. The mutations impair the eye's ability to respond to light, and ultimately lead to the destruction of photoreceptors in the retina.

The treatment consists of a virus loaded with a normal copy of the *RPE65* gene. The virus is injected into the eye, where the gene is expressed and supplies a normal copy of the RPE65 protein.

In a randomized controlled trial that enrolled 31 people, Spark showed that, on average, patients who received the treatment improved their ability to navigate a special obstacle course[1]. This improvement was sustained for the full year during which the company gathered data. The control group, however, showed no improvement overall. This was enough to convince the FDA advisory committee that the benefits of the therapy outweigh the risks.

Long road

That endorsement is an important vote of confidence for a field that has struggled over the past 20 years. In the early 1990s, gene therapy was red hot, says David Williams, chief scientific officer at Boston Children's Hospital in Massachusetts. "You couldn't keep young people out of the field," he says. "Everyone wanted in." Then came the death of a young patient enrolled in a gene-therapy clinical trial, and the realization that a gene therapy used to treat children with an immune disorder could cause leukaemia.

Investors backed away from gene therapy, and some academics grew scornful of it. Although European regulators approved one such therapy in 2012, for a condition that causes severe pancreatitis, many doubted that it worked. (The company that makes it has announced that it will not renew its licence to market the drug when it expires on 25 October.) "You're too smart to work in this field," a colleague told Kay. "It's a pseudoscience."

But some researchers kept plugging away at the problem, improving the vectors that shuttle genes into human cells. Over time, new clinical trials began to show promise, and pharmaceutical companies became more interested in developing treatments for rare genetic diseases. Gradually, investors returned.

Now, demand for gene-therapy vectors is so high that suppliers are oversubscribed, and researchers have to wait between 18 months and 2 years to get some of the reagents that they need for clinical studies, says Williams.

Measured expectations

In the past few years, gene therapies have shown promise in clinical trials for a range of diseases — including haemophilia, sickle cell disease and an immune disorder called Wiskott–Aldrich syndrome. On 4 October, Williams and his colleagues published results of a gene-therapy trial to treat cerebral adrenoleukodystrophy (ALD), a devastating and sometimes fatal disorder that affects the nervous system and adrenal glands[2]. Disease progression was halted for the roughly 2-year duration of the study in 15 of 17 boys who were treated.

The FDA approved its first gene therapy, a treatment in which immune cells are engineered to combat cancer, on 30 August. Unlike Spark's therapy, the cancer treatment does not target a specific disease-causing mutation, and is administered to immune cells that are removed from the body, engineered and then reinfused.

That is why researchers say that an FDA approval for voretigene neparvovec would be a landmark. "The general concept of gene therapy is replacing or compensating for a missing gene, and that's what this does," says Matthew Porteus, a paediatric haematologist also at Stanford. "People are so excited."

But Spark's treatment also highlights the limitations of this generation of gene therapies. Although the treatment seems to improve vision, it is still unclear how long the virus will continue to express the normal *RPE65* gene — and thus how long its effects will last. "It isn't a cure," says Kay.

Similarly, the cerebral ALD therapy seemed to slow the effects of the disease in the brain, but is not expected to treat symptoms in other parts of the body, which can emerge later in life.

"I think we still need to have major improvements in the technology before we're going to be able to cure these diseases," says Kay. "But along the way there may be treatments that help make improvements."

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22819

Comments

Commenting is currently unavailable.

Male scientists share more — but only with other men

Evolutionary differences blamed for squeezing out female researchers.

12 October 2017

Old Visuals/Everett Coll./Mary Evans Picture Library

Male scientists are more likely to collaborate with other men than with women, says a study.

Male scientists are more likely to share their published work than are women — but only with other men, a study of hundreds of researchers has found.

Humans are generally considered to be a highly cooperative species, says

Jorg Massen, a cognitive biologist at the University of Vienna. But most of the evidence for that assumption comes from artificial situations such as computerized cooperation tasks. “I wanted to test human prosociality in an everyday situation,” he says. So he chose one of the most competitive situations he could think of: his own field of research psychology.

To investigate cooperation among psychologists, Massen turned his fellow researchers into guinea pigs. He and his colleagues e-mailed nearly 300 researchers and asked them to share either a PDF of one of their latest papers, or some raw data (pretending that they wanted to include it in a meta-analysis). The results were published in *Scientific Reports* on 10 October[1]. In general, the scientists contacted were highly cooperative, with almost 80% willing to share a PDF and almost 60% willing to send raw data. “I was surprised,” says Massen. “Humans are prosocial even in this competitive field.”

Even more unexpected, however, was a strong gender difference in how the scientists responded to the request for help. Massen and his colleagues had wondered whether men might respond more favourably to women, or vice versa. In fact, men were more likely to share, but only with other men. A male–male request was 15% more likely to be granted than any other gender combination.

Evolution at work?

Massen and his colleagues say that one possible explanation for their results “may be that among male academics there is a network at play, in which they favor each other much like 'Old Boy' networks”. They also suggest that this imbalance might have evolutionary roots and point to an idea called the male-warrior hypothesis, which states that men have evolved to form strong bonds with other males in their group because in the past this enabled them to defend territory from hostile attackers.

“Men are more ready to cooperate with genetic-stranger males to form these fighting coalitions,” says Mark van Vugt, an evolutionary psychologist at the Free University of Amsterdam who first suggested the theory in 2007[2]. Some

of the evidence for this idea comes from lab-based tasks such as public-goods games (in which volunteers choose how many tokens to keep or share), but there are some real-world hints too, he says. Boys tend to play in larger groups than girls, van Vugt says, and in sports such as tennis and boxing, men make more effort to bond with their opponent after a match or fight than women do. However cultural factors are also thought to be at work.

Massen's results "sit very well" with these previous findings, says van Vugt, who suggests that such gender differences might affect professional situations beyond psychology research. Any roles that involve teaming up with strangers — such as business, politics, law and economics — could end up favouring men, he predicts. "Men are always on the lookout to find coalition partners," he says, whereas women tend to be more cautious about cooperating with strangers. "That's an obstacle to building up the same networks that men have."

Many factors, including cultural ones, contribute to gender bias at work. "It is very clear that in science and many other professions, women are discriminated against," says Massen. "Something needs to change." But he suggests that an increased awareness of differences in cooperation might encourage both men and women — in science and other fields — to look at their own behaviour and consider how they might respond differently. "I hope people read it and think about it," he says.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22820

Comments

Commenting is currently unavailable.

South African researchers bemoan slashed funds

Plans to cut funding to a programme that recognizes and rewards excellence in research have met with criticism.

11 October 2017

Academics in South Africa are in uproar after a government research agency announced plans to cut the budget of a prestigious grant programme that rewards the country's best researchers.

The initiative aims to foster academic excellence by awarding grants to individual researchers who volunteer to be rated, with higher-rated academics attracting more money than lower-rated ones. But the National Research Foundation (NRF) said last week that, in an effort to contain costs, it would cut funds to the programme. Some rated researchers will lose up to 90% of their cash.

The move is "catastrophic", according to George Ellis, a top-rated mathematician at the University of Cape Town who receives funding from the programme. He said it would "leave many of the best researchers in the country high and dry".

South Africa's research and higher education system has long struggled with chronic underfunding, exacerbated in recent years by economic and political turmoil. The budget of the government's science and technology department, the NRF's parent body, has increased slightly over the past few years but decreased in real terms owing to rising inflation. And in August 2016, academics wrote an open letter to the government, warning that the system was on the brink of collapse because of systemic underfunding.

The rating system, introduced in 2008, aims to benchmark South Africa's researchers against those in the rest of the world and improve the country's competitiveness. The number of researchers who have been rated has since more than doubled to 3,689.

South Africa's research system is "subject to the availability of resources, and we are being asked to do more with less", says Gansen Pillay, deputy chief executive of the NRF. "The question was sustainability into the future. It hasn't been terminated, but the funding model has been revised."

The system, known as the Incentive Funding for Rated Researchers programme, has five ratings: A (for international leaders in their field), B (for researchers who are internationally acclaimed), C (for established researchers), P (for young researchers, normally aged under 35, who have received prestigious awards and are expected to become international leaders in their subjects), and Y (for emerging young researcher). Ratings were awarded for a period of five years, and came with cash rewards that researchers were free to spend on research of their choice.

The NRF's plans will cut funding across all rating categories, but top-rated researchers will be hit hardest; Y- and C-rated researchers will see comparatively moderate declines. In 2018, newly A-rated researchers will see their funding decline from up to 100,000 South African rands (£5,500) a year over five years to a one-off payment of 50,000 rands in the first year of their rating. Newly Y-rated emerging researchers will receive 100,000 rands from the NRF over two years, instead of 40,000 rands a year over five years.

From 2019, only P-rated researchers will get an annual sum of 50,000 rands. Those in other categories will receive a one-off payment of 30,000 rands if they retain their rating. If they are newly rated or improve their rating, they will receive a one-off payment of 50,000 rands.

"When you are an A-rated researcher, which means you're world renowned, you should be able to access funding from other sources," says Pillay. However, many of the NRF's largest grants programmes are available only to experienced researchers, he says. "It is incentive funding, not a grant. It was just to acknowledge and affirm excellence."

Ellis says that, in practice, many researchers use the incentive funding to supplement their main research grants, to support students or visitors and to travel for conferences. "In practice, it is a termination of this excellent programme and a huge slap in the face for South Africa's top level scientific researchers."

"The incentive grants funding was good: it encouraged researchers to get themselves rated," says Michael Davies-Coleman, dean of science at the University of the Western Cape. "It will become increasingly difficult to convince colleagues to apply for rating in the future, despite the important contribution which increasing numbers of rated researchers make to a university's national research profile." Cutting incentive cash would also have a major effect on the number of students entering research, he says.

An A-rated researcher who spoke on condition of anonymity says that the NRF "were victims of their own success" because of the growth in the number of rated researchers. "In an environment where the budgets are being reduced in real terms, they're desperate to save a bit of money. But from an academic point of view, it's a bit of a disaster."

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22816

Comments

Comments

There are currently no comments.

A more personal view of human-gene regulation

A long-planned effort to examine gene expression and gene regulation in all the major tissues in the human body across many people comes to fruition.

11 October 2017

Dung Vo Trung/Eurelios/Look at Sciences/SPL

Hundreds of post-mortem tissue samples have been analysed for gene expression.

“The observation of and the search for similarities and differences are the basis of all human knowledge,” Alfred Nobel once said. From external events to spiritual influence, each culture and time has found its own way to explain

how we differ from each other and what we have in common. Today, much biological effort focuses on the similarities and differences between people's DNA, and probing the myriad ways that these can combine, for good or ill, is at the cutting edge of genetics.

This week, geneticists announce the results of one such project. The researchers describe how they have analysed the regulatory code in our genomes. This should help scientists to unpick how genetic variants associated with disease function in different tissues of the body.

The project is called GTEx (genotype-tissue expression) and it catalogues genetic variation and its influence on gene expression in 44 tissues across the human body. The results — published in four papers (see pages 204, 239, 244 and 249) and discussed in an accompanying News and Views article — show how most of these critical regulatory regions are located close to the gene they affect. And they report important differences in gene regulation between tissues and between individuals. These results build on the findings of a pilot study that were announced in 2015.

The project results were a long time coming and were widely anticipated. The GTEx study was first proposed back in 2008. Its goal was to establish a resource database and an associated biobank (holding all major human tissues from 1,000 deceased individuals) that could be used by scientists to study the relationship between genetic variation and gene expression.

That seemed so far beyond technical capabilities at the time that many dismissed the idea as unrealistic. How could that many tissues be sampled from a single donor? How could so many individuals be recruited and be appropriately consented? How could high-quality samples be taken within the required post-mortem interval (different for various tissues)? And would the data even reflect living biology and replicate known findings on gene regulation?

LISTEN

Reporter Shamini Bundell learns about the grieving families contributing to a

huge genetics project.

You may need a more recent browser or to install the latest version of the Adobe Flash Plugin.
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What was not questioned was the scientific need to reach for those goals. Following the Human Genome Project in the early 2000s, the genomics community had continued to establish reference catalogues for human genomes. These characterized genetic variation within and between individuals in populations worldwide, and made it possible to begin to identify functional elements in different cell and tissue types. Geneticists also identified genetic variation associated with a wide range of human diseases, a large proportion of which is found in non-coding regions, suggesting a role for gene regulation.

The GTEx Consortium investigates this link. To do so, project scientists needed a framework to consider ethical, legal and social issues that surround post-mortem donation (as discussed in a News story on page 169). Research on samples from deceased donors is not covered by rules on using humans as experimental subjects, and so does not need consent in the United States, where the project was based. But the GTEx scientists decided to include only samples from people for whom consent had been obtained from next of kin. This is commendable. Presumed consent — a sensible policy for organ donation for transplantation — seems less appropriate for basic research, where the benefits are not as immediate and clear-cut. It is good, too, that some researchers kept in touch with donor families, many of whom have attended project meetings to hear about the ongoing contribution of their loved one to science.

Nearly all donor families have said that they would like some genetic results returned, especially information relevant to treatable diseases. The GTEx study was not designed to do this. Nevertheless, project organizers and other researchers should consider in future studies whether and how they could return results to tissue donors’ families.

Why rely on deceased donors? Previous studies were largely limited to cell lines or blood, but the GTEx project wanted to assess other tissues relevant to

disease, for example the heart and kidneys. Combined with the desire to study materials that are not available from living donors, such as the brain, and the need to sample multiple tissues from the same individual, it was clear that the project would have to find a way to source and quickly sample tissue post-mortem. To identify potential donors, the project made use of a network of existing programmes, such as autopsies carried out soon after death, and organ- and tissue-transplantation registers.

In reaching this point, and by providing an open-access database and tissue biobank that is already being widely used in biomedical research, the GTEx project has provided clear guidelines and procedures that are already informing, and providing the groundwork for, a next generation of studies.

These should include, for example, continued expansion of projects such as GTEx to include larger numbers of donors and sampling across different populations to further our understanding of the impact of genetic variation and regulatory differences. Complementary to these studies are projects such as the proposed Human Cell Atlas, which aims to use single-cell sequencing to better resolve cell types and their relationships.

For now, all biomedical researchers should welcome the wealth of data that continues to be released by the GTEx project, and the insights it provides into the regulatory code of our genomes. It is an important step towards the ultimate and ambitious goal of being able to characterize genetic variation and gene regulation in all cells of the human body.

Journal name:
Nature
Volume:
550,
Pages:
157
Date published:
(12 October 2017)
DOI:
doi:10.1038/550157a

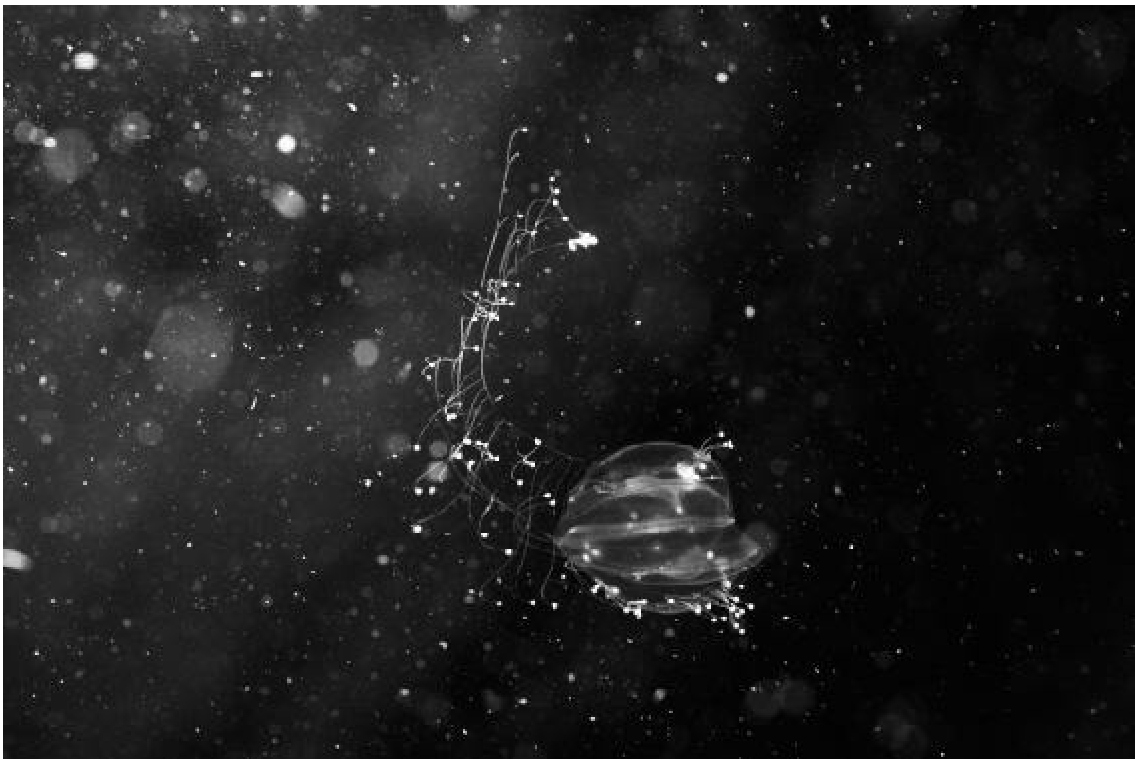
Comments

Commenting is currently unavailable.

Marine snow falls heaviest at the Equator

Organic matter drifts down to the equatorial ocean floor in distinct patterns.

11 October 2017



Flip Nicklin/Minden Pictures/Getty

Scientists have mapped heavy marine snow fall in the equatorial ocean.

According to the Renaissance mathematician Evangelista Torricelli, who discovered atmospheric pressure, “We live submerged at the bottom of an ocean of air.” If the atmosphere is an ocean, then the ocean is also an atmosphere, with its own turbulence and microclimates. And the parallels between these two great fluid environments of our planet go further. When

Japanese scientists took a dive into the ocean in a submersible in 1952 and their lamp revealed a flurry of shining white flakes falling towards the depths, they were going to name it only one thing.

This week, scientists report the most in-depth (and at-depth) analysis of this ‘marine snow’ — in the region that experiences the heaviest falls. For it is more than a mesmeric curiosity. The origins and fate of these oceanic snowflakes — in reality various forms of organic matter ranging from dead plankton to plant and animal detritus — help to determine what happens to carbon in the deep ocean. Carbon that makes it all the way to the depths without being released on its journey is effectively sequestered from the atmosphere for hundreds of years.

Writing in *Nature Geoscience* (R. Kiko *et al. Nature Geosci.* http://doi.org/cdz6; 2017), the scientists describe how they scanned the avalanche of marine snow that makes slow and steady progress towards the depths of the equatorial Atlantic and Pacific oceans. They discovered particularly heavy clouds of the material at depths of between 300 and 600 metres. This is where zooplankton (drifters) and nekton (swimmers) head from the surface during the daytime. The snowy scene, the scientists conclude, is largely made up of the faeces released by these organisms.

The study overturned one common assumption that is included in many models of ocean carbon transport. The researchers found that most of the organic matter that reaches the bottom arrives as a veil of relatively slow-moving small particles, rather than the assumed faster-falling and larger aggregates, which seem to disintegrate steadily as they sink.

The scientists also noted another fascinating effect. Strong and deep equatorial currents stop the snow drifting north or south towards the poles. Instead, it falls as a narrow curtain of flakes drifting down the darkness of the marine sky.

Journal name:
Nature
Volume:
550,
Pages:

158
Date published:
(12 October 2017)
DOI:
doi:10.1038/550158b

Comments

Comments

There are currently no comments.

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ResearchGate lawsuit, walrus spat and a Second World War shipwreck

The week in science: 6–12 October 2017.

11 October 2017

Policy | Awards | Publishing | Universities | People | Events | Space | Trend watch

POLICY

Walrus left off threatened-species list The US government will not list the Pacific walrus (*Odobenus rosmarus divergens*) as a threatened species, despite the dwindling of its Arctic sea-ice habitat, the Fish and Wildlife Service (FWS) announced on 4 October. The decision reverses a 2011 FWS finding that the walrus should be listed. Now, officials say that the population seems to be adapting to the changing environmental conditions. They say that although the walrus's sea-ice habitat may shift, the animal should still be around in the near future, which the FWS defines as the year 2060. The Center for Biological Diversity, based in Tucson, Arizona, filed the original petition to force a decision. It called the announcement "disgraceful".

Mike Korostelev/Biosphoto/FLPA

Drug applications China is overhauling its drug-registration system in a bid to fast-track new medicines to market. The powerful State Council announced rules on 8 October that will allow data from clinical trials in other countries to be used to support drug-approval applications in China. That will make it faster and cheaper for companies to introduce medicines — a boon for multinational pharmaceutical companies hungry for a piece of the Chinese market. After the announcement, shares in China's drug-makers jumped in anticipation of higher profits. The move is the government's latest attempt to clear the way for innovative drugs, reduce the backlog of applications and crack down on fraudulent or otherwise-faulty drug applications. The rules will also help research institutions to conduct clinical trials.

Endocrine row The European Parliament has vetoed draft criteria proposed by the European Commission to identify chemicals known as endocrine disruptors: substances such as bisphenol A that may interfere with hormone systems and cause health problems. Under a 2012 law, the commission had been asked to come up with scientific criteria for defining the chemicals by

the end of 2013 as a step towards restricting the substances. But it failed to do so. Experts from 28 European Union member states finally agreed on criteria in July, but Parliament members rejected them in a 4 October vote. They said that the commission exceeded its mandate in exempting from its definition some chemicals that are designed to attack pests' endocrine systems. The Commission must now draft fresh proposals.

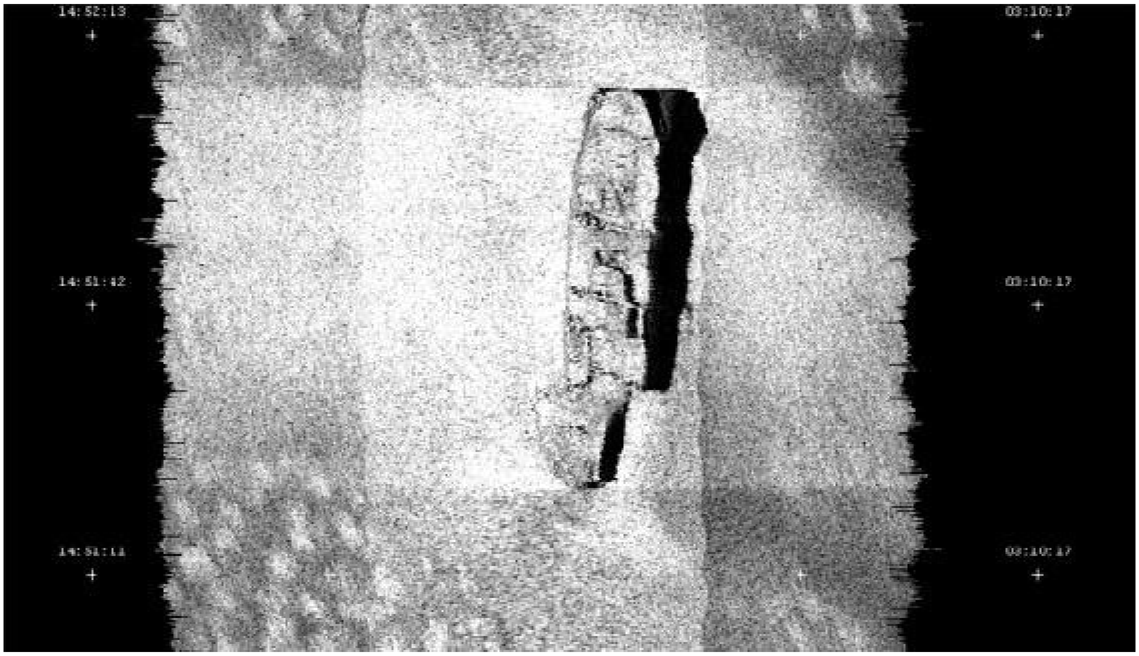
Zika screen On 5 October, the US Food and Drug Administration (FDA) approved a test to detect Zika virus in blood and organ donations. During last year's outbreaks in the US territories of Puerto Rico, the US Virgin Islands and American Samoa, the FDA permitted blood-donation centres to screen blood using the 'cobas' Zika test on an experimental basis, to ensure that people would not be infected through transfusions. The test, manufactured by Roche of Basel, Switzerland, detects Zika virus RNA in blood plasma. The FDA has not yet approved a Zika treatment, vaccine or commercially available diagnostic test.

EVENTS

Climate lawsuit An environmental group is suing the US National Oceanic and Atmospheric Administration (NOAA) to gain access to public records related to the August disbanding of a federal climate-advisory committee. The panel was providing input into the next national climate assessment, a congressionally mandated report on the effects of climate change in the United States, due in 2018. On 18 August, NOAA announced that it would not renew the committee's charter, and on 31 August the Center for Biological Diversity in Tucson, Arizona, asked the agency for documents related to that decision. NOAA failed to respond to that request, and on 3 October the environmental group filed a lawsuit in federal district court, demanding access to the files.

Shipwreck spotted Scientists on board Australia's national deep-water research ship have discovered the wreck of a merchant ship sunk during the Second World War. The wreck of the SS *Macumba* (**pictured**) was found in the Arafura Sea off the coast of the Northern Territory on 4 October during a government-sponsored search by the RV *Investigator*. *Investigator*'s

multibeam sonar located the wreck, which is sitting upright in 40 metres of water. Japanese aircraft sank the *Macumba* on 6 August 1943, killing three crew members.



Marine National Facility, CSIRO

AWARDS

Nobel prizes The 2017 Nobel Prize in Chemistry was awarded on 4 October to Jacques Dubochet, Joachim Frank and Richard Henderson for their development of cryo-electron microscopy, which has transformed the imaging of biomolecules. The Nobel Peace Prize, announced two days later, went to the International Campaign to Abolish Nuclear Weapons in Geneva, Switzerland, for its efforts to achieve a “treaty-based prohibition” of the weapons. The economics prize was awarded on 9 October to Richard Thaler at the University of Chicago, Illinois, in recognition of his work on behavioural economics, which incorporates elements of psychology.

PUBLISHING

Copyright suit Two large scientific publishers, Elsevier and the American Chemical Society, have filed a lawsuit against the scholarly social network ResearchGate to prevent copyrighted material appearing on its site. The publishers are two of five that on 5 October announced they had formed a coalition to start ordering ResearchGate to take down from its site papers that breach copyright. Up to 7 million papers may be affected, the coalition statement said. ResearchGate, based in Berlin, declined to comment on the lawsuit, which was filed in a German court.

UNIVERSITIES

Budapest battle The prestigious Central European University (CEU) in Budapest seems to have dodged a law change that many see as a deliberate attempt to close it down. In April, the Hungarian government sparked mass protests by rushing through a law that requires international universities in the country to also operate as higher-education institutes in their countries of origin. Only the CEU, registered in New York state after being founded in 1991 by Hungarian-born philanthropist George Soros, was seriously affected. The revised law comes into effect on 11 October; the CEU announced on 3 October that it had agreed with Bard College in Annandale-on-Hudson, New York, to provide educational activities in the state.

PEOPLE

WHO leaders Clinical scientist Soumya Swaminathan will be the new deputy director-general for programmes at the World Health Organization (WHO), making the post the most senior in the organization to be held by an Indian national. Swaminathan, a paediatrician and researcher specializing in tuberculosis, is the secretary of India's department of health research and director-general of the Indian Council of Medical Research. Former UK public-health minister Jane Ellison has been appointed as the WHO's deputy director-general for corporate operations. Swaminathan and Ellison are two of 13 new WHO leaders announced by director-general Tedros Adhanom Ghebreyesus on 3 October.

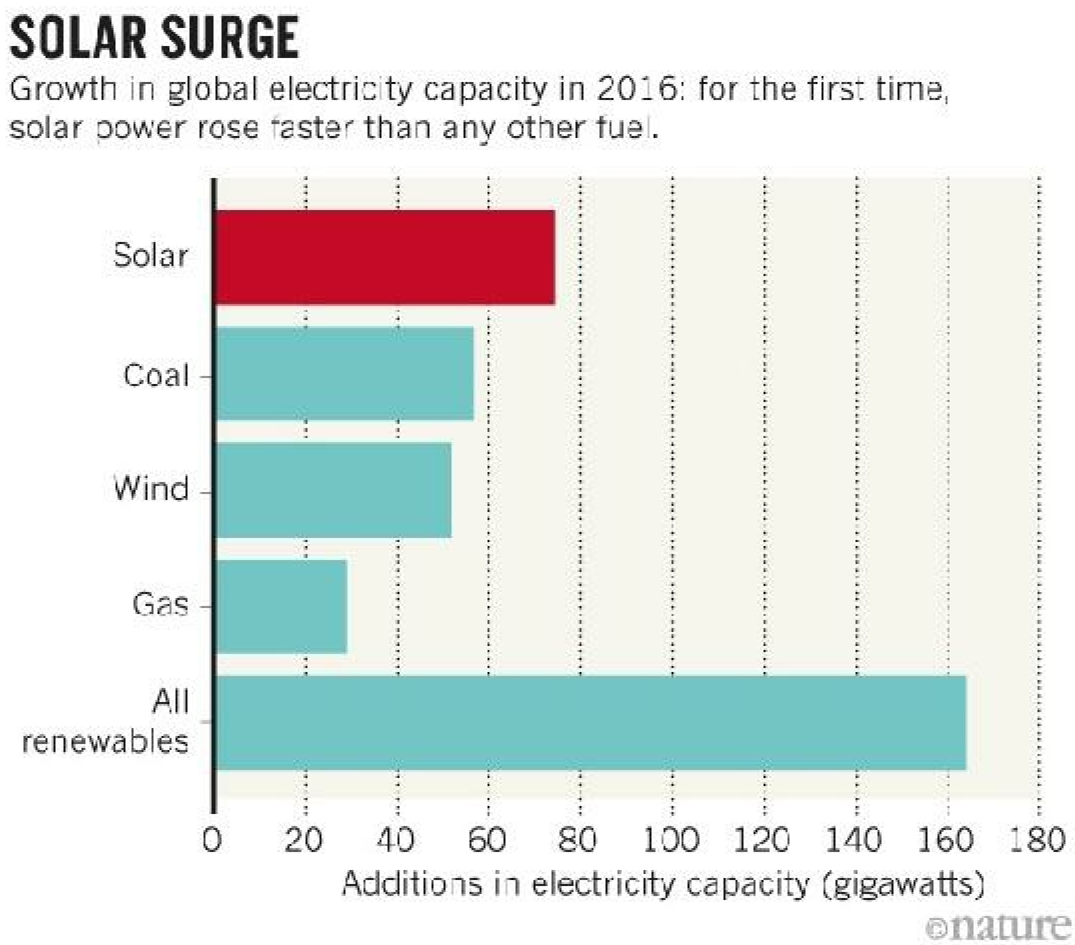
Whistle-blower quits A senior executive who turned whistle-blower at the US Department of the Interior resigned on 4 October, accusing President Donald Trump's administration of advancing fossil-fuel interests ahead of the agency's conservation mission. Joel Clement, who had been at the department for nearly seven years, was director of the office of policy analysis before he was abruptly reassigned to an accounting division in June. Clement has filed a whistle-blower claim against the agency, arguing that his reassignment was in retaliation for speaking out about the threat of climate change to Native Alaskan communities.

SPACE

Plutonium problem NASA's plutonium supply could be threatened if production issues are not addressed soon, according to a report from the US Government Accountability Office (GAO). The space agency uses plutonium-238 to power long-term missions such as some Mars rovers. The review, released on 4 October, found that current stockpiles, along with 100 grams of new ^{238}Pu manufactured by the Department of Energy (DOE), will last NASA until the 2020s. But without fixing one of the two US reactors capable of producing the isotope, the DOE will have trouble producing enough to meet demand. The space agency originally sourced its ^{238}Pu from nuclear-weapons programmes, but the DOE phased them out in the 1980s. NASA began paying the energy agency to manufacture ^{238}Pu in 2011.

TREND WATCH

The solar sector grew faster than any other energy market in 2016, according to the *Renewables 2017* report published on 4 October by the International Energy Agency in Paris. New electricity capacity provided by solar photovoltaics grew by 50% last year — faster than for any other fuel — to more than 74 gigawatts worldwide. China accounted for almost half of this expansion. The surge, driven by government policies and falling costs, opens "a new era for solar power", says the report.



Source: Renewables 2017, IEA

Journal name:
Nature
Volume:
550,
Pages:
162–163
Date published:
(12 October 2017)
DOI:
doi:10.1038/550162a

Comments

1 comment

1. *Phil Sandine* • 2017-10-15 02:35 AM
   In Walrus left off threatened-species list it was reported that The Center for Biological Diversity called the announcement “disgraceful”. However, if the Center had kept up with the information available on walrus population dynamics (see links below), it is reasonable to conclude that they would have recognized that the FWS finding was reasonable (of course they would have had one less reason to ask for donations if they had changed their opinion).
   https://polarbearscience.com/2016/08/02/usgs-report-on-history-of-walrus-haulouts-leaves-out-correlation-with-population-size/
   http://www.thegwpf.org/content/uploads/2014/10/walrus-fuss.pdf

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The ambitious effort to document California’s changing deserts

Ecologists catalogue bird and mammal populations as warming transforms Death Valley.

11 October 2017

Death Valley, California

Jason Ogulnik for Nature

Jim and Carol Patton hunt for kangaroo rats and other desert rodents in Death Valley, California.

Jim Patton brushes a packrat's furry white belly with a vibrant green marker as his wife, Carol, croons over the animal. "We're making you beautiful — punk mice!"

Patton, a retired mammologist, is trapping and releasing desert wildlife as part of an ambitious project to repeat surveys conducted by renowned ecologist Joseph Grinnell from 1908 to 1939. Known as the 'father of field notes', Grinnell criss-crossed California in his Ford Model T to catalogue its birds and mammals. His descriptions are so complete that researchers today can compare the density and distribution of animal populations then and now.

Grinnell's records provide an unparalleled baseline for researchers to explore how urbanization, farming, mining and climate change are reshaping the state's ecosystems. The Grinnell Resurvey Project, run by the University of California, Berkeley, has sought over the past 14 years to capture current conditions, with an eye to quantifying future ecological shifts. The latest phase of the work, which began last month, is focused on cataloguing small mammals in California's rapidly changing deserts.

"The only way to get a sense of what is happening under climate change, and what to expect in the future, is the kind of work going on in the Grinnell research project," says Josh Tewksbury, a sustainability scientist at Future Earth, an environmental-research group in Boulder, Colorado. "It's hard to see how the water boils when you're in the pot."

When Grinnell began his project in the early twentieth century, he was struck by California's varied geography, from snowy mountains to blazing deserts to rocky coasts. Anticipating the state's inevitable transformation as Americans moved west, he documented the distribution of species in about 700 locations. His team deposited more than 100,000 specimens in natural-history museums, including the skull from one of California's last grizzly bears (*Ursos arctos californicus*), as well as 74,000 pages of field notes and 10,000 images.

"The student of the future will have access to the original record of faunal conditions in California," Grinnell wrote in 1910, two years after he became the first director of Berkeley's Museum of Vertebrate Zoology. "This value

will not, however, be realized until the lapse of many years, maybe a century.”

Image Slideshow

1. 

   Jim and Carol Patton have trapped rodents around the world for more than 40 years. They began a new season of fieldwork in Death Valley in September, as part of the Grinnell Resurvey Project.

   Jason Ogulnik for Nature

2. 

Jim Patton marks a rodent so that he can tell if the same animal shows up again in a trap.

Jason Ogulnik for Nature

3. 

Joseph Grinnell, the first director of the Museum of Vertebrate Zoology at the University of California, Berkeley, documented the state's flora and fauna in unparalleled detail from 1908 to 1939.

With permission of the Museum of Vertebrate Zoology, UC Berkeley

4. 

Grinnell and a colleague collected these bushy-tailed woodrats (*Neotoma cinere*a) near Death Valley, but the species is rarely found in the same locations there today.

With permission of the Museum of Vertebrate Zoology, UC Berkeley

In 2003, Grinnell's academic descendants [set out to retrace his survey of Yosemite National Park]. Five years later, they reported that 14 of the 28 mammal species monitored in Yosemite had migrated to higher elevations since Grinnell's time, averaging a gain of 500 metres (C. Moritz *et al. Science* **322,** 261–264; 2008). The animals' climb occurred during a period when winters in the park warmed by about 3 °C. Because Yosemite has been a protected area since 1864, the researchers concluded that land-use changes were not a major factor in the species' shifts.

Steve Beissinger, a conservation biologist at Berkeley and the project's leader, says that recent surveys have yielded less-coherent results. "As we look more broadly across sites in California, we find that responses are much more complicated," he says. "Some species [are] moving to lower elevations in areas that have become rainier, and in some places we see stasis."

But a growing number of studies suggest a dim future for desert dwellers in the coming decades, as they face warmer, drier conditions. Temperatures in Death Valley in July were the hottest for any month anywhere in the world in 2017, averaging 41.9 °C.

Many biologists think that desert organisms are living at the limits of survival — and that cooler regions may be out of reach for slow-moving or short-lived species. Preliminary results from the Grinnell Resurvey Project corroborate this idea. Of the 135 bird species surveyed in the Mojave Desert, only the common raven (*Corvus corax*) has significantly expanded its range since the early twentieth century, Beissinger says. The ranges of 38 other species have contracted.

With permission of the Museum of Vertebrate Zoology, UC Berkeley

Photographs of Vogelsang Lake in Yosemite National Park in 1915 (left) and 2004 show how trees have grown larger as the area has warmed.

A changing landscape

Yet on a cool morning in the Lee Flat area of Death Valley, most of the 160 box traps set out by Patton contain small, furry animals. Within 24 hours, he and Carol mark 90 squirrels, mice and rats belonging to nine species — one more than Grinnell listed in the same area in 1917.

Patton rejects the idea that climate change will soon drive many desert mammals to extinction. Like Grinnell, he is awed by the animals' ability to adapt to extreme conditions. Kangaroo rats (*Dipodomys* sp.) extract water from seeds, and lose little of it because their kidneys concentrate urine to a crystal-like consistency. The rodents' oily coats also prevent water loss through sweat.

Still, Patton sees signs of change. He has not yet captured a bushy-tailed woodrat (*Neotoma cinerea*), prominent in Grinnell's Death Valley accounts. But Patton hesitates to speculate on the species' absence, because reliable data on its distribution come only from Grinnell's time and now. The rat's numbers might have dwindled before desert warming intensified in the 1970s.

Others on the resurvey project are exploring how hotter, drier conditions might harm birds and mammals, by studying species' metabolisms and how much water they lose through evaporation. Ecological modellers can combine these findings with the latest population data to better project how the desert ecosystem might fare as the planet warms.

Ideally, scientists would revisit these forecasts in a few decades using fresh data. But fieldwork of this sort is falling out of favour. Staring at the blue mountains on the horizon, Patton says that he doesn't know who will replace him: very few students today train as naturalists, and museums and national parks are chronically underfunded. "Everyone wants to know how nature is changing and why," he says. "But there's almost nobody doing this kind of work."

Journal name:
Nature
Volume:
550,
Pages:
168–169
Date published:
(12 October 2017)
DOI:
doi:10.1038/550168a

Comments

There are currently no comments.

Gene-expression study raises thorny ethical issues

Project obtains tissues from recently deceased individuals to look for the origins of disease.

11 October 2017

Marc Asnin/Redux/eyevine

Tissues are taken from organ donors after consent has been given by their loved ones.

Sharon Napper was getting ready for school one morning five years ago, when her four-year-old daughter said, “Daddy fell off the bed.” Her husband, Ronald, a retired US Marine who worked as a police officer on an army base, was lying on the floor. He had suffered an aneurysm that spread to the

temporal artery in his head.

At the hospital, the only way to relieve the swelling would have been to open Ronald’s skull, leaving him unable to eat or breathe on his own. “There was a quality-of-life issue. We had discussed this, and so I let everything kind of take its course,” says Napper, who had been planning Ronald’s 50th birthday party the evening before.

The couple had previously discussed Ronald’s desire to be an organ donor, but another request followed: would Napper also donate his tissues for research after he died?

Ronald’s myriad tissues, and those of almost 1,000 other anonymous deceased donors, are now the basis of a first-of-its-kind database. Supported by the US National Institutes of Health, the US$150-million Genotype-Tissue Expression (GTEx) project is amassing data about gene sequences and activity, and other information, across 44 types of tissue, from blood vessels to 10 different brain regions.

“It’s creating a ‘Google Maps’ of the body,” says Kristin Ardlie, a geneticist at the Broad Institute of MIT and Harvard in Cambridge, Massachusetts, who is part of the project’s data-analysis team. It routinely releases new data, which are freely available to qualified researchers. And in this week’s *Nature*, GTEx is publishing its latest and biggest analysis, based on tissue from 449 donors[1–4].

In assembling so much information from such a large number of deceased donors, the project has raised some thorny ethical issues concerning informed consent and scientists’ moral obligations to families who donate the tissues of their loved ones for nothing in return.

The study aims to plug a gap in the search for the genetic origins of disease. Scientists have identified thousands of DNA variants linked to different conditions, but most lie in stretches of the genome that are devoid of protein-coding genes and are, instead, likely to alter the activity of other genes. By relating genes active in different tissues to variations in donors’ genomes, researchers hope that GTEx can join the dots between non-coding variants and gene expression.

When the project was proposed in 2008, many researchers were sceptical that it could succeed, says Manolis Dermitzakis, a human geneticist at the University of Geneva Medical School in Switzerland and an early proponent of GTEx. That is because RNA molecules (a readout of gene activity) start to decompose after a person dies, and no one had ever attempted to measure gene expression in so many different tissues across so many people.

The challenge of amassing that much human tissue wasn't merely technical. Soon after learning of the deaths of their loved ones, the relatives of GTEx donors, such as Sharon Napper, were asked to donate dozens of tissue samples and to consent to the genome, medical history and other data of their loved ones being made widely available to researchers, albeit with most identifying details removed.

"They are being asked to donate to this strange project about which they have never heard anything like it before," says Laura Siminoff, a bioethicist at Temple University in Philadelphia, Pennsylvania, who led a project on GTEx that involved re-contacting donor families to see how they felt about the entire process. Her team found that the stress of suddenly losing a family member had fogged people's memories of what they had consented to. Most recalled that they had agreed to donate their relatives' tissue for research, but often didn't recall much else.

LISTEN

Reporter Shamini Bundell learns about the grieving families contributing to a huge genetics project.

You may need a more recent browser or to install the latest version of the Adobe Flash Plugin.
Go to full podcast

Siminoff suggests that some form of genetic counselling should be made part of the informed-consent process for tissue-donation projects such as GTEx. She also thinks that the project missed an opportunity by seeking tissue donations only from organ donors, because African Americans, Latinos and

other ethnic-minority groups are less likely to register.

Larry Gavan donated his older brother Mark's tissues to GTEx in August 2014, he says, even though he and his family weren't entirely clear how they would be used. Mark, who died of cardiac arrest following a stroke, was born with type 1 diabetes and had lost most of his sight. Gavan says his family saw the donation of Mark's tissues as "an opportunity to make a contribution to future people's lives and be directly related to the diseases my brother suffered from."

Napper, who along with other donor families was part of a GTEx community advisory group, emphasized that altruism motivated her decision to donate her husband's tissues. But Siminoff's research has found[5] that most donor families, including Napper's, want to know the results of tests, such as genome sequencing, conducted on the remains of their loved ones.

The study was not designed to return such findings. But Nicole Lockhart, a programme director at the National Human Genome Research Institute in Bethesda, Maryland, who coordinated the ethical, legal and social aspects of GTEx, says that future tissue-donation studies might consider providing families with medically important results.

"A standing policy of simply 'we will not return results' is becoming less and less common," says Susan Wolf, a lawyer and bioethicist at the University of Minnesota in Minneapolis. Studies such as GTEx should plan to enable families to be identified if researchers discover, for instance, a mutation that dramatically increases the risk of cancer for relatives who inherit it, she says.

GTEx and other tissue-donation studies are likely to offer enormous benefits to scientists and companies (which can also apply for free access to the data), says Siminoff. "We should also think about what we can do for people who are generous and make these kinds of donations that benefit everybody."

Napper, who works as a nurse in cancer and chemotherapy, accepts that her late husband's tissues are now a code in the GTEx database. But, still, she checks the study's website to keep track of new research (191 studies are listed on the project website, and several more appear today in *Nature* and other journals). She sees his participation as an important legacy for their

family, which includes six sons, two daughters and nine grandchildren.

In June, she and other GTEx donor families attended the project's annual meeting in Rockville, Maryland. She met some of the scientists involved, who told her about the research they were doing on tissues such as those from her husband. "To know he's still there is a wonderful thing," she says.

Journal name:
Nature
Volume:
550,
Pages:
169–170
Date published:
(12 October 2017)
DOI:
doi:10.1038/550169a

Comments

1 comment

1. *Manuel Corpas* • 2017-10-12 09:55 AM
   Donating tissues and organs is only the start of the debate of what to do with the remains of deceased relatives. A critical issue still remains undiscussed: what to do with the clinical, genetic and environment data from a person who died? As people get sequenced, their clinical histories made accessible and wearable technology incorporated into clinical care, we need to think about how this data could be used for advancement of research. I am currently exploring this and more with the sequencing of my deceased relative 4.5 years after she passed away: https://personalgenomics.zone/2017/09/01/whole-genome-sequencing-data-from-4-years-deceased-relative-now-in-the-public-domain/

The rise and fall and rise again of 23andMe

How Anne Wojcicki led her company from the brink of failure to scientific pre-eminence.

11 October 2017

Credit: Gabriela Hasbun for *Nature*

There's a placard in Anne Wojcicki's office enshrining the attitude that nearly ran her company, 23andme, aground. Tucked behind a toy unicorn, the small, wood-veneered nameplate reads: “I'm CEO, bitch.”

It was with this kind of brashness that Wojcicki set out to disrupt the health-care industry in 2006. Her goal was to put sophisticated DNA analyses into

the hands of consumers, giving them information about health, disease and ancestry, and allowing the company to sell access to the genetic data to fuel research. But in 2013, that vision hit a snag. Wojcicki didn't think she needed regulatory approval to provide information about her customers' health risks. The US Food and Drug Administration (FDA) disagreed, and ordered the company to stop.

The FDA action prompted months of soul-searching and strategizing on how to reorient the company to work with regulators. “You just accept at some point, you're regulated, and there's no Silicon-Valley, 24-hour, easy fix,” Wojcicki says.

After years of effort, the pay-off came in April this year, when the FDA agreed to allow 23andme to tell consumers their risks of developing ten medical conditions, including Parkinson's disease and late-onset Alzheimer's disease. Surfing a wave of positive news, the company has since launched an advertising blitz to dramatically expand its customer base to 10 million people.

23andme has always been the most visible face of direct-to-consumer genetic testing, and it is more formidable now than ever before. In September, the company announced that it had raised US$250 million: more than the total amount of capital raised by the company since its inception. Investors estimate that it is worth more than $1 billion, making it a 'unicorn' in Silicon Valley parlance — a rare and valuable thing to behold. But for scientists, 23andme's real worth is in its data. With more than 2 million customers, the company hosts by far the largest collection of gene-linked health data anywhere. It has racked up 80 publications, signed more than 20 partnerships with pharmaceutical firms and started a therapeutics division of its own.

“They have quietly become the largest genetic study the world has ever known,” says cardiologist Euan Ashley at Stanford University, California.

But as it matures, 23andme faces new challenges. It must sustain customers' trust, fight off competition and prove that it can use genetic data to make new medicines — a notoriously difficult goal. And 23andme still has a long way to go with the FDA, which won't allow it to tell customers many genetic results directly relevant to human health, such as those for the *BRCA* genes,

which are linked to breast cancer.

Still, Wojcicki is undeterred. “I'm very stubborn,” she says.

In the picture

23andme's headquarters in Mountain View, California, have a start-up vibe that belies the company's 11-year history. Pink and green foil balloons float over cubicles to commemorate employees' work anniversaries. The kitchenette is stocked with healthy snacks. And Polaroid photographs of all employees line the wall of the free cafeteria. Each picture is scrawled with a quirky fact about the person. (“Her favorite drink is green tea,” reads one. “Once won a lip-sync contest singing a New Kids on the Block song,” boasts another.) Arranged by the order in which employees joined the company, the photos make clear where everyone fits in.

The first photo, of course, is of Wojcicki, who grew up on the campus of Stanford University, the child of a teacher and a physics professor. She majored in biology at Yale University in New Haven, Connecticut, where she played ice hockey. (She's still an avid athlete; the bike she rides to work is often parked in 23andme's lobby.)

In 1996, after graduating, Wojcicki worked for investment companies and hedge funds analysing heath-care ventures. She eventually came to dislike how the industry incentivized the development of expensive products and services that earn maximum insurance payments, rather than treatments and devices that consumers can afford to pay for on their own.

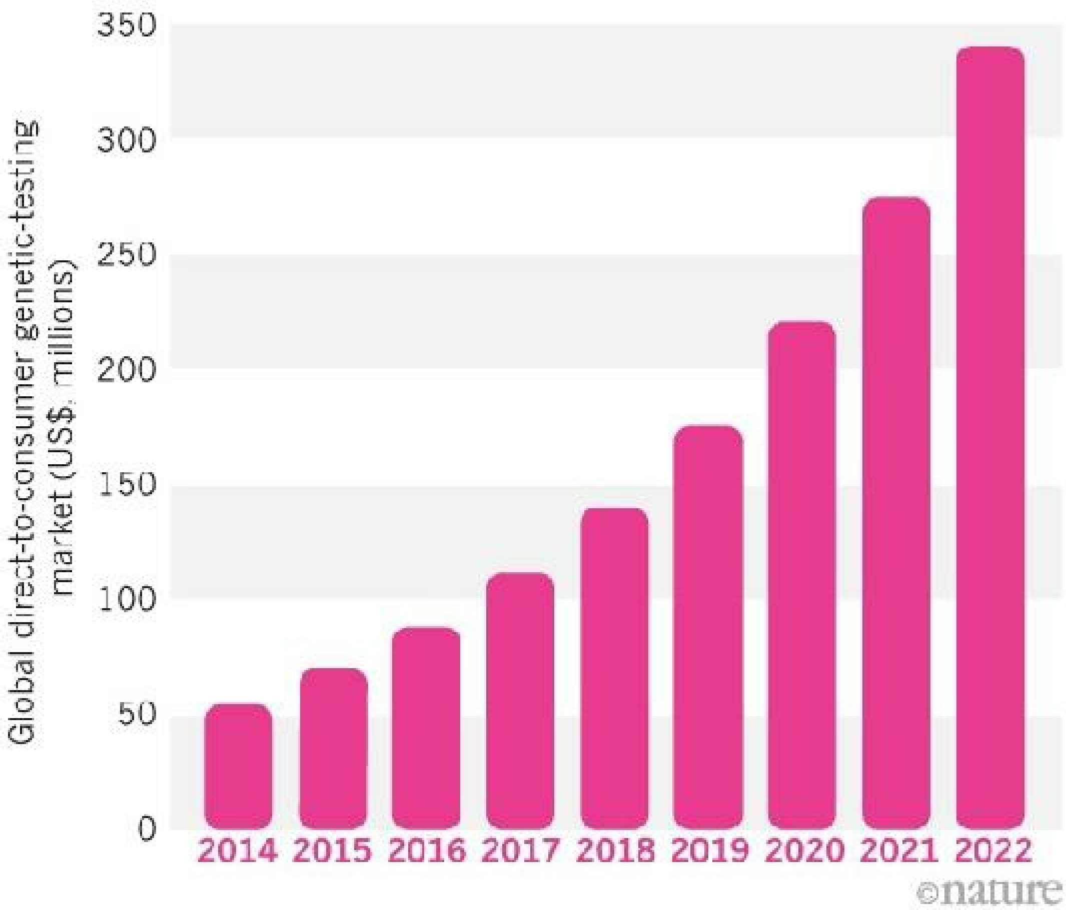
Wojcicki founded 23andme in 2006 with Linda Avey and Paul Cusenza with a goal of upending conventional models of health care. The following year, it received $8.95 million from a number of high-powered investors, including the biotechnology powerhouse Genentech in South San Francisco and Google, whose co-founder Sergey Brin was married to Wojcicki from 2007 to 2015.

Wojcicki aimed to attract millions of customers by selling an inexpensive test that would reveal genetic predispositions for dozens of traits. It would

provide disease risks, but also genetic propensity for baldness, obesity and trivial features such as earwax consistency. Wojcicki wanted to make the genome fun and engaging, the better to attract customers. She hosted celebrity 'spit' parties to get the product in the hands of tastemakers and stir up media interest: after taking one of the company's tests, Ivanka Trump gloated that she had a very low genetic risk of becoming obese. As the tests hit the market in late 2007, Wojcicki and Avey were hailed as visionaries (Cusenza had left in 2007; Avey would depart in 2009).

GENE DRIVE

The direct-to-consumer genetic-testing industry is predicted to grow to US$340 million in the next five years. This is still a small fraction of the overall market for DNA testing, which is expected to reach $10 billion in that time.



Source: Credence Research; Grand View Research

Scientists, meanwhile, were dubious. Family history was and is still a more powerful indicator than genes are for predicting the risk of most diseases. “The evidence is increasingly strong that the benefits of direct-to-consumer testing for these kinds of indications are somewhere between small and zero,” says Stanford University lawyer and ethicist Hank Greely, a long-time critic of the company.

There were also questions about 23andme's plan to sell customer data to help develop medicines. Companies have been trying to mine genetic data to design drugs for at least a decade, with little success. Take deCODE genetics, founded in Reykjavik in 1996, which recruited about half of the adult population of Iceland into a genetic study. Although the company's research has provided insights into the genetic mechanisms of disease, it hasn't yet yielded a drug.

Scientists' scepticism didn't deter hundreds of thousands of customers from signing up to 23andme, nor did it stop investors from ploughing $118 million into the company in its first five years — but a problem was emerging in the background. In 2009, the FDA started asking 23andme for evidence that the company's products worked as advertised and wouldn't harm customers. The agency was worried that people might take drastic medical measures on the basis of their test results, such as deciding to change the dosage of their medications without consulting a doctor or undergoing unnecessary surgery, such as a mastectomy, or treatment based on false positives. Regulators demanded evidence that the tests were accurate, and that customers were well informed what the results meant.

The next years were difficult ones for 23andme. It communicated with the agency on a few occasions and promised in January 2013 that data would be forthcoming. According to the FDA, it then ceased communicating with regulators entirely in May, even as it started a new advertising campaign. Fed up, the agency sent Wojcicki a strongly worded warning letter on 22 November 2013 ordering her company to stop marketing its product.

It was a self-inflicted wound for the company. “There was a bit of arrogance,” says Richard Scheller, who was an executive at Genentech at the

time. As a result, 23andme was forced to drastically cut its customer offerings, threatening its viability.

Wojcicki was stunned. “It became clear that we had pissed them off,” she says. “I really didn't know that we had done so many things that angered them.”

Back on track

Soon after the letter arrived, Wojcicki called Kathy Hibbs, a lawyer then working for Genomic Health, a gene-testing company in nearby Redwood City, California.

“Can I get my whole company back in one year?” Wojcicki asked Hibbs.

“You can get it back, but it will take years,” Hibbs replied. And to get there, she counselled, Wojcicki would have to cooperate with regulators.

It was a tough adjustment for Wojcicki; she didn't think that the FDA should be able to stop customers from learning their own genetic information. But Hibbs and others convinced her that capitulating to the FDA's demands was the fastest way to rescue her company.

“It's almost like being in a relationship,” Wojcicki says. “There's things that you might disagree with, but you just have to do them.” Wojcicki hired Hibbs, who began gathering evidence to respond to the FDA's concerns — a formidable task, because the FDA and the company had tussled over many issues over the years. By the end of 2014, Hibbs felt that the company was ready, so she asked the FDA to approve one test, intended to tell customers whether their children might inherit a genetic risk for a disease called Bloom syndrome.

The FDA approved the test in February 2015. The news didn't make a huge public splash: Bloom syndrome is a very rare disorder, affecting about 1 in 50,000 people with Ashkenazi Jewish heritage. But 23andme was now the first company approved to market a direct-to-consumer genetic test for a disease in the United States, although it had already been offering the test

overseas.

But even after the FDA's decision this April, 23andme is still barred from giving customers lots of available information, such as whether they carry gene variants that raise their risk for certain cancers or that predict how well certain medications will work. Before the FDA lockdown, it had been providing information on hundreds of health conditions.

Greely says that the restrictions make sense: there is very strong evidence that genetic variants cause the ten conditions listed in the FDA's approval in April. But the predictive value is much weaker for the variants linked to the vast majority of common health conditions that 23andme would like to tell its customers about.

Paths of discovery

Even as the company confronted resistance at the FDA, it was making moves into drug development. Key to this plan was bringing Scheller aboard. Wojcicki e-mailed him on the day he announced his retirement from Genentech in December 2014. Four months later, Scheller arrived in Mountain View to start 23andme's therapeutics group; by July, Wojcicki had raised $115 million more from investors.

Scheller was attracted not just by the size of 23andme's database, but by its richness. Customers have each answered an average of 300 questions on a huge array of traits, including their medical histories. That enables Scheller's team to try a different approach for gene-driven drug development.

The standard method has been a genome-wide association study, or GWAS, in which scientists gather people with a disease or trait, and then look for gene variants that seem to contribute to it. Scheller's team can do the reverse. They start with a particular gene that known drugs target, and then look for the diseases or health traits — the phenotypes — that are associated most strongly with different variants in the gene. “We just let the database show us what to work on,” Scheller says.

It's a study design called a phenome-wide association study, or PheWAS —

and Erik Karrer, director of drug discovery, calls it the company's “secret sauce”. 23andme is banking that it will speed drug discovery by allowing scientists to select drug targets that are important in human biology, that can be targeted by drugs and that are less likely to cause side effects.

To see if it works, computational biologist Fah Sathirapongsasuti studied whether 23andme's genetic and health data could predict the success of drugs developed over the past few decades. Sathirapongsasuti surveyed a database of thousands of drug compounds, some of which were approved for sale by regulators.

He compiled a list of all the genes encoding proteins targeted by drugs in this database, and compared it against variations in these genes among 23andme's customers, checking to see what medical conditions they had reported to the company. The process helped to validate the genetic basis for some drugs in humans in a way that mouse studies and other preclinical research often can't. Sathirapongsasuti also found instances in which 23andme customer data correctly predicted side effects of approved drugs.

And the data were able to predict which drugs approved for some conditions might work better for others. Isofagomine tartrate, for instance, was initially intended to treat Gaucher's disease, a rare genetic disorder, but it stalled after a failed clinical trial in 2009. Sathirapongsasuti's data suggest that the drug might also affect the processes underlying Parkinson's disease. The compound has been tested for this condition as well.

Sathirapongsasuti's data suggested that the PheWAS approach could be useful in drug development — and helped to convince 23andme that it should invest in its own drug programme. Using the results of additional phenome-wide association studies, Scheller and his team have now decided to focus on seven drug targets in four categories of disease: cancer, cardiovascular disease, skin disease and immune disorders, such as asthma.

Most scientists no longer see 23andme as a frivolous undertaking. The ability to recruit two million customers, and potentially many more, has been a huge draw, and researchers are lining up to collaborate with the company. Other major biobanks can boast no more than half a million people in their ranks. “They have the power of '*N*',” says cardiologist Eric Topol, director of the

Scripps Translational Science Institute in La Jolla, California.

In October, the US National Institutes of Health awarded the company a $1.7-million grant to sequence the genomes of hundreds of thousands of its African American customers who had already bought the company's standard product, which provides an overview of the genome rather than an in-depth analysis. The project — one of several sequencing initiatives that the company has started — is intended to help rectify the paucity of sequencing data on racial and ethnic minorities.

It's still an adjustment for scientists to work with 23andme data, because the company asks its collaborators to follow unusual rules. Its agreement with customers forbids it from sharing their actual data with collaborators, so scientists see only the results of analyses run by the company and never have access to the raw data that inform the studies.

And some scientists are uneasy about the self-reported data resulting from 23andme questionnaires. Neurogeneticist Ashley Winslow, for instance, who led a high-profile collaboration with Pfizer to identify genetic markers associated with depression, says that peer reviewers of the resulting paper were concerned about the veracity of 23andme's customer data. They argued that people who said that they had been diagnosed with clinical depression might just have been feeling low on the day that they took the company's survey. Winslow's team ran internal studies on the validity of the data, such as analyses showing the percentage of people who also reported using selective serotonin re-uptake inhibitors. The analyses were sufficient to get the paper published, but such concerns will probably come up again.

“Some communities might still be more dubious and demand more from the data to prove its relevance,” says Winslow, who is now at the University of Pennsylvania in Philadelphia. But, she adds, the results of a large study such as hers, which has since been validated by another large psychiatric genetics consortium, are encouraging more scientists to work with the company. “There is definitely an openness that didn't used to exist,” Winslow says.

But that doesn't mean that 23andme's model will definitely lead to new drugs. Several high-profile drugs based on human-genetics research have failed to live up to their potential, or have failed entirely. In May, for instance,

pharmaceutical company Amgen, based in Thousand Oaks, California, announced that its genetically targeted osteoporosis drug romosozumab raised the risk of heart disease by as much as 30% in a clinical trial with 4,000 people. “The idea of developing drugs as a result of genetics isn't as straightforward as many of us would like,” Topol says.

The direct-to-consumer genetic testing market has been transformed since 23andme's early years. And although it is a small slice of the gene-testing market, it is expected to grow to $340 million in the next five years (see 'Gene drive').

And a growing crop of genetic-analysis companies are now competing for 23andme's customers. They include firms offering inexpensive, targeted medical sequencing (Color Genomics in Burlingame, California); ancestry testing (Ancestry DNA, based in Salt Lake City, Utah); whole-genome sequencing, either on its own (Veritas, based in Danvers, Massachusetts) or in combination with medical testing (Craig Venter's Human Longevity in San Diego, California) or with apps for interpreting genomic data (Helix of San Carlos, California).

Wojcicki's competitors give her credit for showing that there may be a business in gathering and selling genetic data. “I'm a big admirer of 23andme and what they've done for the entire industry in pioneering both consumer genetics and this difficult regulatory road,” says Mirza Cifric, chief executive of Veritas. 23andme is still the only company offering FDA-approved direct-to-consumer health tests and no competitors have indicated a willingness to go down that path.

Wojcicki, for her part, still wants to stay ahead. “There's all kinds of ways we want to approach genetics,” she says. For instance, 23andme is watching closely as technology companies such as Apple and Google develop sensors and mobile health-data applications, and the company is looking for pilot projects in this space, which could allow it to seamlessly collect continuous data from its users. And she has no doubt that the company will achieve her goal of recruiting 10 million customers. “Just based on natural growth we'll get there,” she says.

In the 23andme company cafeteria, the fun fact on Wojcicki's Polaroid

picture seems at once trivial and telling: “I once ate so many carrots that I turned orange and was told not to eat carrots for a year.”

Wojcicki's colour has come back. She took the advice. But whether her resolve and ability to correct course can also push 23andme from earwax and ancestry to life-saving drugs remains an open question. If she has her way, it's her doubters who will one day become the real unicorns of Silicon Valley — so rare and shy, you'd hardly believe they exist.

Journal name:
Nature
Volume:
550,
Pages:
174–177
Date published:
(12 October 2017)
DOI:
doi:10.1038/550174a

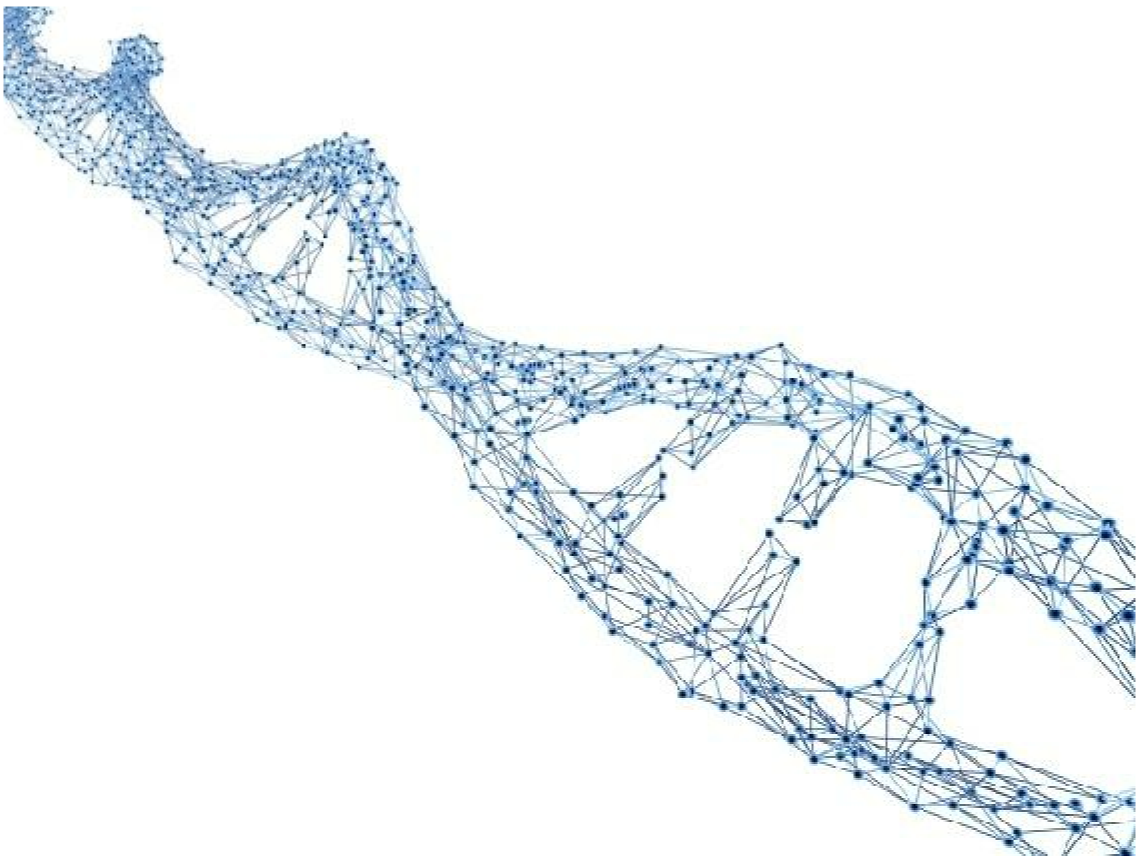
Comments

Commenting is currently unavailable.

The future of DNA sequencing

11 October 2017

Eric D. Green, Edward M. Rubin and Maynard V. Olson speculate on the next forty years of the applications, from policing to data storage.



Alfred Pasieka/SPL

Researchers have an insatiable appetite for DNA-sequence data.

Forty years ago, two papers[1, 2] described the first tractable methods for determining the order of the chemical bases in stretches of DNA. Before these 1977 publications, molecular biologists had been able to sequence only

snippets.

The evolution of DNA sequencing from these nascent protocols to today's high-throughput technologies has occurred at a breathtaking pace[3]. Nearly 30 years of exponential growth in data generation have given way, in the past decade, to super-exponential growth. And the resultant data have spawned transformative applications in basic biology and beyond — from archaeology and criminal investigation to prenatal diagnostics.

What will the next 40 years bring?

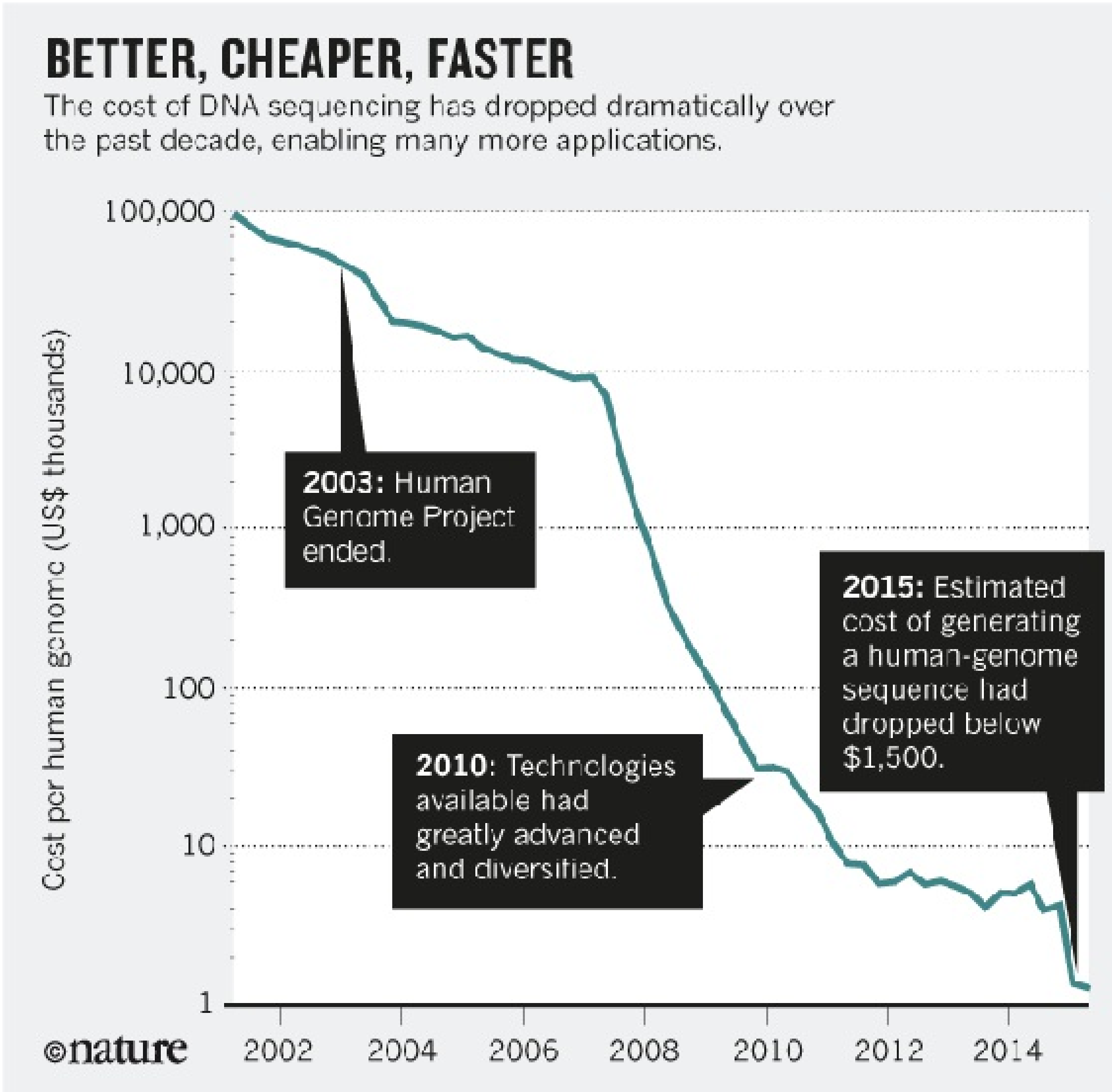
Prognosticators are typically wrong about which technologies — or, more importantly, which applications — will be the most disruptive. In the early days of the Internet, few predicted that e-mail that would achieve staggering popularity. Similarly, traders on Wall Street and investors in Silicon Valley failed to foresee that games, online video streaming and social media would come to dominate the use of today's available processing power and network bandwidth.

We would probably fare no better in predicting the future of DNA sequencing. So instead, we offer a framework for thinking about it. Our central message is that trends in DNA sequencing will be driven by killer applications, not by killer technologies.

In demand

Improvements in a technology can either increase or decrease demand. Microsoft co-founder Bill Gates famously cited radial tyres as an example of the latter: because they were more durable than earlier designs, the need for tyres dropped and the tyre industry shrank.

We think that DNA sequencing will follow the pattern of computing and photography, not of tyres. As it becomes cheaper and more convenient, applications will proliferate, and demand will rise (see 'Better, cheaper, faster'). As DNA sequencing breaks out of the research market and into clinical, consumer and other domains, the rule of 'more supply means more demand' will hold ever more strongly.



SOURCE: National Human genome research Institute

Researchers have an insatiable appetite for DNA-sequence data. In the 1990s, the idea of sequencing a human genome seemed daunting. Now, geneticists would like to have DNA sequences for everyone on Earth, and from every cell in every tissue at every developmental stage (including epigenetic modifications), in health and in disease. They would also like to get comprehensive gene-expression patterns by sequencing the complementary DNA copies of messenger RNA molecules. Meanwhile, archaeologists are beginning to reconstruct the flow of genes through ancestral populations, just as they previously deduced the flow of languages, cultural practices and

material objects. And taxonomists, ecologists, microbiologists and evolutionary biologists are seeking to analyse the genomes of all living (and extinct) species — and even whole ecosystems.

Obviously, a sustained demand for data would require that the vast cataloguing efforts proffer actual understanding. At present, the bottleneck is analysing and interpreting all the DNA-sequence data. But just as new informatics approaches and massive data sets have dramatically improved language translation and image recognition, we predict that massive DNA-sequence data sets coupled with phenotypic information will enable researchers to deduce the biological functions encoded within genome sequences.

LISTEN

Reporter Anand Jagatia speaks with Eric Green about the past and future of DNA sequencing.

You may need a more recent browser or to install the latest version of the Adobe Flash Plugin.
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What's more, much of the basic science needed to interpret the data is already in place for a growing repertoire of practical applications (such as high-quality reference sequences of bacterial genomes, or the rules by which certain gene networks operate in healthy people). These range from recognizing microbial DNA sequences in unbiased surveys of environmental or clinical samples to identifying genome changes associated with known biological consequences.

Killer applications

Over the years, the platforms for DNA sequencing have changed dramatically (see 'Many ways to sequence DNA'). Yet the trajectories of other technologies for which there is a seemingly insatiable demand —

smartphones, the Internet, digital photography — suggest that the real disrupters will be the resulting applications, not the new technologies.

Many ways to sequence DNA

Over the past 40 years, the platforms for DNA sequencing have repeatedly been replaced.

By 1985, almost all DNA sequencing was performed with the Sanger or dideoxy chain-termination method[2]; reaction products were labelled with radionucleotides, separated on acrylamide slab gels, and detected with autoradiography (the use of X-ray or photographic film to detect radioactively labelled samples). By 2000, the four-colour-fluorescence method reigned supreme; reaction products were labelled with chain-terminating nucleotide analogues, separated electrophoretically in capillaries filled with a jelly-like media, and detected with energy-transfer fluorescent dyes. By 2010, the techniques had diversified. The dominant instruments were based on massively parallel analyses of DNA 'polonies' (clonal amplifications of a single DNA molecule) and on sequencing-by-synthesis chemistries (these rely on reversible chain-terminators).

From now on, the requirements for each DNA-sequencing platform will depend on what it is to be used for. In oncology and medical genetics, the goal will often be to identify every base correctly and to define every variant of genomic segments that exist in multiple copies. By contrast, when a yes or no 'match' is required — for instance, in species identification — the ability to run tests quickly and easily in the field may be more important than accuracy.

Another factor that will probably change is the relative need for centralized versus decentralized DNA sequencing. An epidemiologist trying to assess in real time what virus has affected a particular village in Sierra Leone might need cheap, portable devices. But for those generating massive data sets, it might be more efficient and cost effective to ship samples to centralized commercial operations, especially when the laboratories are required to meet exacting standards for quality control and sample tracking, as in clinical

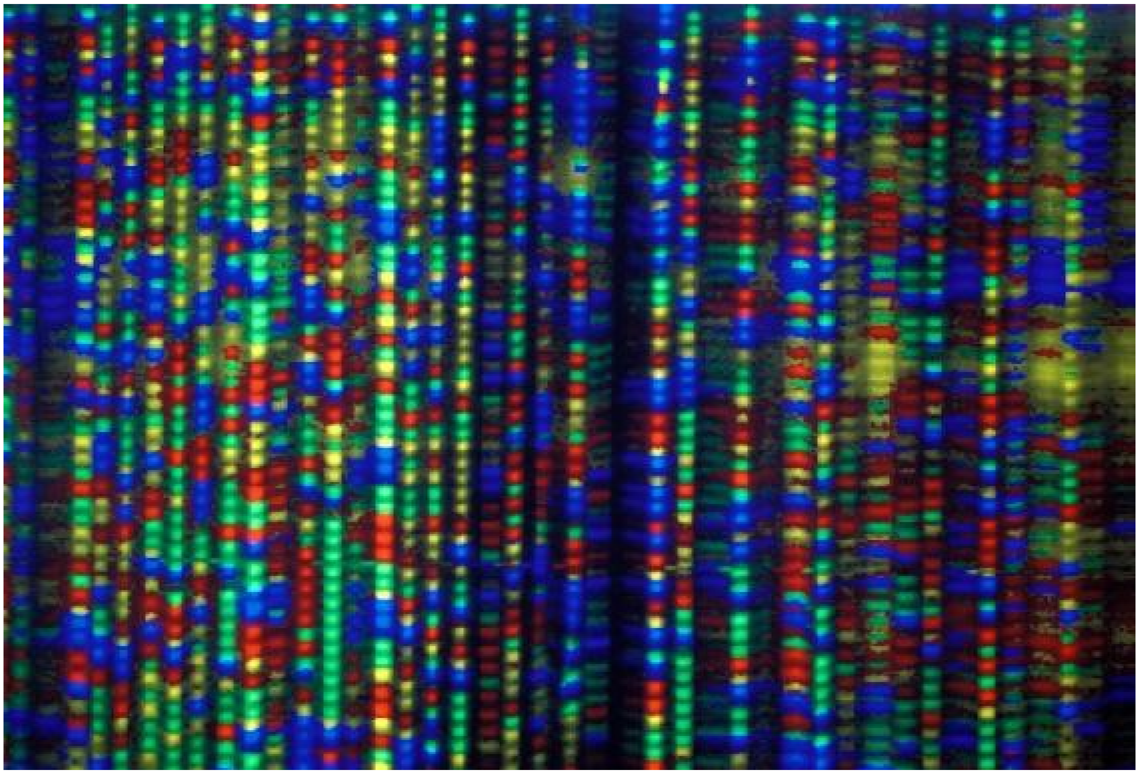
applications.

One domain where we are confident that DNA sequencing will be truly transformative is medicine.

Today's 'breakout' clinical application of DNA sequencing — in terms of the sheer number of tests conducted — is prenatal testing for the presence of an abnormal number of chromosomes, such as trisomy 21, which causes Down's syndrome. This test now relies on detecting the small amount of cell-free fetal DNA that circulates in maternal blood. Not even imagined at the end of the Human Genome Project, it has been described as “the fastest growing genetic test in medical history”[4]. In fact, experts in the field estimate that some 4 million to 6 million pregnant women are now receiving this test each year worldwide, and that the number will surpass 15 million within a decade (D. Bianchi, D. Lo and D. Zhou, personal communication). Some of the hallmarks of the test seem likely to characterize many future applications of DNA sequencing in primary care: it is non-invasive, easy to perform and has low requirements for nucleotide-level accuracy (chromosomes can be counted without assessing sequence variation).

In high-income countries, genome sequencing is already used routinely to evaluate children with ill-defined congenital conditions. Analyses of the resulting sequences can reveal the disease-causing mutations in around 30% of such cases[5, 6] — a figure that will only rise as the ability to interpret the data matures. In some instances, the resulting diagnoses have led to dramatic improvements in clinical management7,8. More typically, they benefit both families and physicians by ending a diagnostic odyssey and providing clinical clarity.

In oncology, considerable investments are being poured into the development of liquid biopsies[9]. It is easy to imagine such a sequence-based cancer test becoming a routine screening tool, used much like Pap smears and colonoscopies. With the advent of cancer treatments that target specific mutations, rather than tumour types[10], liquid biopsies could ultimately guide therapeutic interventions even when tumours are known to exist only from DNA-sequence signatures present in blood samples.



Karen Kasmauski/NGC

Coloured DNA bands.

Various applications can be envisioned outside the clinic, too, particularly for hand-held DNA sequencers. Epidemiologists and even caregivers working in rural areas could use such devices to test air, water, food, and animal and insect vectors, not to mention human throat swabs and body fluids. In fact, easy access to DNA-sequencing technologies in low- and middle-income countries is already facilitating projects such as the Global Virome Project. This aims to sequence numerous samples of wildlife DNA to identify a significant fraction of the viruses that can be transmitted into humans and cause disease.

Meanwhile, public-health specialists are starting to discuss how they might sequence the DNA of all the microorganisms in the waste-water outlets of entire cities to speed up the recognition of disease outbreaks. And marine biologists are exploring ways to monitor the health of the oceans through systematic metagenomic studies.

On the street, portable instruments could bring DNA analysis out of the crime lab and make it a front-line policing tool. Police might be able to 'read' people's DNA, much as they currently check car number plates or identification documents. In fact, the degree to which cheap and easy DNA sequencing opens up possibilities for mass surveillance has recently sparked concern among human-rights groups.

In the home, DNA-sequencing appliances could become the next 'smart' or 'connected' devices, after smoke alarms and thermostats. One commentator even identified the toilet as the ideal place to monitor family health through real-time DNA sequencing[11].

Hitting limits

What are the stumbling blocks?

In a mere 40 years, the central goal of putting molecular data about cells to practical use has changed from an informational challenge to a meta-informational one.

Take clinical applications of genome-sequence data. It may soon be possible to use DNA sequencing routinely to analyse body fluids obtained for any clinical purpose. But only a vast amount of well-organized data about the multi-year medical histories of millions of people will provide the meta-information needed to establish when to ignore such data and when to act on them.

With respect to medicine, we echo the recommendations of advisory groups such as the US National Research Council's Precision Medicine Committee[12] on the need to create a vast "information commons". This would overlay molecular and clinical data onto the germ-line genome sequences of millions of individuals. Several such population-scale efforts are under way, including the UK Biobank resource and the US All of Us Research Program.

Here we have laid out our best guesses. Surprises are a certainty. In fact, it is possible that decades from now, much of the world's data (now residing on

hard drives or in the cloud) will be stored in DNA, and that the main driver of DNA sequencing will be not our quest to tackle disease, but our insatiable appetite for data storage.

Journal name:
Nature
Volume:
550,
Pages:
179–181
Date published:
(12 October 2017)
DOI:
doi:10.1038/550179a

Comments

Comments

There are currently no comments.

Publishers threaten to remove millions of papers from ResearchGate

Take-down notices “imminent” as lawsuit is filed alleging widespread copyright infringement.

10 October 2017 Updated:

1. 10 October 2017

Millions of articles might soon disappear from ResearchGate, the world’s largest scholarly social network. Last week, five publishers said they had formed a coalition that would start ordering ResearchGate to remove research articles from its site because they breach publishers' copyright. A spokesperson for the group said that up to 7 million papers could be affected,

and that a first batch of take-down notices, for around 100,000 articles, would be sent out “imminently”.

Meanwhile, coalition members Elsevier and the American Chemical Society have filed a lawsuit to try to prevent copyrighted material appearing on ResearchGate in future. The complaint, which has not been made public, was filed on 6 October in a regional court in Germany. (ResearchGate is based in Berlin). It makes a “symbolic request for damages” but its goal is to change the site’s behaviour, a spokesperson says.

ResearchGate may already have begun taking articles down, according to a 10 October statement by the coalition. The group said it had noticed that the site had removed "a significant number of copyrighted articles", although ResearchGate hadn't shared information about this with publishers. "At this point, not all violations have been addressed and ResearchGate will need to take additional steps to cease unauthorized distribution of research articles," the statement says.

The clash has been a long time coming. Researchers are increasingly posting paywalled research papers online, many of them on ResearchGate, a network often likened to Facebook for scientists. The site boasts more than 13 million members and has raised more than US$80 million in start-up funding from investors including Microsoft founder Bill Gates and the Wellcome Trust, the London-based biomedical-research funder.

Not only do academics upload articles to the site, but ResearchGate also scrapes material online and invites researchers to claim and upload these papers, says James Milne, a spokesperson for the five-publisher group, which calls itself the Coalition for Responsible Sharing. In February this year, information scientist Hamid Jamali at Charles Sturt University in Wagga Wagga, Australia, reported that he had examined 500 articles at random from ResearchGate, and found that 40% of them breached copyright[1].

Access issues

In September, the International Association of Scientific, Technical, and

Medical Publishers, a trade group based in Oxford, UK, sent a letter to ResearchGate suggesting that the network introduce an automated filtering system, through which uploaded articles would be shared publicly or privately depending on their copyright status. Publishers generally say that paywalled articles for which they own copyright can be shared only privately; scientists are allowed to upload preprints, and peer-reviewed but unedited manuscripts, online for general access.

“ResearchGate refused to engage with us on that,” says Milne. The Coalition for Responsible Sharing, which also includes publishers Wiley, Wolters Kluwer and Brill, says it is “now left with no other choice” but to issue take-down notices.

Litigation has been tried before: in 2013, Elsevier sent 3,000 notices under the US Digital Millennium Copyright Act to scholarly networks including Academia.edu, demanding that they take down papers that breached Elsevier’s copyright. Those notices were passed on to the networks’ academic users. But the new actions would be on a larger scale.

Terms and conditions

ResearchGate declined to comment on the coalition’s statement, but its terms of service ask users not to store information that infringes copyright. They also state that because the site neither previews nor automatically reviews information that users have stored on it, ResearchGate can’t know about — and isn’t liable for — any possible infringements. The site says it will quickly disable access to infringing material after being notified of a problem.

But repeatedly sending lots of take-down notices is not a long-term solution, Milne says — hence the lawsuit, which aims to clarify what responsibility ResearchGate has to prevent copyright breaches. Milne says Elsevier and the American Chemical Society are hoping that the German court will tell the social network that it has a duty to identify copyrighted material on its website, and remove it; that the site must check whether material it scrapes from the Internet is copyrighted before users are invited to ‘claim’ it and upload it; and that ResearchGate will also be told it cannot modify

copyrighted material.

“The expectation is that ResearchGate will be told by the courts to cease certain behaviours. This could take months or years,” says Milne.

Not all publishers have stopped discussions with ResearchGate. On 9 October, the company posted a joint statement with *Nature*’s publisher Springer Nature, saying that the two firms had been in “serious discussions for some time” about sharing journal articles online while protecting intellectual-property rights, and that they were “cautiously optimistic” that a solution could be found. (*Nature*’s news and comment team is editorially independent from its publisher.)

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22793

Updates

Updated:

Updated to include details of a 10 October statement by the coalition of five publishers, which said that ResearchGate had begun removing from public view some copyrighted articles.

Comments

Commenting is currently unavailable.

Trump EPA begins push to overturn Obama-era climate regulation

The agency's plan to reverse limits on greenhouse-gas emissions is likely to draw legal challenges.

10 October 2017

Jabin Botsford/The Washington Post/Getty

EPA administrator Scott Pruitt has questioned his agency's legal authority to regulate greenhouse-gas emissions.

The US Environmental Protection Agency (EPA) is moving to repeal former

president Barack Obama's landmark regulations to reduce greenhouse-gas emissions from power plants.

The plan, introduced on 10 October, is a step towards fulfilling President Donald Trump's promises to reverse Obama-era climate regulations and end the “war on coal”. But any attempt to repeal the power-plant rule is certain to face lawsuits from environmental groups and many states that support Obama's climate policies.

“The Trump Administration’s persistent and indefensible denial of climate change — and their continued assault on actions essential to stemming its increasing devastation — is reprehensible,” said Eric Schneiderman, attorney general for the state of New York, in a prepared statement. “I will use every available legal tool to fight their dangerous agenda.”

US emissions from electricity generation have been falling in recent years as energy utilities have shifted away from coal, and towards cheap natural gas and renewables. The Obama administration established the power-plant regulations to hasten that progress, and to help the United States to meet its commitments under the 2015 Paris climate accord.

The power-plant rule would reduce greenhouse-gas emissions to 32% below 2005 levels by 2030 — but it is mired in legal challenges. In 2016, the US Supreme Court blocked the regulations from taking effect. Legal challenges from 27 state governments are still pending, although a federal appeals court has put the case on hold while the Trump administration reviews the rule.

Trump has shown no fear of challenging environmentalists on climate issues: he has already announced plans to pull the United States out of 2015 Paris climate pact. But his administration's attempts to roll back various environmental regulations have faced legal setbacks. One of the latest rebukes came on 4 October, when a federal court rejected an effort by the Department of the Interior to delay implementing curbs on methane emissions from oil and gas operations on public lands.

A long fight

The power-plant rule that Trump's administration plans to challenge was made possible by the Supreme Court's decision in 2007 that carbon dioxide and other greenhouse gases are pollutants under the terms of the Clean Air Act. Two years later, the EPA ruled that these gases are a threat to human health and the environment — a decision known as an 'endangerment finding'. That allowed the agency to draft regulations to limit greenhouse-gas output from various sources.

EPA administrator Scott Pruitt sued to overturn the endangerment finding in his former role as Oklahoma's attorney general, before Trump took office. More recently, as EPA's chief, he has questioned his own agency's authority to regulate CO_2. Environmentalists fear that he will attempt to repeal the endangerment finding, which would inevitably prompt a flurry of lawsuits.

The legal fight over the EPA's new plan to repeal the Obama power-plant regulations will almost certainly focus on whether the Clean Air Act allows the agency to require that utilities alter their energy portfolios to reduce emissions. The Obama administration set limits on emissions and then allowed states and utilities to decide how to meet those limits, with options that included expanding efforts to reduce energy consumption and developing new sources of renewable energy.

The Trump administration's proposal says that the EPA overstepped its legal authority when it finalized the Obama-era rules. The administration argues that the Clean Air Act limits the EPA to crafting regulations that can be implemented at power plants themselves. The proposal also says that the EPA is still considering whether and how to craft alternative regulations for power-plant emissions.

Jonathan Adler, who heads the Center for Business Law and Regulation at Case Western Reserve University School of Law in Cleveland, Ohio, says the Trump administration can reasonably argue — as many states have — that the Clean Air Act was not designed to regulate greenhouse gases. Courts often give a certain amount of deference to federal agencies on regulatory matters, he says, but only if the agencies show that they have followed all legal and procedural requirements for finalizing new rules.

“Some of the same legal doctrines that helped the Obama administration

defend its regulatory decisions will now help the Trump administration defend its decisions going in the opposite direction," Adler says. "This will certainly be a test for whether this administration is capable of engaging in this sort of heavy lift."

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22813

Comments

Comments

There are currently no comments.

Climate meetings pose serious test in the Trump era

Annual jamborees fail to ignite public passion but are crucial to progress on global-warming.

10 October 2017

Adrien Morlent/AFP Photo/Getty

In the aftermath of the successful 2015 Paris climate conference, the public remained unengaged.

Climate change is a popular topic in Germany right now. Leading researchers are converging in Potsdam this week to take stock of the economic and societal impacts of global warming across sectors from health to agriculture.

In Berlin, experts are meeting to discuss the potential and risks of various geoengineering technologies intended to counteract the effects of climate change. And next month, at the climax of the climate-meeting season, thousands of delegates will flock to the United Nation's annual climate summit, this year in Bonn.

At the UN meeting, governments will discuss the next steps in implementing the global climate agreement that they reached in Paris almost two years ago. The landmark deal, which came into force last November, aims to limit global warming to 1.5 °C above pre-industrial temperatures. To achieve this ambitious (many say unrealistic) goal, the world's major economies might need to phase out emissions of heat-trapping greenhouse gases entirely within a few decades.

The Paris accord, although based on merely voluntary national contributions, was undoubtedly a rare triumph for international climate diplomacy. It was the most that was possible and the least that was needed. Alas, the excitement did not last long. The subsequent U-turn of the United States — President Donald Trump has resolved to leave the deal, deeming it half-baked, essentially unnecessary and intolerably unfair to the US economy — has dampened spirits. Even so, the rest of the world has pledged to stand firm. The first conference of the parties to the agreement in the Trump era must now work out how to proceed without the world's largest economy. In theory, the annual climate roller coaster is idling through one of the low-key phases in which success is measured by nothing going wrong. In practice, the Bonn meeting will serve as a litmus test of how the rest of the world plans to stand united and to keep the spirit of Paris alive.

Keynote speakers in Bonn (and presenters in Berlin and Potsdam) will no doubt reiterate the severity of the global-warming threat and the urgent need to act. Major meetings often galvanize debate among researchers, pundits and policy watchers. But beyond this predictable fuss in the expert world, do high-level climate meetings and policy events, and the media coverage they bring, help push the wider public to engage with the climate problem?

Not quite, it seems. Results of a survey of the German public, published this week in *Nature Climate Change*, suggest that extensive media coverage of the Paris climate summit had a soothing rather than a mobilizing effect (M.

Brüggemann *et al. Nature Clim. Change* http://dx.doi.org/10.1038/nclimate3409; 2017). Respondents who had taken notice of media reports (and many said they had not) had slightly more trust in the efficacy of global climate policy after the unusually successful meeting. However, fewer were in favour of their own country taking a leading role, and most said that they did not intend to change their behaviour. In essence, respondents were relieved that a political deal had finally materialized, but were disinclined to engage further with the issue.

The researchers who conducted the survey say that this is a missed opportunity. The annual UN meetings bring guaranteed media attention to a topic that many news editors are bored with, and so they are an opportunity to mobilize action. As such, the study authors go so far as to suggest that the lack of public engagement is a failure of journalism.

It might indeed seem worrying that despite the avalanche of information, climate change remains marginal to most people's personal and political choices — Germany's strong green movement notwithstanding. It might even seem like a bad case of civil indifference. Does it matter? There is an argument that climate action does not have to depend on media-stirred engagement from agitated citizens. People often choose to leave responsible decision-makers to deal with complex global problems that only concerted international effort can hope to solve, and this has brought progress on issues such as nuclear non-proliferation and the phase-out of ozone-depleting chemicals.

But climate change is a more complex issue, and one that cuts across many overlapping and sometimes contradictory concerns, from cultural and political issues to ethical and psychological ones. As such, organizations, businesses, scientists, policymakers and others who advocate action on global warming must continue to strive to take the public with them. As many experts have pointed out, that will take creativity and more than repeated references to the serious nature of the problem — in Bonn and elsewhere.

Journal name:
Nature
Volume:
550,

Pages:
158
Date published:
(12 October 2017)
DOI:
doi:10.1038/550158a

Comments

Comments

There are currently no comments.

A. Awad

Developing nations need more than just money

Grants from big science funders can be hard to use without better administration and mutual understanding, says Rana Dajani[1].

10 October 2017

As a molecular biologist based in Jordan, I’m used to colleagues from outside the Middle East and North Africa assuming that brain drain and a lack of funds are the chief obstacles to science in my region. That is not my experience. Like me, many scientists return home after studying in the United States or Europe, and successfully apply for grants, often from international philanthropies or funders.

The real problem is using the money. There is a disconnect between the funding systems that we can tap into and the institutions where we work. Granting agencies often fail to appreciate the constraints we’re operating under. Current practices by both funders and universities practically guarantee that our funds — already limited — are spent inefficiently. We need more investment in administrative systems and more flexibility, because science is unpredictable and creative.

I hear the same sorts of struggles again and again. For example, a researcher in the Middle East received a grant from a US institution to study vectors of disease. It included a line item to cover capturing insects in the desert. But the local university overseeing the funds would not disburse them to cover transport, because the team could not supply officially stamped receipts from a petrol station; services at remote locations in developing nations are rarely equipped to provide such documentation. The scientist has not applied for an international grant since.

Another colleague in the region received a grant budgeting for some human genetic analysis to be performed by a third party in the United States, because the necessary capacity doesn’t exist in the Middle East. It took more than a year to get the funder, local university and third party to sign the agreements. But after the samples were shipped, university administrators said they could not process invoices because a bid to supply DNA-analysis services had not first been advertised in local newspapers. It took another year, many committees and much heartache to resolve the issue.

The situation is improving as more grants are awarded. For example, a newly appointed dean of scientific research at my university, Majd Mrayyan — herself a practicing scientist — has reduced the paperwork and minimized the levels of approval needed to begin projects. And the American University in Beirut has set up a department to handle funding logistics, staffed by people who understand the process. It has greatly increased the amount of funding that the university can receive.

Still, few university administrators in developing countries know much about science or how grants are typically handled. Postdoc and technician positions are rare across the Middle East and North Africa. When I hired a lab manager to handle administrative tasks such as ordering equipment, several people told me I was indulging in a luxury.

Institutions such as Harvard University in Cambridge, Massachussetts, where I am currently a visiting fellow, receive as much as 69% of awarded funds as indirect costs, which they put towards infrastructure and overhead — the costs of maintaining a system. By contrast, international grants to researchers in developing countries rarely cover infrastructure or capacity building; in some cases, philanthropists’ charters explicitly prohibit them from putting

money into anything not directly related to a funded project.

Even when overhead funds are available, local universities are often wary of spending them on intangibles such as salaries or training. They prefer to use grants to buy instruments and equipment. In one typical occurrence, an award covered the purchase of a DNA sequencer, but not maintenance. The instrument was effectively rendered useless in three years.

How can we solve this? Through capacity and systems building. Funders need to find ways to ensure that recipients have the administrative staff and skills to use their money well, and to help build these foundations where they are lacking. Agencies should encourage the appointment of administrators who have research experience. They might even consider sponsoring training and exchange programmes for administrators.

People involved also need to sit around a table and talk about these issues in real time. When discussions happen — if they happen at all — it is through e-mail, and most communication occurs within groups rather than across them. People at institutions talk among themselves and then formally approach funders; those at funding agencies take the same approach. Each group misses out on nuance and connection with the other.

For every grant awarded, funders, university administrators and scientists should talk about the project together to identify needs and potential conflicts. They could then take the initiative to make changes, which builds ownership and creates useful precedents.

These discussions might reduce many roadblocks that keep scientists in the developing world from being able to use grants more efficiently. Core facilities that allow expensive equipment to be shared would cut down on redundancies and free up available funds. Provisions for maintaining equipment and paying and training technicians should be built into the budgets of both grants and institutions.

People from developed countries might feel noble when they give money to those in developing countries. What is really needed is more complicated — but it’s doable. For funders to have the most impact, they need to sit down with administrators and scientists in developing countries, listen to their

challenges and decide together what to do. That is the way to genuinely make a difference.

Journal name:
Nature
Volume:
550,
Pages:
159
Date published:
(12 October 2017)
DOI:
doi:10.1038/550159a

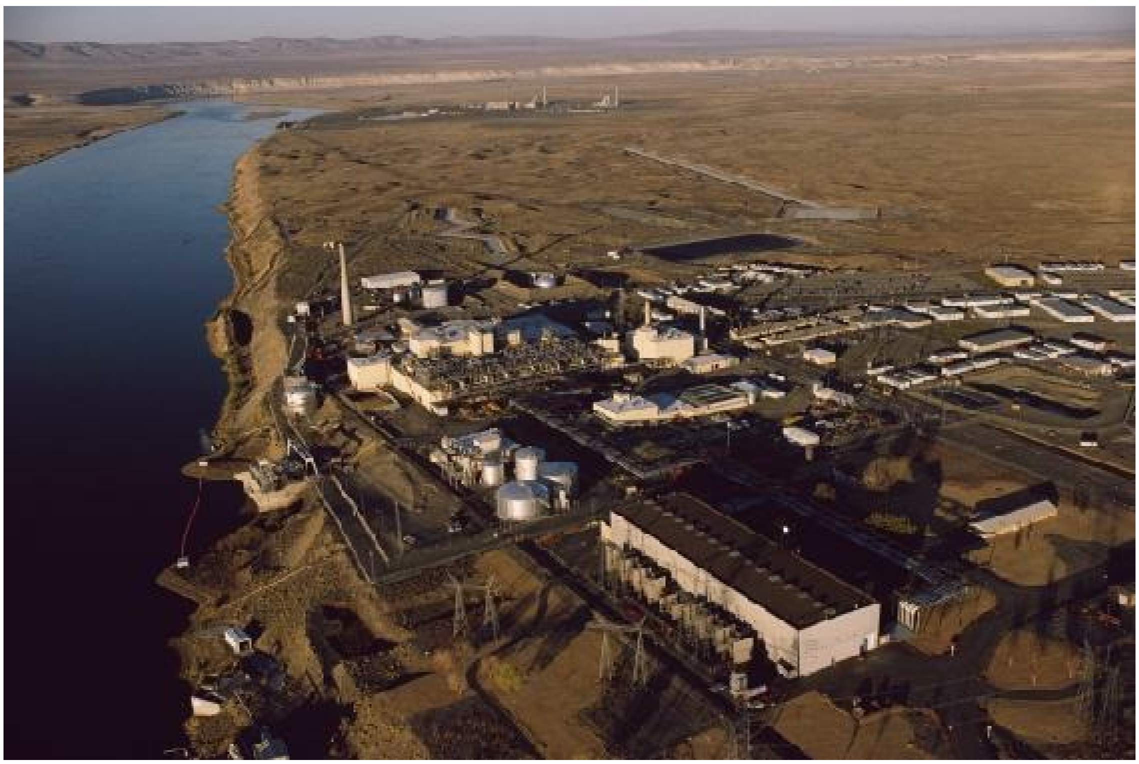
Comments

Commenting is currently unavailable.

How the United States plans to trap its biggest stash of nuclear-weapons waste in glass

After decades of delays, a challenging clean-up project is gaining ground.

10 October 2017



Karen Kasmauski/NGC

Waste from decades of nuclear-weapons production is buried at the Hanford Site in Washington state.

There's a building boom at the Hanford Site, a once-secret complex on the windswept plains of southeastern Washington state. Construction crews are

working to finish a 27-metre-tall concrete structure there by June. If all goes well, the facility will finally enable the US Department of Energy (DOE) to begin treating the toxic, radioactive waste that accumulated at the site for more than 40 years, starting during the Second World War.

Decades after the site stopped producing plutonium for nuclear weapons, the legacy of Hanford's activities is still causing trouble. Just this year, a tunnel holding railway carriages full of radioactive material collapsed. Separately, at least a dozen employees who were tearing down a contaminated building reportedly tested positive for plutonium inhalation. But the site's biggest challenge lies underground, in 177 carbon-steel tanks. Together, these buried containers hold more than 200 million litres of highly hazardous liquids and peanut-buttery sludge — enough to fill 80 Olympic-size swimming pools. More than one-third of the tanks have leaked, contaminating groundwater with radioactive and chemical waste.

In a 1989 legal agreement with the state of Washington and the US Environmental Protection Agency, the DOE committed to immobilizing the most dangerous waste in sturdy glass logs through a process called vitrification. Several years later, the agency agreed to vitrify other tank waste as well. All told, the process is expected to generate tens of thousands of logs, each weighing multiple tonnes. Those containing high-level waste would be shipped to a permanent storage facility; the rest could be stored on site. But the effort has been plagued by cost overruns, delays and safety concerns. Although the DOE has spent roughly US$20 billion on the tank problem since 1997, no waste has been vitrified.

Four years ago, the agency hit reset. Rather than making a single vitrification plant, it split the project in two. One plant — the building now under construction — would begin vitrifying the less-hazardous, 'low-activity' liquid in the tanks. A bigger, more-complex plant to process the high-level sludge would follow once researchers resolved some thorny safety questions.

On both fronts, there have been signs of progress. This year, the DOE reported that it had resolved crucial questions related to treating the high-level waste. And a laboratory needed for real-time analysis of the low-level waste is nearing completion. If work continues as planned, the site could crank out its first glass logs as early as 2022.

Hanford's critics, accustomed to missed deadlines and management scandals, remain sceptical. But even officials with the state of Washington, which has battled the DOE in court for nearly three decades over clean-up goals and deadlines, are hopeful that efforts are now on track. “There's reason for optimism,” says Suzanne Dahl, who oversees tank activities for the Washington Department of Ecology.

Scientists have been studying vitrification since the 1950s, and a number of countries have used the process to stabilize nuclear waste, including France, India, Russia and the United Kingdom. The United States vitrifies waste at the DOE's Savannah River Site in South Carolina. But the size and complexity of the problem is on a different scale at Hanford.

Established as part of the Manhattan Project during the Second World War, the Hanford Site delivered the plutonium that went into the first nuclear-weapon test and the bomb that was dropped on Nagasaki, Japan, in 1945. It went on to produce the bulk of the plutonium for the US nuclear arsenal. “Hanford is the whole history of nuclear development,” says Ian Pegg, a physicist at the Catholic University of America in Washington DC, who works with the DOE on vitrification experiments.

Toxic brews

The ever-shifting suite of technologies used at the site produced uniquely toxic brews that include radioactive caesium, strontium, americium and residual plutonium; salts; heavy metals; and myriad industrial chemicals. The containers also hold other surprises. People “threw everything imaginable into those tanks”, says Albert Kruger, a glass scientist with the DOE in Richland, Washington. His list includes contaminated gloves, planks of wood, rocks and tape measures.

Once such detritus is removed, vitrification calls for the waste to be combined with ingredients that include silica and boron, then heated to nearly 1,150 °C. The molten mixture is next cooled in stainless-steel canisters to create large cylinders of borosilicate glass — the same material used in oven-safe glassware.

The process is complicated by that fact that each tank contains a cocktail of chemicals and radionuclides that cannot be fully characterized until the waste is extracted. Some of those substances can weaken glass. Others, such as iodine, can't be readily trapped and must be removed. Hanford scientists will have to tailor glass recipes for each batch of waste — a bit like blending different vintages to produce a fine cognac. “Nobody will test the nose, and nobody will take a taste test, but it's an equivalent mechanism,” Kruger says.

Multiple contractors have worked on the Hanford project since 1989, including British Nuclear Fuels Limited, a UK-government-owned company that exported the technology it was using at the Sellafield nuclear-decommissioning complex. After price estimates rose, in 2000 the DOE hired construction and engineering giant Bechtel of San Francisco, California, as the primary contractor.

At that time, the Hanford plant was expected to cost $4.3 billion and to begin making logs in 2007. But as engineers began working through the safety and technical details, the project ballooned in price and complexity. By 2012, senior officials — including a former DOE employee and two contractors who later filed whistle-blower complaints after being fired — were raising concerns. One was that hydrogen, which is generated when heat and radiation split water molecules, would build up in tanks and pipes, creating a risk of explosion. Another was that mixing vessels meant to keep heavy particles moving would not be powerful enough. Over time, enough residual plutonium could settle out to create a dangerous chain reaction.

Then-DOE secretary Steven Chu assembled an expert panel to investigate. Ultimately, Bechtel was ordered to first construct a plant that would vitrify only liquid waste. The liquid represents 90% of the waste volume but just 10% of its radioactivity, and requires less processing than the high-level waste: it can be skimmed off, stripped of highly radioactive caesium and then sent directly to vitrification. “It makes sense,” says David Kosson, a chemical engineer at Vanderbilt University in Nashville, Tennessee, who was on Chu's expert panel. If you have got to pick one place to start, he says, “the low-activity waste is not a bad choice”.

Lingering questions

The high-level-waste facilities remain on hold, but the DOE and its contractors have spent years investigating the technical issues using computer models and prototypes. In February, the agency announced it had resolved issues related to hydrogen build-up and uncontrolled reactions. Scientists familiar with the effort says tests of a newly designed mixing vessel are nearing completion, apparently without any major hitches. The vessel is equipped with six 'pulse jet mixers' that pull waste in and out like turkey basters, to keep solids from settling.

Researchers are also making progress on the glass recipes. Kruger and external scientists have shown that certain compositions can accommodate more waste than previously estimated, and so potentially save on costs. The number of glass logs produced in the high-level waste facility could drop from 18,000 to as few as 7,000, Kruger says. The low-level plant may need to make just 70,000 logs or so, instead of 145,000.

But questions remain. A 2015 DOE report documented more than 500 vulnerabilities that could affect low-level plant operations — including some in the electrical and mechanical systems that would be used to handle radioactive materials. Tom Carpenter, executive director of the watchdog group Hanford Challenge, hopes the plant will work as advertised. But he is concerned that the DOE, its contractors and even the state of Washington are too eager to bring the facility online. “Everyone is desperate to show progress,” he says. “I get that, but you can't paper over the safety issues.” Senior DOE officials at Hanford declined to be interviewed for this story; a Bechtel spokesperson said the company has addressed the vast majority of concerns raised in the report and has submitted its responses to the DOE for verification.

Not everyone is convinced that vitrification is the way to go. The DOE is bound by legal agreements and nuclear-waste regulations to pursue the process, but from a technical standpoint there are better options, says Jim Conca, a consultant and former director of an independent research centre that supports the Waste Isolation Pilot Plant (WIPP) outside Carlsbad, New Mexico, the nation's only operating deep geological repository.

Hanford's high-level wastes are currently slated for disposal at Yucca Mountain, a long-stalled geological repository in Nevada. Water infiltration

is a concern there, so the waste must be encased in glass to help ensure that it remains stable over thousands of years. But Conca says that the tank sludge is safe enough to simply be dried out and sent to WIPP — if regulations could be changed to allow it. Similarly, low-activity waste could be mixed with grout to create concrete-like material, which would be cheaper and, many believe, just as safe. “Does all of that waste technically need to be vitrified for environmental safety? Probably not,” says Kosson. But in the end, Kosson believes that the DOE will press forward with the plan.

Chu remains confident that vitrification can work, but says the DOE should be receptive to new science and shift course as needed. More generally, he says, the country has a long way to go in resolving questions about how — and where — it will dispose of all its nuclear waste. “This is a significant problem, and there has to be a lot of good science in figuring out a better path forward,” he says. “Always keep your mind open.”

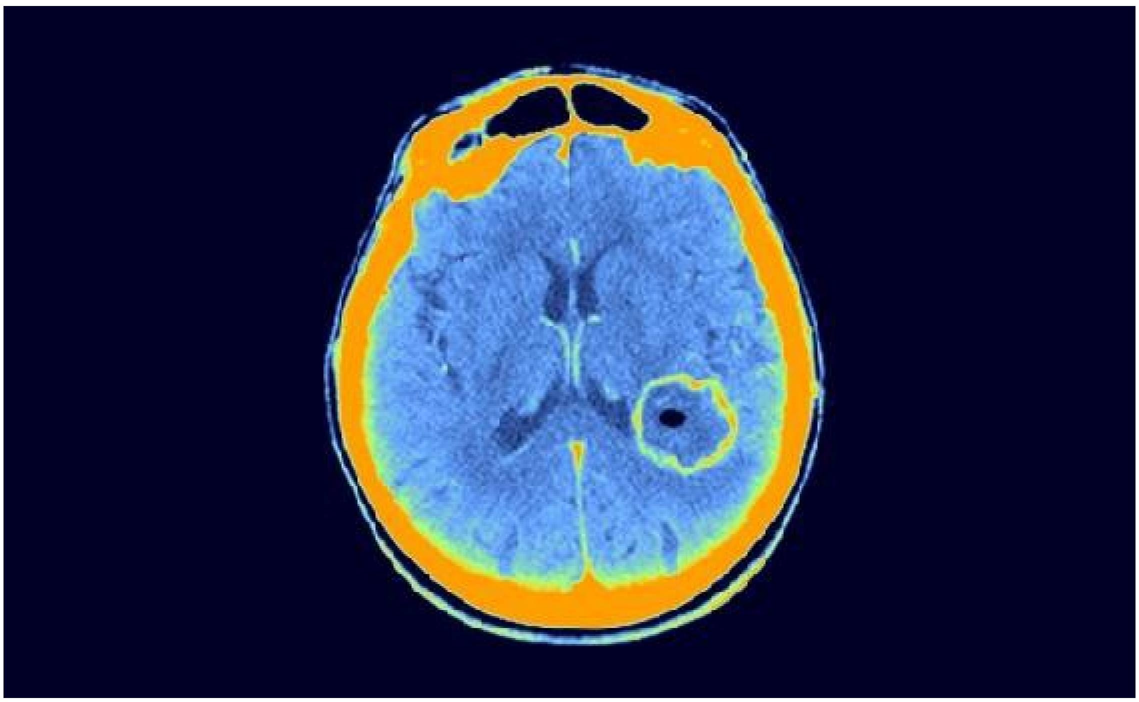
The price tag on Hanford's vitrification facilities now stands at $16.8 billion. Assuming that the latest timetable holds, the plant for high-level waste will open for business in the early 2030s, and operations will continue for decades. In the meantime, dangerous waste will remain underground, out of sight but not out of mind.

Journal name:
Nature
Volume:
550,
Pages:
172–173
Date published:
(12 October 2017)
DOI:
doi:10.1038/550172a

Cancer-genome study challenges mouse 'avatars'

Grafting human cancer cells into mice alters tumour evolution.

09 October 2017



Centre Jean Perrin/ISM/SPL

A brain tumour called glioblastoma, shown here as the circular region in a patient's brain scan, is among the cancers that have been tested in mouse avatars.

An analysis of more than 1,000 mouse models of cancer has challenged their ability to predict patients' response to therapy.

The study, published today in *Nature Genetics*[1], catalogues the genetic

changes that occur in human tumours after they have been grafted into mouse hosts. Such models, called patient-derived xenografts (PDXs), are used in basic research and as ‘avatars’ for individual patients. Researchers use these avatar mice to test a bevy of chemotherapies against a person's tumour, in the hope of tailoring a treatment plan for the patient's specific cancer.

But fresh data from geneticists at the Broad Institute of MIT and Harvard in Cambridge, Massachusetts, suggest that transplanting human cancer cells into a mouse alters the cells' evolution, reshaping the tumour's genome in ways that could affect responses to chemotherapy.

“The assumption is that what grows out in the PDX is reflective of the bulk of the tumour in the patient,” says cancer geneticist Todd Golub, a lead author on the study. “But there’s quite dramatic resculpting of the tumour genome.”

No animal model is perfect, and researchers have long acknowledged that PDXs have their limitations. To avoid an immune assault on the foreign tumour, for example, PDXs are typically grafted into mice that lack a functioning immune system. This compromises scientists' ability to study how immune cells interact with the tumour — an area of increasing interest given the success of cancer therapies that unleash the immune system.

PDXs can also take months to generate, making them too slow to serve as avatars for those patients who need to make immediate decisions about their therapy.

Reasonable reproductions

But previous research had suggested that the PDXs were reasonably faithful reproductions of the human tumours they are meant to model, offering researchers a chance to explore the tumour’s interaction with its environment in ways that are not possible using cells grown in a Petri dish. The US National Cancer Institute has developed a library of more than 100 PDXs for distribution to researchers, and European scientists have launched EurOPDX, a consortium that boasts more than 1,500 models for more than 30 tumour

types. One company, Champions Oncology of Hackensack, New Jersey, creates and tests mouse avatars for individual patients and for pharmaceutical companies to use in research.

For the latest study, Golub and Broad Institute cancer geneticist Rameen Beroukhim, together with their colleagues, decided to examine how PDXs changed over time. The researchers studied data from tumour cells that were implanted into a mouse, allowed to grow into a tumour, and then harvested and re-implanted into a fresh mouse — sometimes for multiple cycles.

The researchers looked for alterations in the number of copies of a given gene in the cell. They did so for more than 1,000 PDX samples representing 24 cancer types, often extrapolating gene copy number from data on gene expression.

The analysis suggests that tumours implanted in mice change in ways that are not commonly seen in the human body. For example, human brain tumours called glioblastomas tend to gain extra copies of chromosome 7. But the mouse PDXs tend to lose those extra copies over time, says Beroukhim.

Some of these genetic changes were also associated with differences in how the PDXs responded to cancer drugs. For researchers studying many PDXs and looking for relationships between genetics and drug sensitivity, the finding does not spell disaster, says Golub. “That’s not to say that PDXs should be abandoned as a model — far from it,” he says. “But they’re not a panacea.”

Golub is more worried about using PDXs to predict outcomes in individual patients. “It raises some important questions around how to interpret the results of avatars,” he says.

But Champions Oncology founder David Sidransky, an oncologist at Johns Hopkins University School of Medicine in Baltimore, Maryland, points to his team's study of 92 patients, published in August. That showed an 87% association between the drug responses in a patient and their corresponding PDX[2].

The genetic analysis by Golub and his team could offer clues as to what goes

wrong in the other 15% of PDXs, Sidransky says.

The work is important, says David Tuveson, a cancer researcher at Cold Spring Harbor Laboratory in New York. But Tuveson also notes that PDX approaches are changing. Researchers are increasingly likely to graft a human tumour into the analogous location in the mouse avatar — for instance, by transplanting human pancreatic cancer cells into a mouse pancreas — rather than merely grafting them under the skin. This, he says, is thought to be an environment that is more similar to that of the original tumour.

Researchers are also turning to mice that have been ‘humanized’ in various ways, perhaps by introducing aspects of a human immune system or human versions of proteins that interact with the tumour.

As for those PDXs that have already been generated, researchers will continue to embrace them, says Carlos Caldas, a researcher at the Cancer Research UK Cambridge Institute at the University of Cambridge, UK.

Caldas notes that his own studies with breast cancer PDXs have not found such dramatic differences between PDXs and the tumours from which they were made. “We’re going to continue to see a lot of activity with these models — they are a great development, not a hindrance,” he says. “They are here to stay.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22782

Comments

Comments

There are currently no comments.

LIGO's unsung heroes

Nature highlights just a few of the people who played a crucial part in the discovery of gravitational waves — but didn't win the Nobel Prize.

09 October 2017

Joe McNally/Getty

LIGO hunts gravitational waves with the help of two laser interferometers —

Every October, the announcements of the Nobel Prizes bring with them some controversy. This year's physics prize — in recognition of the Laser Interferometer Gravitational-Wave Observatory (LIGO) in the United States — was less debated than most. The three winners — Kip Thorne and Barry Barish, both at the California Institute of Technology (Caltech) in Pasadena, and Rainer Weiss at the Massachusetts Institute of Technology (MIT) in

Cambridge — had attracted near-universal praise for their roles in the project's success.

But the award has still put into stark relief the difficulty of singling out just a few individuals from the large collaborations of today's 'Big Science'. The LIGO collaboration uses two giant laser interferometers to listen for deformations in space-time caused by some of the Universe's most cataclysmic events. Physicists detected their first gravitational waves — interpreted as being produced by the collision of two black holes more than a billion years ago — in September 2015. The resulting paper, published in February 2016[1], has a mind-boggling 1,004 authors.

Some of those are members of the LIGO Laboratory, the Caltech–MIT consortium that manages LIGO's two interferometers in Louisiana and Washington State. But the list also includes the larger LIGO Scientific Collaboration: researchers from 18 countries, some of which — such as Germany and the United Kingdom — have made crucial contributions to the detectors.

Yet more authors are from LIGO's sister Virgo Collaboration, led by France and Italy, which built the Virgo interferometer near Pisa, Italy. The two experiments pool their data and analyse them together. Countless other people not named on the paper have also been involved in LIGO's design, development, construction and operation since Weiss first detailed how to build a laser interferometer in 1972.

To honour the many unsung heroes of gravitational waves, *Nature* collected testimonials about just a few of them. Like the Nobel Prize, this list is inevitably very incomplete.

1. The pioneer: Joseph Weber

Researchers using two detectors in the United States shook the world when they announced their discovery of gravitational waves. The year was 1969, and the detectors were not LIGO but tonne-sized cylinders of aluminium built by Joseph Weber, a physicist at the University of Maryland in College Park.

His claim was later found to be invalid, but many physicists still credit Weber for having founded the field. “Joe Weber indeed started thinking about how to detect gravitational waves in about 1957,” Virginia Trimble, an astrophysicist and Weber’s widow, told *Nature* in an e-mail. At that time, many researchers were not even sure that gravitational waves existed. In the 1960s, Weber was also one of the first researchers to consider the possibility of using interferometers to detect them.

2. The German connection: Heinz Billing

The founder of Germany’s side of LIGO, Heinz Billing, a physicist at the Max Planck Institute for Astrophysics near Munich, first heard of Weiss’s pioneering interferometer designs in 1975, when he was asked to review Weiss’s request to the National Science Foundation to fund a prototype at MIT. Billing and his team liked it so much that they started building one themselves. “The Munich group quickly invented some of the most important ingredients that made the detectors possible,” says Karsten Danzmann, a director at the Max Planck Institute for Gravitational Physics in Hanover, Germany. Billing, in particular, came up with an idea to stabilize the laser that was later used in the UK–German GEO600 interferometer based near Hanover — and in LIGO itself. GEO600 is still a crucial testing and development centre for technologies introduced in the successive rounds of LIGO upgrades. “There is an awful lot of GEO in LIGO,” says Danzmann. Billing, who died on 4 January at the age of 102, was also a pioneer in magnetic data storage.

3. The laser expert: Alain Brillet

The 1980s were years of intense research and development for gravitational-wave detectors. Alain Brillet, an optical physicist with extensive experience in interferometers, then at the University of Paris-Sud in Orsay, France, saw an opportunity to contribute. “I decided to start with the optical part, the lasers and optics, because that was my specialty,” he says. Brillet went on to co-found Virgo. But many of his ideas — in particular, the type of laser that would give the most stable signal — were implemented in LIGO and other interferometers as well, says MIT physicist David Shoemaker, who studied with Brillet in Orsay and is now LIGO’s spokesperson.

4. The facilitator: Richard Isaacson

Gravitational theorist Richard Isaacson went to Washington DC to work at the National Science Foundation (NSF) in 1973 for what he thought would be a brief stint as one of the programme directors. During the handover, his predecessor advised him to pay attention to an “interesting guy” called Rainer Weiss. Isaacson secured Weiss a small grant for his 1975 prototype, and later became LIGO’s chief advocate inside government. He was instrumental in the project's winning hundreds of millions of dollars in funding, despite the uncertain prospect of success. It was the first time that the NSF had managed a large project: US facilities such as particle accelerators were traditionally the remit of the Department of Energy, which had field offices staffed with dozens of experts. Isaacson did it by himself for more than ten years, and by the early 1990s he had paid a high personal cost. “Eventually, my health broke and my marriage went bad,” says Isaacson. By the time he retired in 2001, the construction of LIGO had been completed.

5. The first director: Rochus ‘Robbie’ Vogt

Before Barry Barish took the reins of LIGO, another director had left his mark on the collaboration: Rochus Vogt. The Caltech physicist, a veteran of the NASA Voyager mission, was put in charge in 1987. Until then, the project had been led by the ‘troika’ of visionary founders — Thorne, Weiss, and the physicist Ronald Drever, who started UK research on gravitational waves at the University of Glasgow before moving to Caltech — but managing large organizations was not their strength. “Thank God that was done,” Weiss recalled in a talk at NSF headquarters last year. “You don't manage it with three guys who are sort of a little bit flaky.” Vogt, who was once described as a taller and leaner Henry Kissinger, had a booming voice and forceful style that did not please everyone. But he was able to put together the first major request for NSF funding and, Thorne recalled in a 5 October press conference, “laid the foundations for moving LIGO forward to our construction”.

6. The theorist: Alessandra Buonanno

As Thorne realized early on, in the future field of gravitational-wave astronomy, it would not be enough to collect data; researchers would also need to know what signals to look for. But it is notoriously difficult to extract quantitative predictions from the equations of Einstein’s general relativity. Theoretical physicist Alessandra Buonanno had devised formulae for calculating the approximate orbits of spiralling objects and the gravitational waves they would generate in work she had done, in part with her PhD adviser Thibault Damour, at the Institute of Advanced Scientific Studies near Paris. The LIGO and Virgo collaborations use a database of hundreds of thousands of these waveforms for spotting gravitational waves in their data in real time. Buonanno is now a director at the Max Planck Institute for Gravitational Physics in Potsdam and a senior member of the LIGO Scientific Collaboration.

Journal name:
    Nature
DOI:
    doi:10.1038/nature.2017.22786

Comments

4 comments

1. *Pentcho Valev* • 2017-10-11 07:14 AM
    The "discovery" of gravitational waves is just one of those "major breakthroughs" imposed by science bureaucrats like Ms. Davis: "LEONARD: I have to say I'm a little nervous. Ms. DAVIS: You should be. LEONARD: Look, I know I screwed up, but it was only one interview. How much damage could it have caused? Ms. DAVIS: Would you like for me to read you the e-mails from donors asking why are they giving us money if physics is a dead

end? LEONARD: I didn't say it was a dead end. I just said that I was worried it might be. Ms. DAVIS: So if I just said I was worried you might not have a job next week, how would you feel? LEONARD: Light-headed, and glad you asked me to sit down. Okay, just tell me what I can do. Ms. DAVIS: I'm gonna need you to make a statement saying that you misspoke, and that you're confident the physics community is close to a major breakthrough. LEONARD: You want me to lie. Ms. DAVIS: Look, Dr. Hofstadter, I'm counting on you. I think that you are the smartest physicist at this university. LEONARD: Really? Ms. DAVIS: See? Lies. They're not that hard." [END OF QUOTATION] https://www.youtube.com/watch?v=GDNP9KOEdh0 Physicist Leonard Hofstadter tries to repent but in the end comes to the following conclusion: LEONARD: "I know I said physics is dead, but it is the opposite of dead. If anything, it is undead, like a zombie." "Physics is dead" is a commonplace knowledge - scientists express it in various ways: Peter Woit: "If, as seems increasingly all too possible, we're now at an endpoint of fundamental physics, with the field killed off by a pseudo-scientific argument..." http://www.math.columbia.edu/~woit/wordpress/?p=9444 Peter Woit: "I think the worst thing that has happened to theoretical physics over the past 25 years is this descent into ideology, something that has accelerated with the multiverse mania of the last 10-15 years." http://www.math.columbia.edu/~woit/wordpress/?p=9375 Correct, except for the number 25 - it should be replaced by 112: "This paper investigates an alternative possibility: that the critics were right and that the success of Einstein's theory in overcoming them was due to its strengths as an ideology rather than as a science. The clock paradox illustrates how relativity theory does indeed contain inconsistencies that make it scientifically problematic. These same inconsistencies, however, make the theory ideologically powerful. [...] The gatekeepers of professional physics in the universities and research institutes are disinclined to support or employ anyone who raises problems over the elementary inconsistencies of relativity. A winnowing out process has made it very difficult for critics of Einstein to achieve or maintain professional status. Relativists are then able to use the argument of authority to discredit these critics. Were relativists to admit that Einstein may have made a series of elementary logical errors, they would be faced with the embarrassing question of why this had not been noticed earlier. Under these circumstances the marginalisation of antirelativists, unjustified on scientific grounds, is eminently justifiable on grounds of realpolitik. Supporters of relativity theory have protected both the theory and their own reputations by shutting their opponents out of professional discourse. [...] The triumph of relativity theory represents the triumph of ideology not only in the profession of physics bur also in the philosophy of science." Peter Hayes, The Ideology of Relativity: The Case of the Clock Paradox http://www.informaworld.com/smpp/content~content=a909857880 And when ideology replaces science, bureaucrats replace scientists of course: Mike Alder: "It is easy to see the consequences of the takeover by the bureaucrats. Bureaucrats favour uniformity, it simplifies their lives. They want rules to follow. They prefer the dead to the living. They have taken over religions, the universities and now they are taking over Science. And they are killing it in the process. The forms and rituals remain, but the spirit is dead. The cold frozen corpse is so much more appealing to the bureaucratic mind-set than the living spirit of the quest for insight. Bureaucracies put a premium on the old being in charge, which puts a stop to innovation. Something perhaps will remain, but it will no longer attract the best minds. This, essentially, is the Smolin position. He gives details and examples of the death of Physics, although he, being American, is optimistic that it can be reversed. I am not. [...] Developing ideas and applying them is done by a certain kind of temperament in a certain kind of setting, one where there is a good deal of personal freedom and a willingness to take risks. No doubt we still have the people. But the setting is gone and will not come back. Science is a product of the renaissance and an entrepreneurial spirit. It will not survive the triumph of bureacracy. Despite having the infrastructure, China never developed Science. And soon the West won't have it either." https://www.highbeam.com/doc/1G1-172684821.html Pentcho Valev

2. *Pentcho Valev* • 2017-10-10 01:08 AM

Gravitational waves (ripples in spacetime) don't exist because spacetime doesn't exist: Nima Arkani-Hamed (06:09): "Almost all of us believe that space-time doesn't really exist, space-time is doomed and has to be replaced by some more primitive building blocks." https://www.youtube.com/watch?v=U47kyV4TMnE Nobel Laureate David Gross observed, "Everyone in string theory is convinced...that spacetime is doomed. But we don't know what it's replaced by." https://www.edge.org/response-detail/26563 What scientific idea is ready for retirement? Steve Giddings: "Spacetime. Physics has always been regarded as playing out on an underlying stage of space and time. Special relativity joined these into spacetime... [...] The apparent need to retire classical spacetime as a fundamental concept is profound..." https://www.edge.org/response-detail/25477 And spacetime doesn't exist because the underlying premise, Einstein's constant-speed-of-light postulate, is false: "Special relativity is based on the observation that the speed of light is always the same, independently of who measures it, or how fast the source of the light is moving with respect to the observer. Einstein demonstrated that as an immediate consequence, space and time can no longer be independent, but should rather be considered a new joint entity called "spacetime." http://community.bowdoin.edu/news/2015/04/professor-baumgarte-describes-100-years-of-gravity/ Is the speed of light "always the same, independently of who measures it"? Of course not - even Einstein knew that this is nonsense: John Stachel: "But this seems to be nonsense. How can it happen that the speed of light relative to an observer cannot be increased or decreased if that observer moves towards or away from a light beam? Einstein states that he wrestled with this problem over a lengthy period of time, to the point of despair." http://www.aip.org/history/exhibits/einstein/essay-einstein-relativity.htm In the quotation below, the statement "four pulses are received in the time it takes the source to emit three pulses" means that the speed of light is VARIABLE - the speed of the pulses relative to the receiver (observer) is greater than their speed relative to the source, in violation of Einstein's relativity: http://www.einstein-online.info/spotlights/doppler Albert Einstein Institute: "The frequency of a wave-like signal - such as sound or light - depends on the movement of the sender and of the receiver. This is known as the Doppler effect. [...] Here is an animation of the receiver moving towards the source: Stationary receiver: http://www.einstein-online.info/images/spotlights/doppler/doppler_static.gif Moving receiver: http://www.einstein-online.info/images/spotlights/doppler/doppler_detector_blue.gif By observing the two indicator lights, you can see for yourself that, once more, there is a blue-shift - the pulse frequency measured at the receiver is somewhat higher than the frequency with which the pulses are sent out. This time, the distances between subsequent pulses are not affected, but still there is a frequency shift: As the receiver moves towards each pulse, the time until pulse and receiver meet up is shortened. In this particular animation, which has the receiver moving towards the source at one third the speed of the pulses themselves, four pulses are received in the time it takes the source to emit three pulses." [END OF QUOTATION] Pentcho Valev

3. *Pentcho Valev* • 2017-10-09 02:33 PM

   "As Thorne realized early on, in the future field of gravitational-wave astronomy, it would not be enough to collect data; researchers would also need to know what signals to look for. But it is notoriously difficult to extract quantitative predictions from the equations of Einstein's general relativity. Theoretical physicist Alessandra Buonanno had devised formulae for calculating the approximate orbits of spiralling objects and the gravitational waves they would generate in work she had done, in part with her PhD adviser Thibault Damour, at the Institute of Advanced Scientific Studies near Paris. The LIGO and Virgo collaborations use a database of hundreds of thousands of these waveforms for spotting gravitational waves in their data in real time." Not true. Actually LIGO conspirators don't use theoretically calculated waveforms in detecting (more precisely, faking) gravitational wave signals: The Nobel Committee for Physics: "While these waveforms provide a reasonable match, further important improvements are obtained using numerical methods that are very computationally intensive [23]. The analytical methods are crucial to producing the big library of template waveforms used by LIGO. While the waveforms produced in this way are necessary for determining the detailed properties of the objects involved, as well as identifying weak signals, they were not essential for the very first detection of GW150914. This was a model-independent detection of a gravitational-wave transient." https://www.nobelprize.org/nobel_prizes/physics/laureates/2017/adv physicsprize2017.pdf According to Rana Adhikari, professor of Physics at Caltech and a member of the LIGO team, LIGO conspirators have no preliminary knowledge about the signals. Adhikari declares: "the only thing that we really know is what we measure. And that's the mantra of the true empirical person": Rana Adhikari: "You split it in two and you send it in two separate directions, and then when the waves come back, they interfere with each other. And you look at differences in that interference to tell you the difference in how long it took for one beam to go one way, and the other beam to go the other way. The way I said it was really careful there because there's a lot of confusion about the idea of, these are waves and space is bending, and everything is shrinking, and how come the light's not shrinking, and so on. We don't really know. There's no real difference between the ideas of space and time warping. It could be space warping or time warping but the only thing that we really know is what we measure. And that's the mantra of the true empirical person. We sent out the light and the light comes back and interferes, and the pattern changes. And that tells us something about effectively the delay that the light's on. And it could be that the space-time curved so that the light took longer to get there. But you could also imagine that there was a change in the time in one path as opposed to the other instead of the space but it's a mixture of space and time. So it sort of depends on your viewpoint." https://blog.ycombinator.com/the-technical-challenges-of-measuring-gravitational-waves-rana-adhikari-of-ligo/ Pentcho Valev

4. *Pentcho Valev* • 2017-10-09 04:23 PM

Another sword of Damocles hanging over LIGO conspirators (and over the Nobel committee as well). They had no idea what they were measuring (faking) and produced signal correlation but also noise correlation that they are unable to explain: James Creswell, Sebastian von Hausegger, Andrew D. Jackson, Hao Liu, Pavel Naselsky, June 27, 2017: "As a member of the LIGO collaboration, Ian Harry states that he "tried to reproduce the results quoted in 'On the time lags of the LIGO signals'", but that he "[could] not reproduce the correlations claimed in section 3". Subsequent discussions with Ian Harry have revealed that this failure was due to several errors in his code. After necessary corrections were made, his script reproduces our results. His published version was subsequently updated. [...] It would appear that the 7 ms time delay associated with the GW150914 signal is also an intrinsic property of the noise. The purpose in having two independent detectors is precisely to ensure that, after sufficient cleaning, the only genuine correlations between them will be due to gravitational wave effects. The results presented here suggest this level of cleaning has not yet been obtained and that the identification of the GW events needs to be re-evaluated with a more careful consideration of noise properties." http://www.nbi.ku.dk/gravitational-waves/gravitational-waves.html James Creswell, Sebastian von Hausegger, Andrew D. Jackson, Hao Liu, Pavel Naselsky, August 21, 2017: "In view of unsubstantiated claims of errors in our calculations, we appreciated the opportunity to go through our respective codes together - line by line when necessary - until agreement was reached. This check did not lead to revisions in the results of calculations reported in versions 1 and 2 of arXiv:1706.04191 or in the version of our paper published in JCAP. It did result in changes to the codes used by our visitors [LIGO conspirators]. [...] In light of the above, our view should be clear: We believe that LIGO has not yet attained acceptable standards of data cleaning. Since we regard proof of suitable cleaning as a mandatory prerequisite for any meaningful comparison with specific astrophysical models of GW events, we continue to regard LIGO's claims of GW discovery as interesting but premature." http://www.nbi.ku.dk/gravitational-waves/gravitational-waves-comment2.html Here is Sabine Hossenfelder's article: Sabine Hossenfelder: "Was It All Just Noise? Independent Analysis Casts Doubt On LIGO's Detections. A team of five researchers - James Creswell, Sebastian von Hausegger, Andrew D. Jackson, Hao Liu, and Pavel Naselsky - from the Niels Bohr Institute in Copenhagen, presented their own analysis of the openly available LIGO data. And, unlike the LIGO collaboration itself, they come to a disturbing conclusion: that these gravitational waves might not be signals at all, but rather patterns in the noise that have hoodwinked even the best scientists working on this puzzle. [...] A few weeks ago, Andrew Jackson presented his results in Munich. A member of the local physics faculty (who'd rather not be named) finds the results "quite disturbing" and hopes that the collaboration will take the criticism of the Danes to heart. "Until LIGO will provide clear scientific(!) explanation why these findings are wrong, I would say the result of the paper to some extent invalidates the reliability of the LIGO discovery." https://www.forbes.com/sites/startswithabang/2017/06/16/was-it-all-just-noise-independent-analysis-casts-doubt-on-ligos-detections/ In a world different from our post-truth world the disclosure of the noise correlation would mark the end of the LIGO project and the beginning of an interrogation. In the post-truth world the glory of the fraudsters can only increase - if the absurd noise correlation cannot topple them, nothing can! Immediate Nobel prize - should have been given to LIGO fraudsters a year ago! Pentcho Valev

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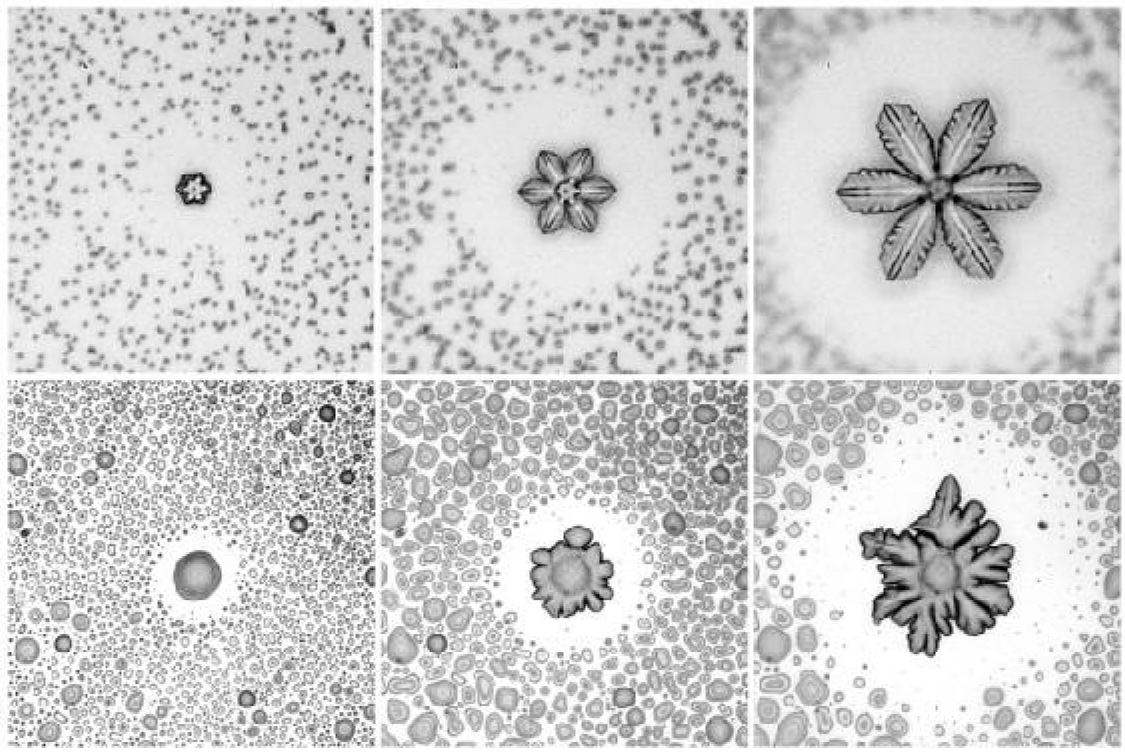
Water-repellent coatings could make de-icing a breeze

Coatings that force ice to grow upwards from the surface could make it easier to remove.

09 October 2017



Wang et al., DOI 10.1073/pnas.1712829114

Ice growth on hydrophillic (top layer) and hydrophobic surfaces

When water droplets suspended in the air freeze, they generate snowflakes — ice crystals with six-fold symmetry. But when ice grows along a solid surface, like frost growing on windows, it can take on an almost infinite range of different shapes.

These crystalline patterns are affected by whether a surface repels or absorbs water, says a team led by materials scientists Jianjun Wang of the Chinese Academy of Sciences Institute of Chemistry in Beijing and Xiao Cheng Xeng of the University of Nebraska–Lincoln. The researchers showed that when a surface tends to repel water, ice crystals can be cultivated to grow away from the surface at an angle, resembling a clover with six leaves.

The work was published on 9 October in the *Proceedings of the National Academies of Science*[1].

Clover crystals

Using a high-speed camera attached to a microscope, the team captured imagery of ice forming on aluminium that had been covered with a hydrophobic, or water-repellent, coating. Water drops sprayed on the surface remained taut and spherical instead of spreading out.

The researchers triggered ice formation across the entire surface by spraying it with silver iodide nanoparticles, which acted as seeds for ice growth. As the ice developed, the crystals grew outwards and up from the nanoparticle, forming a symmetrical, six-leafed clover with only a single point of contact with the surface.

On hydrophilic, or absorbant, surfaces, water spread out quickly, and so did ice — forming a sunflower-shaped crystal in full contact with the surface.

And, when the team prepared a hybrid surface with both hydrophilic and hydrophobic parts, ice spreading on the hydrophilic side came to a halt at the boundary with the hydrophobic side.

The researchers also observed that the clover-like ice crystals growing away from a hydrophobic surface could be removed by wind more easily than crystals on a hydrophilic surface.

They suggest that this could be exploited to make surfaces such as car windscreens more resistant to icing by embedding nanoparticles inside them. “The key is to have these stable ice-nucleation sites,” says Wang.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22790

Comments

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Build on the outer space treaty

09 October 2017

Fifty years on, the agreement is being pushed to its limits by changing geopolitics, technology and commercial interests, warns Joan Johnson-Freese.

Reuters

The Long March-5 Y2 rocket takes off from Wenchang Satellite Launch Center in Wenchang, Hainan Province, China in July 2017.

On 10 October 1967, the Outer Space Treaty went into force. Agreed on during a golden age of cooperation between the then-dominant superpowers, the Soviet Union and the United States, the treaty deems space a domain to

be shared by all nations. It states: “The exploration and use of outer space, including the moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind.”

The treaty gave rise to a series of others that govern space today: the Rescue Agreement (1968), the Liability Convention (1972), the Registration Convention (1976) and the Moon Agreement (1984). Although the United States and Soviet Union declined to sign the Moon Agreement, to avoid having to share lunar resources and technologies, most issues were seemingly covered — liability for damage caused by space objects, the safety and rescue of spacecraft and astronauts, and the rules governing the exploitation of space resources and settling disputes.

A lot has changed since. Launch costs have plummeted — from US$20,000 to send one kilogram into orbit in the late twentieth and early twenty-first centuries to as little as $5,000 now. And more nations, people, businesses and organizations are seeking to establish themselves in space. 'NewSpace' entities — non-governmental actors, often with commercial interests and financed through personal wealth — are diversifying the space landscape, with motivations ranging from human settlement to economic development. SpaceX founder Elon Musk, for example, has said that becoming an interplanetary species is the only way for humanity to avoid an eventual extinction event on Earth, and that he wants to “die on Mars, just not on impact”. Planetary Resources, a US-based asteroid-mining company, states that its vision is to extend the economy into space.

Meanwhile, conventional interests of prestige, geostrategic influence and military missions in space have come to the fore. Access to space is considered a “vital national interest” by the United States[1], an area of revitalized national interest by Russia, and an aspiration of China, India[2] and a growing number of other countries. India and China's 'space race', crucial to each country's national prestige, is arguably fiercer than even the twentieth-century US–Soviet race.

In terms of military competition, the United States sees China's encroachment

on space as heightening the risk of a space war[3]. China's launch of a 'science mission' in May 2013 that nearly reached geosynchronous orbit (about 36,000 kilometres above Earth) caused quiet panic in the Pentagon and in US intelligence circles. The United States had considered that orbit a sanctuary, out of reach of foes, for some of its most strategically important spy satellites, such as those in the Keyhole series.

LISTEN

Earlier this year, the Nature Podcast marked half a century since the Outer Space Treaty was opened. Here, reporter Adam Levy looks at its relevance to our relationship with space today.

You may need a more recent browser or to install the latest version of the Adobe Flash Plugin.

Fifty years on, the Outer Space Treaty and its spin-offs are still appropriate. But interpretations of its provisions are, more than ever, being influenced by commercial interests and politics. Supplementary rules and norms are needed. In an era in which international cooperation on treaties is tenuous, informal agreements and resolutions must guide space-faring actors, protect the environment and prevent wars.

Competing interests

The United States is the largest player in terms of space spending, capabilities and assets in orbit. The government alone spends about $40 billion each year on space activities through the Department of Defense and NASA, with China and Russia next, at about $6 billion each. Japan, France, Germany, Italy, India, Canada and the United Kingdom together spend around $11 billion. As of 1 January, there were 1,459 satellites in orbit, of which 593 belong to the United States, 135 to Russia and 192 to China.

US strategic thinking will largely shape the direction of future global space policies. And the 2011 US National Security Space Strategy described the

official US view of space as “congested, contested, and competitive”. Active satellites and debris from old missions clutter the skies. More than 500,000 pieces of debris, ranging in size from a baseball to a school bus, are being tracked in Earth orbit. Millions of smaller but nonetheless dangerous pieces are not.

The number of countries, consortia and companies involved in space is growing. In 1959, when the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) was formed, there were 24 members. Today, there are 84. Although few countries can afford to develop their own launch capabilities, none wishes to be left out of the expanding information age facilitated by space technology. Data that were once available only to or through governments, such as remotely sensed data, are now available through private companies. Commercial communications satellites increasingly carry military traffic. In 2013, US troops operating in Africa began using a Chinese Apstar-7 satellite to carry data.

Almost 50 commercial and non-profit organizations are listed in the informal directory of the Space Frontier Foundation in Arlington, Virgina, which is committed to facilitating the human settlement of space. These companies are exploring ideas from satellite refuelling to mining asteroids for water and providing extraterrestrial human habitats, among other projects.

The main driver of change in US thinking about space security is the number of countries that are developing capabilities with potential military uses. Since the 1990–91 Gulf War, when the use of the Global Positioning System (GPS) allowed coalition troops and equipment to be moved across the desert without being detected, the US military has reaped the advantages of its advanced space-based technologies. Satellites are used for command, control, communications, reconnaissance and intelligence.

AL SEIB/Los Angeles Times/Getty

Sir Richard Branson presents Virgin Galactic SpaceShipTwo, part of the company's space-travel efforts.

Many countries desire similar capabilities and are developing a wide range of 'dual-use' space technologies, which are of value to both the civil and military sectors. China and Russia have their own versions of GPS. Missile-defence systems being built by the United States, China, Russia and India use targeting systems similar to those required for an anti-satellite weapon. Yet, so far, no country has crossed the Rubicon of explicitly and officially developing a space weapon.

Space security

Two debates have broken out among space-security analysts. First, are more rules needed for managing the space environment sustainably for all? Second, is space warfare inevitable or how should one deter it?

Space-resource ownership and traffic need to be managed. In 2015, the US Congress enacted legislation to protect the interests and investments of US companies, such as Planetary Resources, that seek to harvest the potentially vast mineral and water resources of the asteroid belt as early as the 2020s. The Spurring Private Aerospace Competitiveness and Entrepreneurship Act of 2015, or SPACE Act, entitles US citizens to “possess, own, transport, use and sell” extracted materials, subject to the obligations of the United States under the various treaties it has previously signed[4].

Some argue that this act violates Article II of the Outer Space Treaty. It states: “Outer space, including the moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means.” Even without making territorial claims, appropriation of resources could restrict access to resources for others and potentially encourage environmentally risky exploitation of the Moon, planets and asteroids.

Space-traffic management is the equivalent of air-traffic control. It is in no one's interest to have thousands of planes flying around unchecked, and so is the case with satellites. You need to know where they are and where they will be. Traffic-management systems must be able to notify parties of potential collisions and events, such as when a satellite 'goes rogue' and is beyond control, or suddenly comes back to life, as the LES-1 satellite did in 2016 after 46 years of silence.

Public organizations such as the US military's Joint Space Operations Center (JSpOC) and private bodies such as the Space Data Association are making progress on these issues, including coordination between the public and private sectors. The addition of a Commercial Integration Cell, where commercial operators are able to interact with their military counterparts, at JSpOC in 2015 was seen as a landmark in commercial–military cooperation. Nevertheless, some satellite owners, especially intelligence agencies, are reluctant to share too much information. That spurs the question of whether traffic rules for operation are needed, or even acceptable. Rules restrict actions, which neither companies nor governments welcome.

The United States has largely shunned multilateral rules for coordinating and limiting space operations beyond the provisions already in place through the

Outer Space Treaty. Three key arms-control provisions of the Outer Space Treaty reside in Article IV. First, parties should not place in orbit around Earth any objects carrying nuclear weapons or other weapons of mass destruction, install such weapons on celestial bodies or station them in outer space. Second, the Moon and other celestial bodies must be used exclusively for peaceful purposes. And third, it is forbidden to establish military bases, installations or fortifications, or to test any type of weapon or conduct military manoeuvres on celestial bodies.

However, military personnel's involvement in scientific research or other peaceful endeavours is not prohibited. Many early astronauts and cosmonauts were members of the military. Similarly permitted is the use of military equipment or facilities for peaceful purposes. But the dual-use nature of many space technologies means that civilian efforts often concurrently improve military capabilities. For example, developing tracking stations for human spaceflight missions also improves missile-tracking ability. The many definitions of peaceful — ranging from non-military to non-offensive — have allowed space to slip through the cracks of arms-control efforts since 1984.

Although weapons of mass destruction are banned in space, weapons in general are not. Releasing energy or kinetic force in space, through lasers and electromagnetic pulses, flak or collisions, can pollute the orbital environment for decades. From the 1962 US Starfish Prime test of nuclear weapons in space to the more recent anti-satellite weapons test carried out by China in 2007, the debris created can take decades to clear. The 2007 Chinese test generated some 3,000 pieces of space debris through some of the most populated low-Earth-orbit positions. As more satellites switch off and remnants break up, space becomes more difficult, expensive and dangerous to use. The International Space Station, for example, has had to manoeuvre several times to avoid colliding with space junk.

Since the contentious May 2013 Chinese launch, the United States has shifted its position on space warfare. Previously, its stance was strategic restraint, refraining from introducing offensive space capabilities in the hope of moderating the behaviour of friends and potential foes; since 2013 it has been preparing for war in space, whatever that might look like. US officials are

now actively exploring offensive and defensive space-based activities, with the only caveat being to avoid creating debris.

In 2008 and again in 2014, China and Russia submitted a joint proposal to the United Nations for a Treaty on Prevention of the Placement of Weapons in Outer Space and of the Threat or Use of Force Against Outer Space Objects, dubbed the PPWT. Each time, the United States rejected the proposal as “fundamentally flawed”. Among the reasons cited are that it is unverifiable — it is difficult to define a space weapon owing to the dual-use nature of most of the technology; it does not prohibit the development and stockpiling of space arms; and it does not consider ground-based space weapons, such as that demonstrated by the Chinese in 2007.

Rather than shift to aggressive policies, nations should instead show further restraint and cooperation.

The way forward

Space laws need to be updated for our time. Extending the Outer Space Treaty or writing a new one is unlikely to work, as US hesitancy to sign the PPWT shows. 'Soft law', driven by need, seems the best option for revising the rules for space operators.

Soft law comprises rules or guidelines that have legal significance but are not binding. It sets standards of conduct for agreeing parties, much like those that protect the environment and endangered species. 'Rules of the road' and best practices for space should be developed. These could take a similar form to the navigation guidelines set out in the 1972 Convention on International Regulations for Preventing Collisions at Sea, which govern when one vessel should give way to another, as well as other interactions.

Soft law works when it is in the interest of all parties to abide by it. If countries and companies want to maintain the space environment as a usable domain, then it is in their interests to accommodate a variety of operations. Space is more complex to manage than air, land or sea because of the distance, physics and technology involved. Just as in the cyber domain,

technology has preceded regulation, making it difficult to impose after the fact.

The first focus of an analogous set of space guidelines should be environmental protection and debris avoidance, areas that most spacefaring nations agree on. Governments are engaged in groups such as the 13-member Inter-Agency Space Debris Coordination Committee (IADC). The 84-member COPUOS works through two subsidiary bodies to develop best practices for sustaining the space environment, including mitigating debris. COPUOS working groups will begin meeting again in January 2018 to continue developing best practices, with new proposals to be presented to the committee in June 2018. Commercial perspectives should be included through national delegations and external observers.

Politicization of any guiding principles must be resisted, for example, by seeking consensus. The IADC Steering Committee releases information and materials to the public only when all parties agree, and it works through sub-committees operating from a technical rather than a political perspective. COPUOS discussions are progressing, albeit slowly.

Encouraging mutual understanding and building trust between nations is crucial to avoid conflict. It is impossible to verify exactly what is happening in space if a satellite ceases to function: has there been an intentional attack, an act of nature or a technical glitch? This problem of distance and the nature of dual-use technology create ripe circumstances for mishaps. Transparency and confidence-building measures developed in 2013 by the UN-sponsored Group of Governmental Experts are designed to help avoid misunderstanding and miscalculations and should be widely adopted.

A coordinated human spaceflight mission, in which different nations work together towards a common goal, could build the kind of space environment envisioned in the Outer Space Treaty. US–Russian cooperation on the International Space Station has shown that when terrestrial tensions get high, working together can maintain ties.

Coordination is easier than cooperation when there are technology-transfer concerns. Proposing a big mission and inviting other countries to join would give the US human spaceflight programme a direction, as well as serving

strategic purposes. A crewed fly-by mission of Venus and Mars, for example, has been on the table since the days of the Apollo missions and could yet be resurrected. An encouraging example is the 'space armada' of coordinated missions to study Halley's comet in 1986, involving the Soviet Union, European Space Agency and Japan.

With the expansion of national and commercial space activities, the Outer Space Treaty will be stretched to its limits. In that regard, it will be serving its intent — paving the way for the peaceful exploration and development of space.

Journal name:
    Nature
Volume:
    550,
Pages:
    182–184
Date published:
    (12 October 2017)
DOI:
    doi:10.1038/550182a

Comments

Comments

There are currently no comments.

Nature News

周二, 24 10月 2017

Nature News

[周二, 24 10月 2017]

- **Nature News**

Nature News

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  Ahmadreza Djalali, a researcher in disaster medicine, has 20 days to appeal against his death sentence.
- **Photons pair up like superconducting electrons** [周五, 20 10月 08:00]
  Discovery raises questions about how a light 'supercurrent' might behave.
- **Quantum machine goes in search of the Higgs boson** [周四, 19 10月 08:00]
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- **Jupiter's stormy winds churn deep into the planet** [周四, 19 10月 08:00]
  Juno probe discovers surprising activity in the giant planet’s interior.
- **The science of puppy dog eyes** [周四, 19 10月 08:00]
  Dogs' facial expressions depend on human attention.
- **The Human Cell Atlas: from vision to reality** [周三, 18 10月 08:00]
  As an ambitious project to map all the cells in the human body gets officially under way, Aviv Regev, Sarah Teichmann and colleagues outline some key challenges.
- **Top Chinese university to consider social-media posts in researcher evaluations** [周三, 18 10月 08:00]
  Controversial policy means mainstream media are starting to rival rigorous academic publications in some universities in China.
- **Mysterious particles spotted in Saturn’s atmosphere** [周三, 18 10月 08:00]
  Source may be dust shed by planet’s iconic rings, according to data from NASA's doomed Cassini probe.

- [Efforts to save leading Hungarian university hit hurdle]() [周三, 18 10月 08:00]
  US-registered Central European University faces another year of uncertainty over whether it can continue to operate in Hungary.
- [Sleeping sickness can now be cured with pills]() [周三, 18 10月 08:00]
  Researchers seek approval from regulators for this quicker, easier treatment.
- [Self-taught AI is best yet at strategy game Go]() [周三, 18 10月 08:00]
  Artificial-intelligence program AlphaGo Zero trained in just days, without any human input.
- [Science must examine the future of work]() [周三, 18 10月 08:00]
  As automation changes employment, researchers should gather the evidence to help map the implications.
- [Blue is in the eye of the bee-holder]() [周三, 18 10月 08:00]
  Flowers have evolved an ingenious way to attract pollinators.
- [Epic star collision, asteroid fly-by and journal resignations]() [周三, 18 10月 08:00]
  The week in science: 13–19 October 2017.
- [New definitions of scientific units are on the horizon]() [周三, 18 10月 08:00]
  Metrologists are poised to change how scientists measure the Universe.
- [The future of work]() [周三, 18 10月 08:00]
  Digital technologies are upending the workforce. The right research can tell us how.
- [The shape of work to come]() [周三, 18 10月 08:00]
  Three ways that the digital revolution is reshaping workforces around the world.
- [Lessons from history for the future of work]() [周三, 18 10月 08:00]
  Global comparisons of previous social and economic upheavals suggest that what is to come depends on where you are now, argues Robert C. Allen.
- [The second Renaissance]() [周三, 18 10月 08:00]
  Ian Goldin calls on scientists to help society to weather the disruptive transformations afoot.
- [Archaeology: The wonder of the pyramids]() [周三, 18 10月 08:00]
  Andrew Robinson enjoys a volume rounding up research on the complex at Giza, Egypt.
- [Books in brief]() [周三, 18 10月 08:00]
  Barbara Kiser reviews five of the week's best science picks.
- [History: Five millennia of Indian science]() [周三, 18 10月 08:00]
  James Poskett applauds a show celebrating discovery on the subcontinent, from zero to the boson.
- [Federal funding: Stifled by budgets, not irrelevance]() [周三, 18 10月 08:00]
- [Ornithology: Danish dairy farmer delivers data coup]() [周三, 18 10月 08:00]

- **[Open data: Spot data glitches before publication]** [周三, 18 10月 08:00]
- **[PhD students: living wage key to diversity]** [周三, 18 10月 08:00]
- **[PhD students: side jobs are no solution]** [周三, 18 10月 08:00]
- **[Breaking and entering]** [周三, 18 10月 08:00]
  Escape is not an option.
- **[Brazilian Amazon still plagued by illegal use of natural resources]** [周二, 17 10月 08:00]
  Practices such as poaching and illegal logging are concentrated near inhabited areas and along rivers, study finds.
- **[Give researchers a lifetime word limit]** [周二, 17 10月 08:00]
  Brian C. Martinson imagines how rationing the number of publications a scientist could put out might improve the scientific literature.
- **[Japanese research leaders warn about national science decline]** [周二, 17 10月 08:00]
  Concern mounts over budget cuts and other changes that undermine basic science.
- **[Reboot for the AI revolution]** [周二, 17 10月 08:00]
  As artificial intelligence puts many out of work, we must forge new economic, social and educational systems, argues Yuval Noah Harari.

Shrew skulls shrink for winter survival

Getting smaller by absorbing bone tissue may help animals to save energy when food is scarce.

23 October 2017

Karol Zub

Skulls of the common shrew (*Sorex araneus*) shrink by about 15% in winter and regrow the next summer.

Common shrews shrink their heads — including their skulls — in winter, researchers have found. They believe that this dramatic example of downsizing may help the animals to survive when food is scarce.

Individual wild common shrews (*Sorex araneus*) captured and tagged in Germany showed large reductions in skull size and body mass over the winter. Their spines also got shorter, and major organs, including the heart, lungs and spleen, shrank. Even their brain mass dropped by 20–30%, according to Javier Lázaro, a biologist at the Max Planck Institute for Ornithology in Radolfzell, Germany. In spring, the animals started to regrow.

“We hypothesize that these seasonal changes could have adaptive value,” says Lázaro, who led the work. Shrews have an extremely fast metabolism, he points out, and reducing their body mass during winter might increase their chances of survival, because they wouldn’t need so much food. In particular, he adds, “reducing brain size might save energy, as the brain is energetically so expensive”.

Up and down

The researchers trapped live shrews, then anaesthetized, X-rayed and weighed them. They also fitted each animal with a microchip, so they could monitor changes in shrews that were recaptured over their roughly 14-month lifespan. Twelve animals were captured during each key life stage: the first summer of their lives, the next winter and the following spring and summer.

The results are published in *Current Biology*[1] on 23 October. The shrews’ skulls shrank by about 15% from summer to winter, an effect that the X-ray images suggest was caused by resorption of tissue at the joints between skull bones. This bone then regenerated in spring, although the skulls didn’t quite return to their original summer size.

“Tracking of individual animals is crucial here — this is really great work,” says zoologist Leszek Rychlik of Adam Mickiewicz University in Poznań, Poland. Rychlik has previously found[2] that common shrews in northeastern Poland show seasonal changes in body mass on a population level. But Lázaro’s team is the first to show that the skulls of individual shrews shrink.

Cold comfort

Lázaro and his colleagues are now investigating which brain structures change most from season to season, and whether the animals experience any cognitive impairments in winter. If they do, it might not matter too much, says Rychlik. “Their winter life is more boring,” he says. “They are less active, less involved in interactions, not busy with reproduction and searching for partners. They are just focused on foraging and saving energy.”

Just how many species might shrink their brains for winter is not known. Even at the population level, seasonal comparisons are often not possible, because biologists tend to collect specimens in summer rather than winter. In work being prepared for publication, Rychlik has found seasonal differences in skull size and body mass in two other members of the red-toothed-shrew sub-family: the pygmy shrew (*Sorex minutus*) and the Eurasian water shrew (*Neomys fodiens*). Some of Lázaro’s co-authors have also found[3] similar differences in two species of weasel.

These differences were observed in dead animals, but “we think they are caused by the same individual shrink–regrow process”, says Lázaro. He adds that a similar ability might exist in other small, high-metabolism animals that live in seasonal environments and don’t hibernate or use other strategies to save energy. Although still exceptional, he says, “the phenomenon might be more common than we think”.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22874

Comments

Comments

There are currently no comments.

Iranian scholar sentenced to death

Ahmadreza Djalali, a researcher in disaster medicine, has 20 days to appeal against his death sentence.

23 October 2017

Courtesy of Vida Mehrannia

Researcher Ahmadreza Djalali was convicted of espionage and sentenced in Iran on 21 October.

A judge in Tehran has ordered the death penalty for Iranian researcher Ahmadreza Djalali, according to his wife and diplomatic sources in Italy.

Djalali is affiliated with the Karolinska Institute in Stockholm, Sweden, and the University of Eastern Piedmont in Novara, Italy. A resident of Sweden

with his family, Djalali was arrested in April 2016 on an academic visit to Tehran and accused of “collaboration with a hostile government”. He works on improving hospitals’ emergency responses to armed terrorism and radiological, chemical and biological threats.

Djalali was convicted of espionage following a trial led by Abolqasem Salavati, a judge in Iran's revolutionary court, and sentenced to death on 21 October, according to Djalali's wife Vida Mehrannia and to Italian diplomatic sources. They say he has 20 days to appeal against the sentence.

Mehrannia says that her husband was accused of obtaining money, academic positions and research projects in exchange for spying on Iran for Israel.

Djalali document

Shortly before the sentence was announced, a close contact of Djalali's (who would prefer to remain anonymous) circulated a document that claims to be a literal transcription of a handwritten text produced by Djalali inside Evin prison, where he is being held. The document states that Djalali believes he was arrested for refusing to spy for the Iranian intelligence service.

According to the document, in 2014 two representatives of the Iranian military and intelligence service asked Djalali to spy on European countries for Iran — in particular, on “critical infrastructures, counter-terrorism and CBRNE [chemical, biological, radiological, nuclear and explosives] capabilities, sensitive operational plans, and also research projects, relevant to terrorism and crisis.” It says he refused.

The document claims that Djalali was forced to make false confessions following “multiple psychological and physical tortures”. “I have never acted against my country, I have never spied for Israel or any other country. My only fault is that I did not accept to use the trust of my colleagues and universities in EU to spy for Iran's intelligence services,” the text states.

Djalali’s colleagues have reacted with dismay. “None of our shared research projects had partners in Israel and I am not aware of any money transfer from Israel to Djalali. We relied on European Commission funds,” says Luca

Ragazzoni, a health researcher at the University of Eastern Piedmont, who worked with Djalali from 2012 to 2015. “We did not have access to secret data,” he says.

Mehrannia says that Djalali is considering a hunger strike in protest at the sentence. Since his imprisonment, Djalali has carried out multiple hunger and thirst strikes. He was also forced to change his lawyer against his will, according to the Committee of Concerned Scientists, a lobby group. Several scholars and human-rights organizations have repeatedly called for a fair trial or release for Djalali.

Djalali’s story echoes those of other Iranian scientists. Omid Kokabee, a physicist released from a Tehran jail in August 2016 after five years' imprisonment, says he believes he was punished for refusing to help a covert nuclear-weapons programme. Hamid Babaei, who was undertaking a PhD in finance in Belgium but is now serving a six-year prison sentence in Iran, has said he was arrested for refusing to spy on his colleagues.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22875

Comments

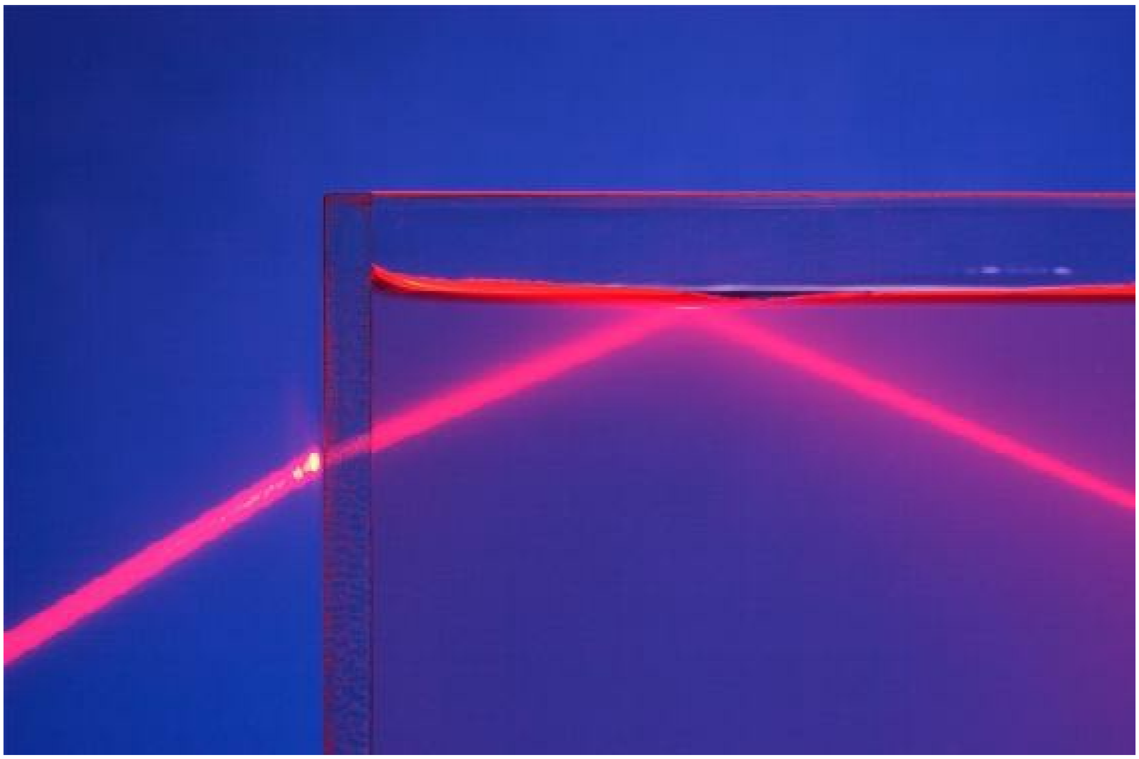
Comments

There are currently no comments.

Photons pair up like superconducting electrons

Discovery raises questions about how a light 'supercurrent' might behave.

20 October 2017



GIPhotoStock/SPL

Photons of light pair up as they travel through water, just like electrons in a superconductor.

Superconductivity — a phenomenon in which electrons can travel through certain materials with zero resistance — has revolutionized parts of medicine, travel and science. Now, an intriguing experiment has seen the same behaviour that underlies superconductivity — but in particles of light. The

finding has left physicists wondering how far the comparison might reach.

“This is really exciting work,” says Nick Vamivakas, a quantum physicist at the University of Rochester, New York, who was not involved with the research. “It’s a beautiful connection between light scattering, condensed-matter physics and quantum optics.”

Conventional superconductivity relies on the formation of ‘Cooper pairs’ of electrons, which stabilize each other’s path and allow electricity to flow without resistance. Its discovery led to the development of powerful superconducting magnets, which are now used in medical scanners, particle accelerators, wind turbines and magnetically levitated trains.

Physicists in Brazil have now seen evidence of photons of light forming similar pairs. The process occurs at room temperature when light passes through a range of transparent liquids, including water, although it is very difficult to observe. “Not only is this formation of pairs possible, but it is everywhere,” says André Saraiva, a theoretical physicist at the Federal University of Rio de Janeiro (UFRJ) and co-author of a paper that has been accepted for publication in *Physical Review Letters.*

The team has yet to explore how far the parallel with superconductivity goes. As photons already interact less with their environment than electrons do, similar pairs in light are unlikely to lead to such dramatic effects as in electric currents. But the work is already triggering speculation about how light ‘supercurrents’ might behave, and how they might be used.

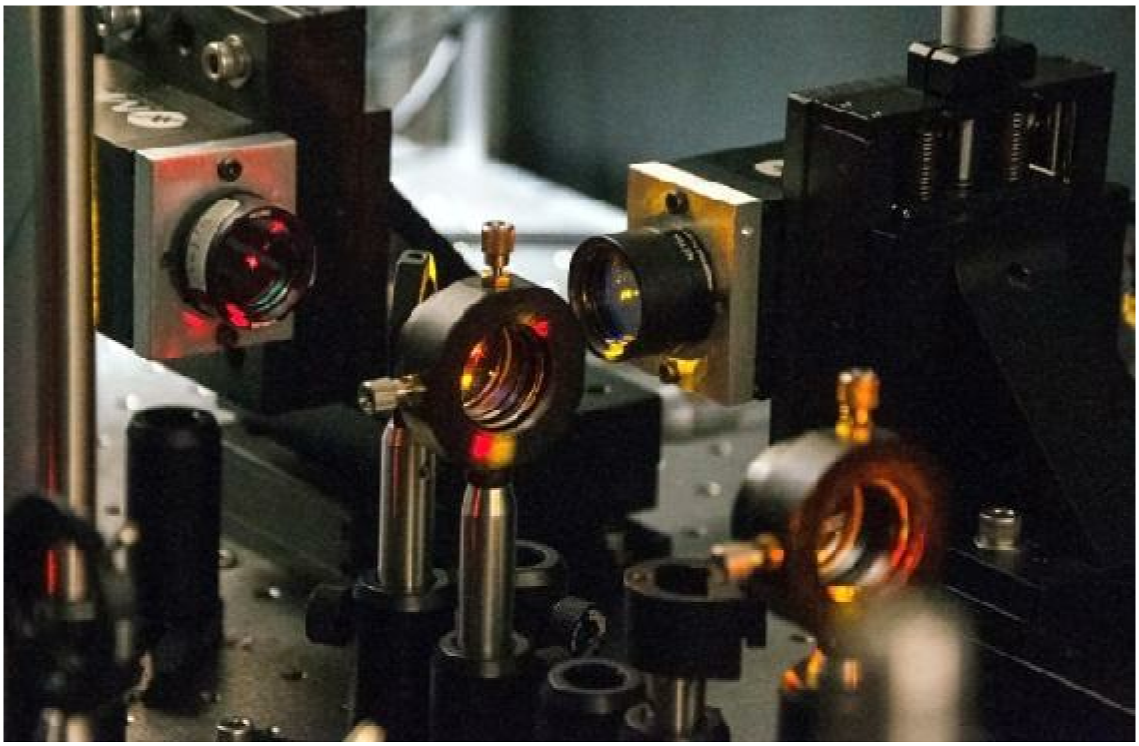
Pairing up

The discovery stems from work led by Ado Jorio at the Federal University of Minas Gerais in Belo Horizonte, Brazil, which investigated how light scatters within materials. When this happens, photons can lose energy to the atoms in the material, which vibrate. If a second photon immediately absorbs this packet of vibrational energy, the two photons become indirectly linked, with one gaining the energy the other lost.

When Jorio described his research to the condensed-matter department at

UFRJ, it sparked an idea in physicist Belita Koiller. She noticed the similarity between this process (in which vibrations caused by one photon affect another) and the formation of Cooper pairs in superconductivity, when distortions in an atomic lattice, caused by a speeding electron, allow the particle to attract a partner in its wake.

In both cases, pairs form as a result of movement in the atoms around them. In superconductors, however, the vibrations are of a fleeting kind allowed by quantum mechanics, known as virtual phonons. Koiller and her team wondered: was this true for light as well?



Cassiano Rabelo

Physicists in Brazil used a filter to capture only photon pairs created by quantum vibrations known as virtual phonons.

First, the UFRJ team showed mathematically that if photons also interact via virtual phonons, their behaviour would be an exact match for Cooper pairs in superconductors. Then the researchers looked for evidence of such pairs by shining pulses of laser light at room temperature through water and seven other transparent liquids. They used detectors to examine the emerging photons, searching for pairs that arrived simultaneously, in which one photon had shifted towards red (losing energy) and the other towards blue (gaining energy).

If the arriving pairs were created by virtual phonons, rather than the standard scattering process, the energy shifts of the photons should be too small to come from classically allowed vibrations, so the team applied a filter to let through only this range of energy shifts. They compared the results with the number they saw when both types of energy shifts were allowed.

In both cases, they saw the same rate of photon pairs, suggesting that the pairs had to be created by the virtual process. The signal was tiny: of around 10 quadrillion photons pumped through the material per second, they saw 10 pairs, compared with the 1 pair every 10 seconds that they would have expected to see by chance.

It's an interesting discovery, says Andrea Ferrari, a physicist at the University of Cambridge, UK, although he cautions that the explanation will need to be validated by other groups. “I would say this is not the end, but certainly the beginning.”

Intriguing possibilities

The possibility of Cooper-like pairs in light has both quantum optics and condensed matter physicists taking notice, says Saraiva, largely because they want to see how far the analogy with superconductivity can be stretched. In matter, Cooper pairs are behind a wide range of intriguing effects — but so far the team has no data to hint whether the same would apply with light. “These are very important questions we’re keen to answer,” says Saraiva.

If the team can boost the number of photon pairs, there could also be applications. Harnessing the way the paired photons interact with matter might reveal currently invisible properties of a material. And if the particles can be shown to correlate in ways beyond their timing — to have their quantum properties intrinsically linked — room-temperature water could

prove a remarkably cheap source of 'entangled' photons, which are essential for quantum cryptography and computing.

Physicists are also wondering whether the pairs might form supercurrents, behaving similarly to their electron counterparts: perhaps light would disperse less as it travels through a material, for example, leading to more efficient quantum communication. Might paired photons even make materials more transparent? At this stage, says Saraiva, we just don't know.

For now, all this is pure speculation. But mapping concepts from condensed-matter physics onto light research has a pedigree of generating useful technologies, says Vamivakas. Photonic crystals, for example, which are used to tailor how photons flow through materials, grew out of insights about how a crystal lattice influences electrons in mattter, he points out. Vamivakas says that when he first heard of the latest work, he asked his students: "Hey, why didn’t we think of this?"

The discovery might not have happened at all if it hadn't involved such a simple experimental set-up. Funding for science in Brazil has been cut by 60% since 2013, leaving many laboratories unable to sustain their equipment. “We were fortunate to come across such a profoundly important phenomenon that does not require special equipment to see,” says Saraiva. “We can’t count on this kind of luck every time."

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22868

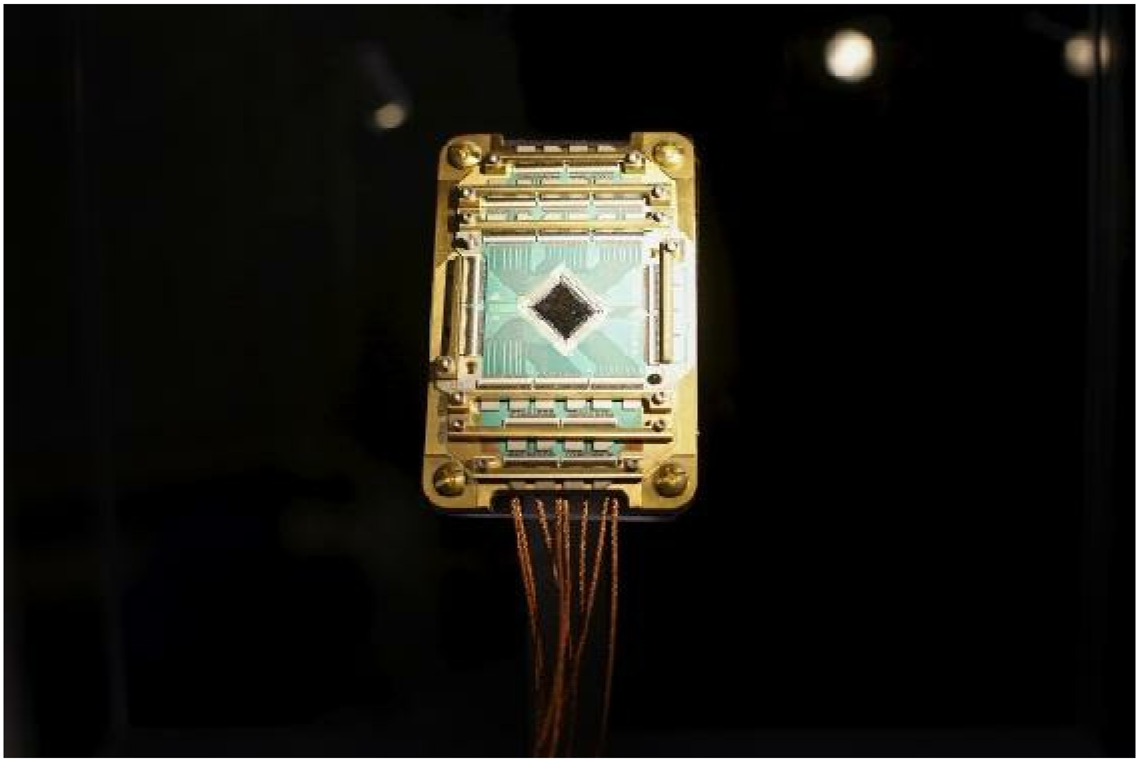
Comments

Commenting is currently unavailable.

Quantum machine goes in search of the Higgs boson

D-Wave system shows quantum computers can learn to detect particle signatures in mountains of data, but doesn't outpace conventional methods — yet.

19 October 2017



Stephen Lam/Reuters

A quantum processing unit such as this might soon offer a more efficient way to detect rare particles.

A rudimentary quantum computer has rediscovered the Higgs boson. Sort of.

Physicists have been working hard to develop machines that can use quantum mechanical tricks to speed up computation. But they also hope that such quantum computers can return the favour and help them to discover new laws of nature.

Now, a team has shown that a quantum circuit can learn to sift through reams of data from atom-smashing experiments in search of a new particle. Their proof-of-principle study — performed using a machine built by quantum-computing company D-Wave working on the now-familiar case of the Higgs boson — does not yet provide a clear advantage over conventional techniques. But the authors say that quantum machine learning could make a difference in future experiments, when the amounts data will grow even larger. Their research was published on 18 October in *Nature*[1].

Kyle Cranmer, a physicist at New York University who wasn't involved in the work, says that it's refreshing to see a quantum machine applied to a practical physics problem — instead of the usual mathematical questions such as factoring whole numbers into primes. "Before this point, people were aware that this maybe some day will be relevant," he says. "This makes it looks like maybe it is."

Optimal solutions

In 2012, two experiments at the Large Hadron Collider (LHC) at CERN, Europe's high-energy physics lab near Geneva, Switzerland, announced that they had proof of the existence of the Higgs boson, the last missing piece in the standard model of particle physics. The two experiments, called CMS and ATLAS, found evidence of the boson created in proton collisions from the way in which the Higgs decayed into more-common ones, such as pairs of high-energy photons. But each time the LHC collides two protons, hundreds of other particles are created, some of which can be misinterpreted as photons when they hit the detectors.

To help speed up their search for the Higgs, ATLAS and CMS physicists used simulated data to train machine-learning algorithms to tell wheat from chaff — photons from impostors.

More recently, particle physicist Maria Spiropulu, who helped lead the Higgs search at CMS, wanted to know whether a quantum computer could help to make the training process more efficient, in particular by reducing the amount of simulated data required to train the system. “I wanted to see if it can solve the Higgs problem, because I know the Higgs problem,” says Spiropulu, who is at the California Institute of Technology in Pasadena.

Her collaborator Alex Mott, a physicist who is now at DeepMind in London, translated the learning process into something that could be calculated by a ‘quantum annealing’ computer built by D-Wave, which is based in Burnaby, Canada. This type of machine finds the optimal solutions to certain problems by allowing superconducting loops, which encode quantum information, to fall into their lowest-energy state.

The idea was to have the quantum machine find the optimal criteria that an ordinary computer could then use to look for the photon signatures of the Higgs in real data. To test their theory, the team gained access to a D-Wave machine at the University of Southern California in Los Angeles. The experiment was successful, Spiropulu says: “We can train with small data sets and find the optimal solution.”

The researchers didn’t use those criteria to rediscover the Higgs — because they didn't need to. Showing that it is possible was “the coolest part” of their work, says Cranmer, who is a data-analysis specialist and helped lead the Higgs search in the ATLAS collaboration.

Beyond physics

Don’t expect physicists to switch to quantum computers just yet: so far, the machine hasn’t performed better than a virtual version of itself that Spiropolu and her team ran on a conventional computer. And there is a long way to go to demonstrate that these techniques are more efficient than some existing machine-learning algorithms that are able to train on relatively small data sets, Cranmer says. Spiropulu agrees, adding that it will be necessary to test the various approaches against one another to see which is best.

But the results could have an impact in fields beyond physics. Davide Venturelli, a physicist working for the non-profit Universities Space Research Association and at the NASA Ames Research Center in Mountain View, California, manages a programme that makes a D-Wave machine at Ames (jointly run by Google and NASA) available to experimenters around the world. Researchers in fields ranging from Earth science to bioinformatics are interested in using quantum annealers, in particular for machine-learning applications, he says.

“The interesting thing is that this whole thing works,” Mott says.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22860

Comments

Comments

There are currently no comments.

Sabre-toothed cats prowled Europe 200,000 years after supposedly going extinct

Ancient-DNA analysis also suggests a surprising connection with sabretooths in North America.

19 October 2017

Roman Uchytel/SPL

The sabre-toothed cat *Homotherium latidens* might have travelled between Eurasia and North America.

Sabre-toothed cats existed in Europe for hundreds of thousands of years longer than previously thought, according to a study[1] that settles a long-running debate among palaeontologists. The authors also found evidence that *Homotherium latidens*, a Eurasian sabretooth, and *Homotherium* serum from North America are genetically almost indistinguishable.

The findings are part of a project that used partial genome reconstructions to examine the evolutionary history of *Homotherium* sabre-toothed cats, which had smaller, more serrated fangs than *Smilodon* — the sabretooth most people think of, with its long fangs. The latest results, published on 19 October in *Current Biology*[1], upend ideas of how *Homotherium* moved between continents and when it went extinct.

When a trawler dredged up an ancient *H. latidens* jawbone while fishing in the North Sea off the Netherlands in 2000, it sparked controversy. Radiocarbon dating showed that the specimen was just 28,000 years old[2], shocking palaeontologists: the youngest *Homotherium* fossil found in Eurasia up to that point was about 300,000 years old. The analysis of ancient DNA in the latest study confirms the age of the North Sea specimen.

The team also constructed partial genomes of two *H. serum* fossils from the Yukon Territory in Canada and the North Sea *H. latidens* specimen. The two species were so similar genetically that they should probably be combined under the *H. latidens* name, says Johanna Paijmans, a palaeogeneticist at the University of Potsdam in Germany and lead author of the study.

But combining the species might be a bit premature until researchers find more sabretooth specimens in Europe, says Julie Meachen, a palaeontologist at Des Moines University in Iowa.

Mind the gap

Until then, researchers can only speculate as to why there’s such a huge gap in the Eurasian sabretooth fossil record and how animals on two different continents could be so genetically similar. Migration between *Homotherium* populations in Eurasia and North America could explain the species’ similarities, Meachen says.

It could also explain why sabretooths seem to pop back into existence in the fossil record hundreds of thousands of years after researchers thought they died out in Europe. The North Sea specimen could be evidence that the cats migrated back into Western Europe from Asia or over the Bering land bridge from North America. Or it could be that the Eurasian *H. latidens* population dwindled to such low numbers that the animals just don't show up in the fossil record, says Paijmans.

“There's no reason it can't be both,” says Margaret Lewis, a palaeontologist at Stockton University in Galloway, New Jersey. She adds that the species was probably very mobile, and that carnivores in general are always rarer in the fossil record than prey animals because there aren't as many predators. Some answers certainly lie in the DNA of the older European fossils, says Lewis.

But the technology to obtain those answers simply doesn't exist yet, says Paijmans. As DNA ages, it degrades and becomes harder to extract. Right now, researchers can obtain DNA from the mitochondria — a cell's battery pack — of younger specimens such as the North Sea *Homotherium*, but not from older fossils. However, Paijmans remains hopeful that the technology will eventually catch up.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22861

Comments

Comments

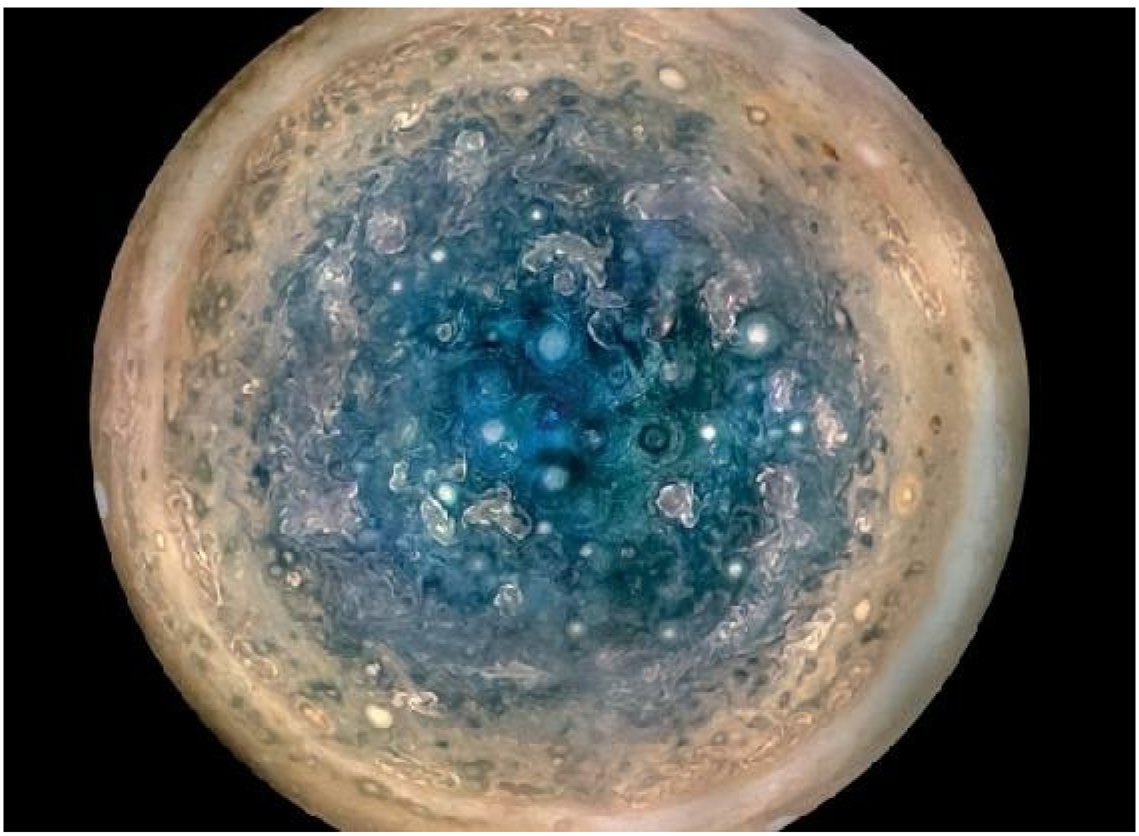
There are currently no comments.

Jupiter's stormy winds churn deep into the planet

Juno probe discovers surprising activity in the giant planet’s interior.

19 October 2017

Provo, Utah



NASA/JPL-Caltech/SwRI/MSSS/Betsy Asher Hall/Gervasio Robles

A ring of cyclones swirls around Jupiter's south pole.

NASA’s Juno spacecraft has plumbed the depths of Jupiter, revealing that the planet’s famous bands of swirling winds extend thousands of kilometres down. The work is the sharpest glimpse yet into Jupiter’s interior.

Jupiter’s colourful stripes are atmospheric patterns composed of winds that flow alternately east and west. Until now, researchers haven’t been able to say whether those bands are confined to a shallow layer or reach deeper into the planet. “Determining this is one of the main goals of the Juno mission,” said team member Yohai Kaspi, a geophysicist at the Weizmann Institute of Science in Rehovot, Israel, on 18 October at the American Astronomical Society’s Division for Planetary Sciences meeting in Provo, Utah.

Juno arrived at Jupiter in July 2016 and has been looping around it once every 53 days. The mission has already revealed several mysterious phenomena, such as Jupiter's patchy magnetic field and sets of cyclones that whirl around the planet's north and south poles like dancers around a maypole.

By studying Jupiter's gravitational field, researchers can probe thousands of kilometres into the planet. On each close fly-by, Juno measures the planet’s complex gravitational tug. These observations have already revealed that Jupiter has a small, ‘fuzzy’, poorly defined core[1].

Inner whirl

The latest results show that Jupiter’s gravitational field is askew, with different patterns in its northern and southern hemispheres, said Tristan Guillot, a planetary scientist at the Observatory of the Côte d’Azur in Nice, France. That suggests that its hydrogen-rich gas is flowing asymmetrically deep in the planet. “This is something that was not expected,” Guillot said at the meeting. “We were not sure at all whether we would be able to see that.”

Another clue to the structure of Jupiter’s interior came from how the gravity field varies with depth. Theoretical studies predict that the bigger the gravity signal, the stronger the flow of gas deep down[2, 3]. That information is important for teasing out whether all of Jupiter’s interior is rotating as a single solid body, or whether different layers spin separately from one another, like a set of nesting Russian dolls moving within each other.

Juno detected a gravity signal powerful enough to indicate that material is flowing as far down as 3,000 kilometres. “We’re just taking the clouds and the winds and extending them into the interior,” Kaspi said. Future work could help to pinpoint how strong the flow is at various depths, which could resolve whether Jupiter’s interior really resembles Russian dolls.

Juno scientists are now looking to see what else the gravity data will tell them, such as how far the famous storm called the Great Red Spot extends into the atmosphere. Another instrument aboard Juno has already hinted that the Great Red Spot’s roots may go hundreds of kilometres down, and it could go even deeper. “It’s not yet clear that it is so deep it will show up in gravity data,” said David Stevenson, a planetary scientist at the California Institute of Technology in Pasadena. “But we’re trying.”

Polar circles

Juno has also been peering into Jupiter’s depths in other ways. One big surprise from the mission was the clusters of cyclones at each pole, seen by Juno’s cameras in visible and infrared wavelengths. Scientists had not spotted the storms before because Juno is the first spacecraft to fly over Jupiter’s polar regions. There are eight cyclones around the north pole and five around the south pole — all are mysterious, because computer modelling suggests that such small storms would not be stable in swirling polar winds.

The answer may lie in a quirky physics concept known as a vortex crystal, said Fachreddin Tabataba-Vakili, a planetary scientist at NASA’s Jet Propulsion Laboratory in Pasadena. Such crystals have been seen in a few Earth-based phenomena such as rotating superfluids; they are born when small vortices form and persist as the material in which they are embedded continues to flow.

Something about the flow around Jupiter’s poles may set up the same dynamics, Tabataba-Vakili said. Next up is to work out why there are eight cyclones at one pole and five at the other, he added.

Between Jupiter’s polar cyclones and its deep interior flows, Juno continues to tease out new surprises from the Solar System’s biggest planet. “It’s clear that giant planets have a lot of secrets,” Guillot said.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22866

Comments

Comments

There are currently no comments.

The science of puppy dog eyes

Dogs' facial expressions depend on human attention.

19 October 2017

Everett Coll./Mary Evans Picture Library

Making eyes: dogs' facial expressions really are aimed at us, research suggests.

Every dog owner is familiar with the ‘puppy dog eyes’ expression. As the inner brow lifts, the eyes get bigger and bigger … It’s tempting to interpret this as a plea from a sad dog for a scrap of the family dinner. Now, a small study provides support for the idea that dogs do indeed produce facial expressions to communicate with people — although perhaps just to engage us, rather than to manipulate us.

The dogs in the study produced more than twice as many facial expressions (‘puppy dog eyes’ was one of the most common) when a researcher was facing them than when she was turned away. But it didn't seem to matter whether she also held food. Earlier studies have shown that seeing food is more exciting to a dog than is social contact with a silent person, so something other than the dogs’ emotional state must have been responsible for the effect.

“Dogs make their eyes more attractive to us while we are watching, not just when we are in the vicinity or in response to food,” says Brian Hare, a cognitive neuroscientist and co-director of the Duke Canine Cognition Center at Duke University in Durham, North Carolina. “This is fantastic work.”

The study, published on 19 October in *Scientific Reports*[1], adds to a growing body of work that shows how sensitive dogs are to human attention. It also provides the first evidence in a non-primate species that facial expressions can be used actively to communicate, says psychologist Juliane Kaminski at the Dog Cognition Centre at the University of Portsmouth, UK, who led the research. Researchers had previously assumed that such expressions are an involuntary reflection of an animal’s emotional state.

Brow-raising results

Kaminksi and her colleagues studied 24 pet dogs of various breeds (including 10 mongrels) and ages (from 1 to 12 years). Each dog was tied with a lead in a quiet room, with a video camera trained on its face. An experimenter, to whom the dog had been introduced, stood a metre away.

The person adopted four different positions, in turn: facing the dog and displaying food in her hands; facing it and not displaying food; facing away from the dog and displaying food; and facing away and not displaying food. Throughout, she tried to keep her gaze focused on a spot on the wall, and did not respond to the dog’s behaviours. All the dogs completed two such trials, on separate days.

Their facial expressions were analysed by the Dog Cognition Centre’s

Bridget Waller, using a system she helped to create, called DogFACS. It is based on the Facial Action Coding System for people, which identifies observable facial changes associated with underlying muscle movements. Although the ‘inner brow raiser’ expression signifies sadness in people, there’s no evidence that it indicates sadness in dogs, she notes. But humans tend to find it appealing.

Kaminski cautions against concluding that dogs use the expression to communicate any specific message, however. “Seeing the food plus seeing the human being attentive does not make the dogs want to look super cute.”

It would be interesting to determine whether dogs modulate these expressions based on the identity of the person, says Gregory Berns, a neuroscientist at Emory University in Atlanta, Georgia, who has used brain scans to explore dog behaviour. “My impression is that dogs frequently attempt to communicate with us humans, but we are not very good at recognizing the signs.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22867

Comments

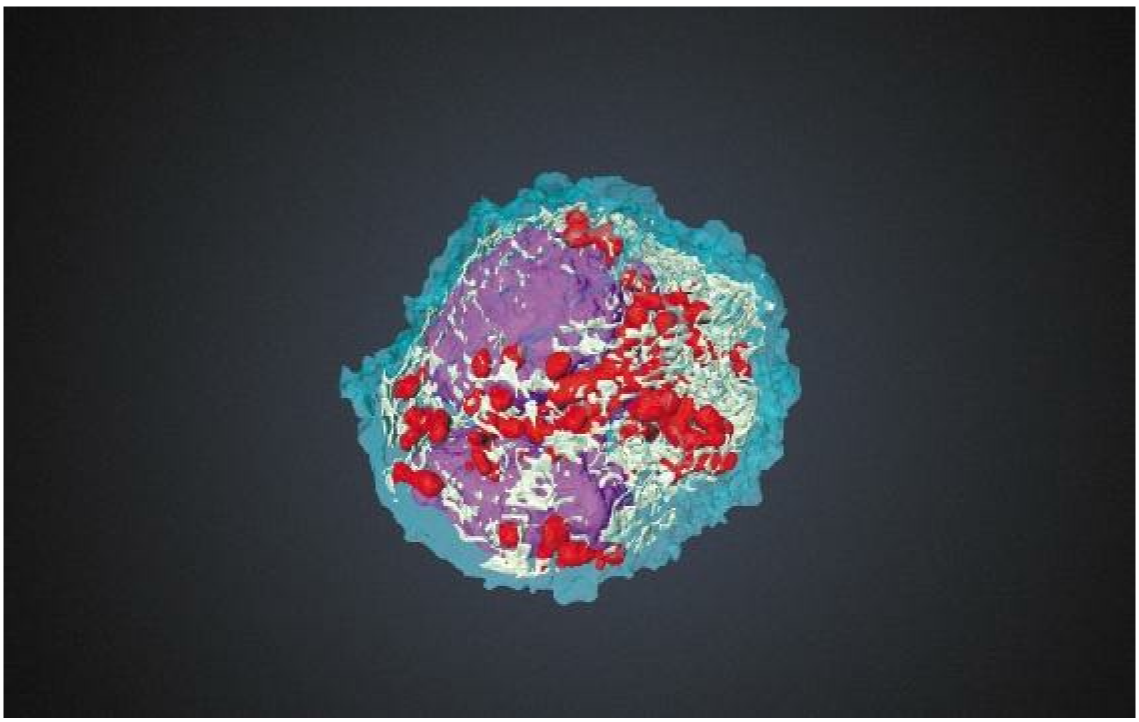
Comments

There are currently no comments.

The Human Cell Atlas: from vision to reality

18 October 2017

As an ambitious project to map all the cells in the human body gets officially under way, Aviv Regev, Sarah Teichmann and colleagues outline some key challenges.



Villani, A.-C. ET AL. SCIENCE 356, EAAH453 (2017); image Kathryn White; reconstruction James Fletcher

A new type of human dendritic cell recently discovered using single-cell RNA sequencing.

Our knowledge of the cells that make up the human body, and how they vary

from person to person, or throughout development and in health or disease, is still very limited. This week, a year after project planning began, more than 130 biologists, computational scientists, technologists and clinicians are reconvening in Rehovot, Israel, to kick the Human Cell Atlas initiative[1] into full gear. This international collaboration between hundreds of scientists from dozens of universities and institutes — including the UK Wellcome Trust Sanger Institute, RIKEN in Japan, the Karolinska Institute in Stockholm and the Broad Institute of MIT and Harvard in Cambridge, Massachusetts — aims to create comprehensive reference maps of all human cells as a basis for research, diagnosis, monitoring and treatment.

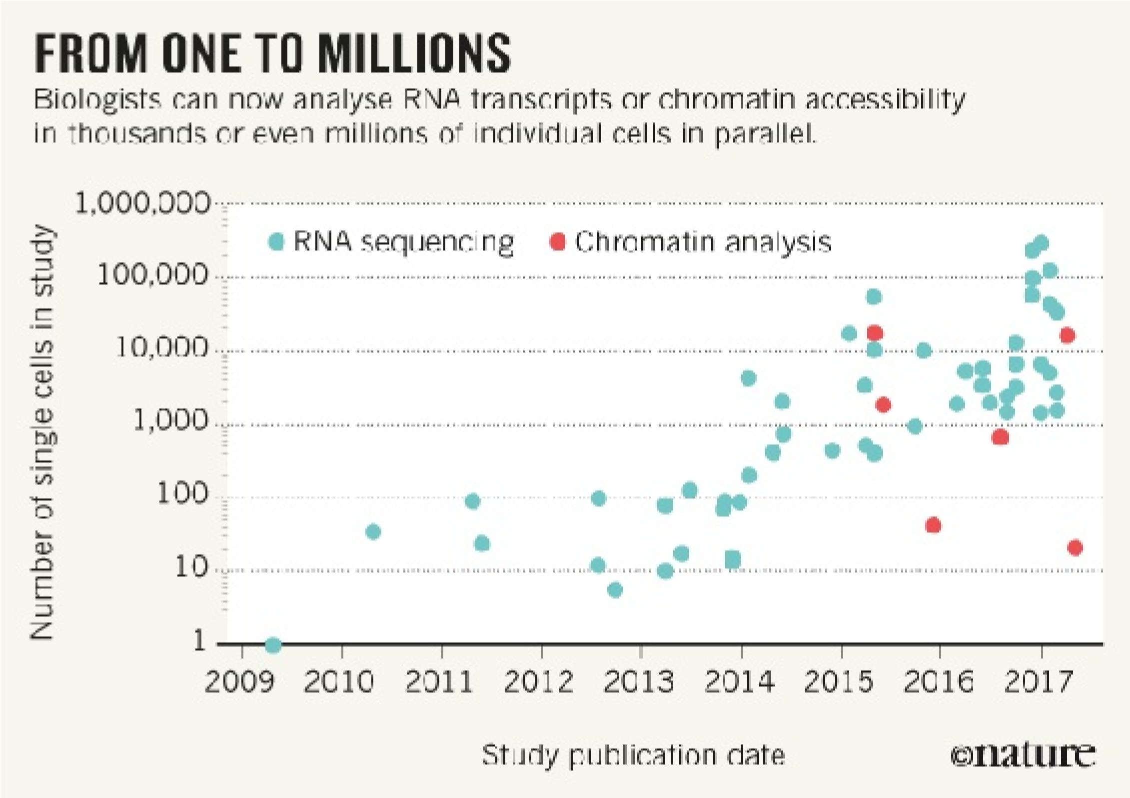
On behalf of the Human Cell Atlas organizing committee, we outline here some of the key challenges faced in building such an atlas — and our proposed strategies. For more details on how the atlas will be built as an open global resource, see the white paper[2] posted on the Human Cell Atlas website.

Cells have been characterized and classified with increasing precision since Robert Hooke first identified them under the microscope in the seventeenth century. But biologists have not yet determined all the molecular constituents of cells, nor have they established how all these constituents are associated with each other in tissues, systems and organs. As a result, there are many cell types we don't know about. We also don't know how all the cells in the body change from one state to another, which other cells they interact with or how they are altered during development.

Technology revolution

New technologies offer an opportunity to build a systematic atlas at unprecedented resolution. These tools range from single-cell RNA sequencing to techniques for assessing a cell's protein molecules and profiling the accessibility of the chromatin. For example, we can now determine the RNA profiles for millions of individual cells in parallel (see 'From one to millions'). Protein composition and chromatin features can be studied in hundreds or thousands of individual cells, and mutations or other markers tracked to reconstruct cell lineages. We can also profile multiple

variants of RNA and proteins *in situ* to map cells and their molecules to their locations in tissues.



Source: Svensson, V., Vento-Tormo, R. & Teichmann, S. A. Preprint at https://arxiv.org/abs/1704.01379 (2017)

We anticipate that the atlas will help researchers to answer key questions in diverse biological fields. In cellular taxonomy, it might enable the discovery and identification of cell types and molecular markers or signatures (a collection of genes, say, that characterize a specific cell type). In histology, it should enable researchers to relate tissue structure to the position of cells and molecules. Developmental biologists will be able to use it to track cell fate and lineage. Physiologists could characterize dynamic states, such as the cell cycle, and transient responses such as a T cell’s reaction to a pathogen.

The atlas could also facilitate research on the molecular mechanisms of communication within and between cells. And it should allow biologists to compare cell types across species to better understand human evolution, and

to determine to what extent animal model systems and organoids reflect human biology.

Crucially, the atlas should help researchers to compare healthy reference cells to diseased ones in the relevant tissues — and so facilitate the development of better drugs and more accurate predictions of unintended toxicity. The atlas could also aid regenerative medicine — the process of replacing, engineering or regenerating human cells, tissues or organs to establish normal function. Key diagnostic tests, such as the complete blood count — a routine blood screen that provides crude counts of white blood cells, red blood cells and so on — would become vastly more informative if cell types and states could be identified with much finer granularity. Such information could, for example, help to diagnose blood cancer, autoimmunity or infection before clinical symptoms appear.

Early studies are already showing tremendous potential in all these areas. New cell types have been found in the brain[3–7], gut[8], retina[9] and immune system[10], and these discoveries have yielded new insight — into how the immune system[11] functions, for example, and into the dynamics of tumour ecosystems[12]. Yet, to take the next step — to build a human cell atlas that is truly useful — requires taking the long view and addressing various systemic and organizational challenges, as well as technical and scientific ones.

The challenges

Agree on scope. In light of the enormous complexity of the human body, and the rapid evolution of technologies for probing cells and tissues, and for analysing the data, we plan to build this resource in phases and generate reference maps at increasing resolution as the project progresses.

The first draft of the atlas will profile cells' molecular and spatial characteristics, capturing only those cell types that occur above a pre-specified rarity — ones that make up more than 1% of a sample, say. These cells will be obtained from major tissues from healthy donors, taking into account the genetic diversity, geographical location and person's age. Although disease will not be a focus of the first draft of the atlas, we plan to

look at some disease samples to compare them with healthy cell types.

The first draft will focus on tissues, not whole organs. Extremely rare cells may be missed, and sample sizes may be too small to fully reveal the links between cellular characteristics and human diversity. In later phases, the atlas could take on entire organs, include small cohorts of people (say, 50–60) with diseases of interest, gather bigger sample sizes and provide greater power to associate molecular variation with the underlying genetic diversity. A similar step-wise strategy was deployed in the Human Genome Project; even a partially assembled genome proved immediately useful to researchers, and human genetic variation in health and disease was tackled over several years after the full genome was sequenced.

The atlas will provide an important starting point for functional studies — for instance, those aimed at establishing the mechanistic links between cell states and disease. But such studies are themselves beyond its scope. Again, this parallels what happened with the Human Genome Project: studies of functional elements in the genome, which are ongoing, have relied on the reference sequence obtained through the project.

The atlas will aim to provide a detailed representation of molecules, cells, tissues, organs and systems, allowing researchers to zoom in and out to identify patterns and interactions at various levels of resolution. To this end, those compiling the atlas must establish how many cells to sample, which types of molecular features to analyse, how to assign cells to different categories and how to subdivide those categories. At the spatial level, they must decide how to sample complex anatomies and histologies. Lastly, they need to establish ways of connecting the various layers of cellular and spatial information from different samples to a single anatomical reference by developing what is termed a common coordinate framework.

To ensure the best use of resources, those involved in the initiative must agree on the desired resolution for each phase of the atlas. Researchers could, of course, try to pursue ever-rarer cell types, but potentially at ever-greater expense. In this respect, the Human Cell Atlas will pursue similar approaches to those used in human genetic studies that focus on variants present at a certain frequency. Here, geneticists have begun to tackle increasingly rare variants as technologies have advanced.

Be open and fair. To have maximum impact, the Human Cell Atlas must be an open resource, on many levels.

The project is already open to all interested participants who are committed to its values. Discussions about particular organs, tissues, technologies or computational approaches are running on more than a dozen Slack channels that anyone can join.

Wherever consent agreements allow, atlas data will be made publicly available in an open-source data-coordination platform as soon as possible, after they have been collected and have passed quality-control checks. All standards established to ensure the production of high-quality data, and any updates to those standards, will also be shared. The same goes for new technologies and computational methods resulting from the project.

Atlas data and analysis products will exist in multiple public clouds (currently, those hosted by Google, Amazon and Microsoft) to ensure that people with different preferred cloud environments can access them. Because computation will happen in the cloud, individual researchers will not need to download and store all the data or have access to their own high-performance computing power. Finally, in addition to the continual release of data and periodic formal data releases, publications interpreting the data will help to establish standardized approaches and disseminate the insights and value that can be gained from them.

As much as possible, the atlas must reflect the diversity of humans and human experience. The broad distribution of participating researchers, institutions and countries involved in the initiative will, in itself, help to ensure tissue diversity. The initiative currently includes members from 5 continents and more than 18 countries, including Japan, Israel, South Africa, China, India, Singapore, Canada and Australia.

Getting appropriate consent agreements and fostering public trust from the outset will also help efforts to obtain sufficient geographical, gender, age and genetic diversity in sampling. As part of the global initiative, an ethics working group will establish how best to obtain informed consent from sample donors, how the terms of that consent can be adhered to and how to protect the privacy of participants and donors appropriately. Various existing

projects involving human samples, such as the public-research project ENCODE (the Encyclopedia of DNA Elements), which aims to identify all the functional elements of the human genome, can provide guidance on this.

Procure samples appropriately. Obtaining tissue samples using standardized procedures, with appropriate consent and in a way that enables other researchers to know exactly where the sample came from is a complex endeavour. To access the diversity of human tissues needed, researchers will work with both fresh tissue from live donors and specimens obtained postmortem or from transplant organ donors.

We plan to learn from, and build on, pre-existing reliable procurement processes. Examples include those used in the Genotype-Tissue Expression Project (GTEx, a database and tissue bank designed to help researchers to gain insight into the mechanisms of gene regulation in humans) and the Cambridge Biorepository for Translational Medicine, a resource for multidisciplinary research projects for which fresh tissue is required.

Organize effectively. The Human Cell Atlas consortium is built on four distinct and interconnected pillars. Collaborative biological networks involve experts in biological systems or organs as well as in genomics, computation and engineering, working together to build maps of each tissue, system or organ. Several biological-network pilot projects have been formulated through grass-roots efforts in the Human Cell Atlas community. As well as revealing new biology and helping to build a collaborative international network, these activities are informing the community about how to structure sampling and conduct analyses for a full-scale cell atlas.

A technical forum involving genomics experts, imaging specialists and biotechnologists, is developing new technologies, and testing, comparing and disseminating existing ones. A data-coordination platform is being designed to bring researchers to the data by developing the software to upload, store, process and serve data. The platform also provides an open environment in which computational methods and algorithms developed by any interested group can be shared. Finally, an analysis garden involves computational biologists working together to develop sophisticated techniques for data mining and interpretation.

Activities across all areas are currently governed by a scientific steering group, the Human Cell Atlas organizing committee. Co-chaired by two of us (A. R. and S. A. T.), this includes 27 scientists from 10 countries and diverse areas of expertise. The committee establishes working groups (about 5 so far, consisting of about 5 to 15 members each) that tackle specific key areas. For instance, an analysis working group is crafting best practices for computational analysis through a community-wide process, including workshops and jamborees. The committee governs the data-coordination platform, including making all policy decisions and approving its overall plan.

Join the effort

Having a catalogue of genes at our fingertips has transformed research in human biology and disease. Similarly, we believe that the Human Cell Atlas will catalyse progress in biology and medicine. Descriptors such as 'cell type' and 'cell state' can be difficult to define at the moment. An integrative, systematic effort by many teams of scientists working together and bringing different expertise to the problem could dramatically sharpen our terminology, and revolutionize the way we see our cells, tissues and organs. We invite you to join the effort.

Journal name:
Nature
DOI:
doi:10.1038/550451a

Supplementary information

PDF files

1. HCA organizing committee (61K)

Comments

Comments

There are currently no comments.

Top Chinese university to consider social-media posts in researcher evaluations

Controversial policy means mainstream media are starting to rival rigorous academic publications in some universities in China.

18 October 2017

Wang Zhao/AFP/Getty

News articles written by researchers at some Chinese universities will now be considered in evaluations.

One of China's most prestigious universities plans to give some articles in

newspapers and posts on major social-media outlets the same weight as peer-reviewed publications when it evaluates researchers.

The policy has sparked a vigorous debate among Chinese academics. Proponents say it will encourage researchers to engage with the public, but many are concerned that it will promote those who toe the party line established by China’s strictly censored media and social media, at the expense of more highly qualified researchers. Critics also say the system could be manipulated to inflate a researcher’s impact, for example by artificially boosting page views.

Zhejiang University in Hangzhou announced the policy on its WeChat page on 15 September, saying that it would mainly apply to the humanities and social sciences. But Chinese researchers say the move could influence science as well, by giving a hiring and promotion advantage to politically minded scientists.

“You do not need to be good scientist, you do not need to publish good science papers,” says one biologist at a prominent Beijing-based university who requested anonymity. He is concerned that the policy could alter evaluations at China’s main grant agency, the National Natural Science Foundation of China (NSFC). “If they open the Pandora’s box, the NSFC might change its policy as well,” he says. The agency's head, Yang Wei, says it will do no such thing. NSFC grants are given solely “according to the judgement of peer reviewers”, he says.

Viewing figures

The Zhejiang policy sets specific criteria: articles have to be original, written by the researcher and at least 1,000 words long; they need to be picked up by major news outlets and widely disseminated through social media; and they need to have been seen by a large number of people. The policy requires an article to be viewed more than 100,000 times on WeChat, China’s most popular instant-messaging service, or 400,000 times on news aggregators such as Toutiao. Articles that meet the criteria will be considered publications, alongside papers in peer-reviewed journals.

The university has also established a publication hierarchy, with official media outlets such as the *People's Daily* considered most important, regional newspapers and magazines occupying a second tier, and online news sites such as Sina, NetEase or Sohu ranking third.

Ping Fu, who researches library science at Central Washington University in Ellensburg, is concerned that the policy will blur the distinction between peer-reviewed academic publications and popular writing. This could affect the top levels of scholarship in China, he says. Liu Jin-ping, a biologist at Hainan University in Haikou, also worries that the policy will give prominence to stories that “flatter the government”. Some academics will aim to “become Internet stars” so they can be promoted, he wrote on his blog.

Full credit

Lin Boqiang, an energy-policy and climate-change researcher at Xiamen University who has published some 800 media commentaries, thinks researchers should get credit for this work. He “criticizes government policy all the time” and would never write something incorrect to please political powers, he says: “Our reputation is on the line.”

But both Liu and Lin are concerned the system could be gamed, either for self-interest or with political motivation. Lin says these articles should not be considered equal to academic publications. “Other universities will do this,” he says. “I hope they do it in a more sophisticated way.”

Zhejiang University refused to answer *Nature*'s questions about the policy, but it posted a statement on its homepage in response to the controversy, saying that the commentaries in the mainstream media will supplement and not replace peer-reviewed journals: “This policy is to explore more forms of exposure of research, especially for humanities and social sciences, and the assessment will be made by a strict panel review, which will not lower the academic standard.”

Grant committees in other countries encourage researchers to do public outreach, but the Zhejiang policy is rare in how it ranks such efforts for

researcher evaluation. Jilin University in Changchun announced a similar policy in August.

Balancing act

Glen Peters, a climate-policy researcher at the Center for International Climate Research in Oslo, agrees that researchers should be acknowledged for important contributions to public understanding, but he says the challenge in giving scientists credit for public outreach is how to measure its quality and impact against those of conventional journal publications. “If you don’t get the weighting right, then incentives could be perverted and lead to bad outcomes, such as poor quality and political bias,” he says. “The potential is high, but so are the risks.”

One journalist at China’s *Legal Daily* has questioned whether such a policy is legal. It was drafted by the university’s propaganda department, part of the Communist Party of China. According to the laws that govern universities, evaluation decisions are supposed to be made by university administrative departments or faculty committees, writes the journalist.

Some scientists contacted by *Nature* are confident that this initiative will not affect science. But others see it as part of the government’s attempts to control information. There is already concern about Chinese President Xi Jinping’s efforts to align education with communist values and to control what is written by journalists or on social media. Scientists say that bans on Google, Google Scholar and other Internet-based technologies hamper their ability to stay in touch with international peers. “There are certainly many layers of concern,” says one environmental scientist who did not want to be named for fear of damaging relationships with Chinese colleagues.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22822

Comments

Commenting is currently unavailable.

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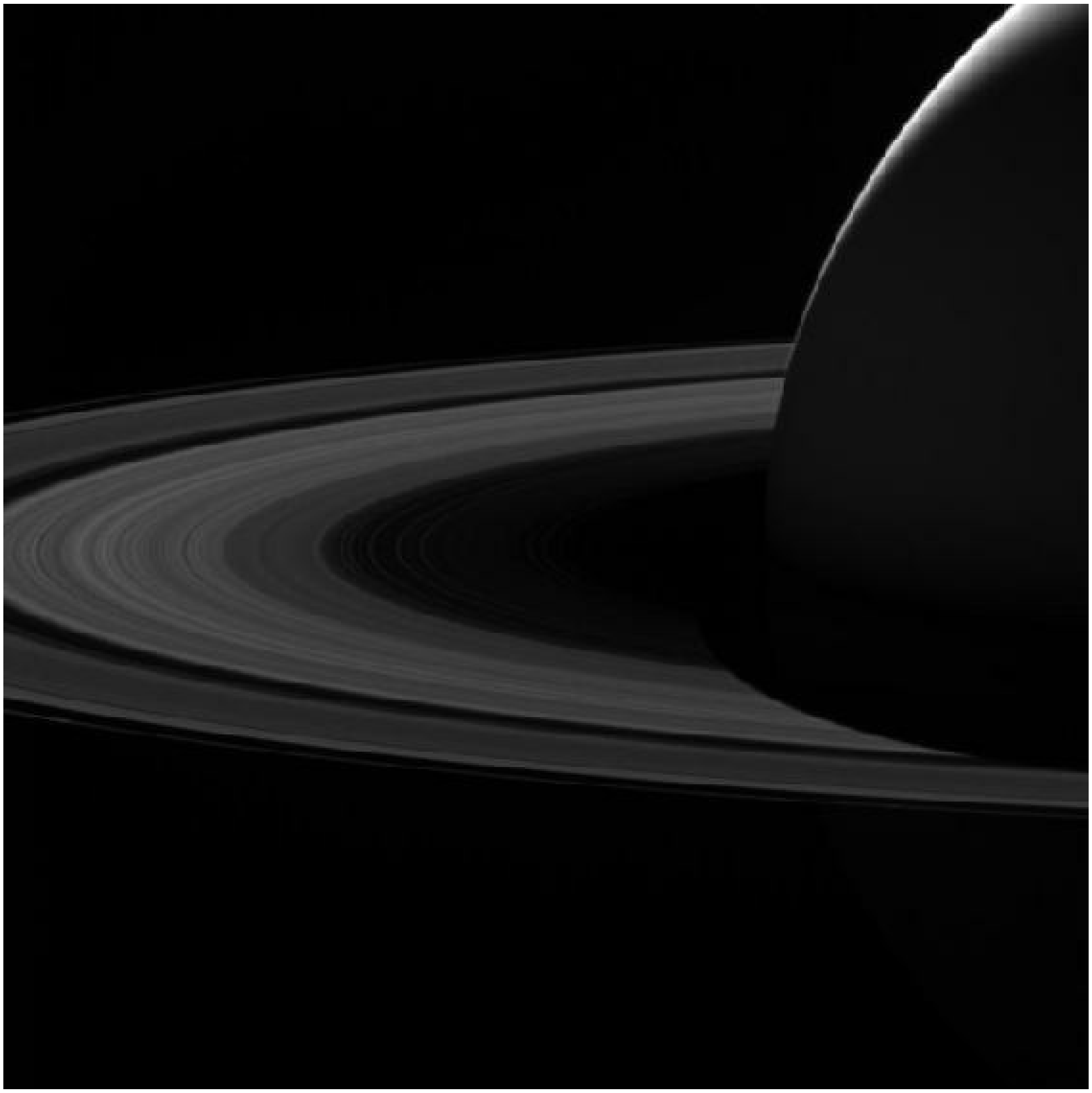
Mysterious particles spotted in Saturn’s atmosphere

Source may be dust shed by planet’s iconic rings, according to data from NASA's doomed Cassini probe.

18 October 2017

Provo, Utah



NASA/JPL-Caltech/SSI

Saturn's rings are made of whirling bands of ice and dust.

NASA's Cassini spacecraft continues to yield surprising discoveries, more than a month after it burned up on its mission-ending dive into Saturn. New data from the probe suggest that Saturn's majestic rings are showering tiny dust particles into the planet's upper atmosphere, where they form a complicated and unexpected chemical mix.

A mass spectrometer aboard Cassini detected the strange chemistry as the

probe spent its final five months looping between Saturn and its rings.

“We really hit the jackpot,” said Mark Perry, a planetary scientist at the Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland. He reported the findings on 17 October at a meeting of the American Astronomical Society’s Division for Planetary Sciences in Provo, Utah.

Mission scientists had expected Cassini's mass spectrometer to spot the signature of water molecules as the spacecraft slipped between the planet and its rings. In the 1970s and 1980s, NASA's Pioneer and Voyager missions found fewer charged particles than expected in Saturn’s uppermost atmosphere. On the basis of those data, researchers proposed in 1984 that water molecules coming off the rings — mostly in the form of ice — act as catalysts to strip charged particles from the atmosphere[1]. Cassini's final months gave scientists their first opportunity to test this idea directly.

Chemical surprise

But it wasn't evidence of water that jumped out at Cassini's science team. Data from the mass spectrometer revealed a witch’s brew of chemicals, including methane, a molecule that could be carbon monoxide and more-complex molecules. The concentrations of these chemicals are greatest around Saturn’s equator and at high altitudes, which suggests that the material is shedding off the planet’s rings.

The deeper the probe went into the atmosphere, the stranger the measurements became. Cassini’s closest swings past Saturn's surface revealed a panopoly of heavy molecules, Perry told conference attendees. The scientists have not yet pinpointed each type of molecule, but clearly, there is much more than just water around.

By analysing the types of material that could be coming off the rings, Perry’s team concluded that the debris must be fragments of tiny dust particles, which measure just 1 to 10 nanometres across but are relatively heavy. When these particles spiralled off the rings and slammed into Cassini’s mass spectrometer, they shattered into smaller pieces.

Exactly how those particles make the journey from the rings to the atmosphere remains to be seen. “We have a lot of work to do to understand how they are getting in there,” Perry said. “None of the models predict this.”

On these final plunges, pulled along by Saturn’s gravity, Cassini was zooming along at more than 30 kilometres per second — a speed more than four times greater than the mass spectrometer was designed to withstand. “These are higher speeds than anything it has ever seen,” noted Linda Spilker, a planetary scientist at the Jet Propulsion Laboratory in Pasadena, California, and Cassini’s project scientist.

At such enormous speeds, anything that Cassini rammed into would have splintered into bits.

Journal name:
    Nature
DOI:
    doi:10.1038/nature.2017.22838

Comments

Comments

There are currently no comments.

Efforts to save leading Hungarian university hit hurdle

US-registered Central European University faces another year of uncertainty over whether it can continue to operate in Hungary.

18 October 2017

Ferenc Isza/AFP/Getty Images

A sudden change to Hungarian higher-education law in April led to widespread protests.

The threatened Central European University (CEU) in Budapest has been dealt a blow in its efforts to avert possible closure in Hungary.

The country’s parliament voted on 17 October to postpone for a year a

decision that would allow the university to keep operating there. At a press conference held by the university shortly after the vote, CEU rector Michael Ignatieff called the delay “unacceptable” and “unnecessary”.

In April, the Hungarian government unexpectedly amended its higher-education law to require that all foreign-accredited universities there had to operate as higher-education institutes in their countries of origin by 1 January 2018.

The change drew protests and was widely believed to be politically motivated. Critics saw it as an attack on billionaire philanthropist George Soros, who founded the university in 1991 and has openly criticized Hungary’s strict refugee policies.

The CEU took steps to comply with the new requirements and on 3 October sealed an agreement with Bard College in Annandale-on-Hudson, New York, to provide educational activities there. Accredited courses run jointly by the universities would be launched next year, the CEU said. The agreement still needs to be signed by the Hungarian government and ratified by the country’s parliament.

But on 16 October the government proposed delaying the implementation of the amendment until 1 January 2019, and the parliament approved the delay the next day.

A government spokesperson told *Nature* that the purpose of the delay was to give other foreign higher-education institutions time to comply with the new requirements, adding that three institutions, including the CEU, are still in negotiation.

Zoltan Balogh, Hungary’s minister for human capacity, suggested on 16 October that government sign-off of the CEU’s agreement might have to wait for the new deadline.

“We are being deliberately kept in legal limbo,” said Ignatieff, who fears the uncertainty will make it hard to retain faculty and recruit students. “We are being slowly strangled in this battle for academic freedom.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22855

Comments

Comments

There are currently no comments.

Sleeping sickness can now be cured with pills

Researchers seek approval from regulators for this quicker, easier treatment.

18 October 2017

Neil Brandvold

Health workers screen people in a remote village in the Democratic Repulic of the Congo for sleeping sickness.

For the first time, researchers have cured the deadly neurological disease sleeping sickness using pills instead of a combination of intravenous infusions and pills. The investigators presented the results from final clinical trials on 17 October at the European Congress on Tropical Medicine and

International Health in Antwerp, Belgium, providing hope that the treatment will help to eliminate the malady within a decade.

The oral therapy — called fexinidazole — cured 91% of people with severe sleeping sickness, compared with 98% who were treated with the combination therapy. It also cured 99% of people in an early stage of the disease who would typically undergo a spinal tap to determine whether they needed infusions. The relative ease of the treatment with fexinidazole means that if approved, it might save more lives than the current option, say the investigators leading the phase 3 trial, the final phase of testing before the drug goes to regulators for approval.

Sleeping sickness is endemic to Africa and generally infects extremely poor people who live in remote regions. The sick often suffer from the disease for years before seeking treatment, causing them and those caring for them to miss work and spend their savings on traditional medicines. Trekking to a hospital and remaining there for intravenous infusions is costly as well.

“It’s not just the person with sleeping sickness, it’s the family that takes care of them during years of this neurological, very serious disease,” says Philippe Büscher, a sleeping-sickness specialist at the Institute of Tropical Medicine in Antwerp, Belgium, who was not involved in the study. “Whatever money they have, they’ll spend on this instead of anything else.”

Büscher commends the team for conducting a quality clinical trial under extraordinary circumstances in countries hit hardest by the disease, the Democratic Republic of the Congo and the Central African Republic. Investigators had to carry equipment to remote clinics over rugged terrain; one study site was repeatedly robbed; and early on in the trial, some participants fled armed conflict. “I need to congratulate them for beautiful work,” Büscher says.

Neil Brandvold

The hospital where Pablo Loela was being treated for sleeping sickness canno afford to provide food for their patients: families must provide meals for their loved ones.

A better way

Sleeping sickness — also known as human African trypanosomiasis — is spread through the bite of tsetse flies carrying parasites, most commonly *Trypanosoma brucei gambiense*. The organism infects the central nervous system, and patients can experience confusion, daytime sleepiness, night-time insomnia and various psychiatric symptoms, including manic episodes and aggression. If left untreated, they enter a coma and die. For decades, the only treatment was a toxic arsenic-based drug that killed one in 20 patients.

In 2009, researchers introduced a safer option: nifurtimox–eflornithine combination therapy, or NECT, which consists of pills and 14 intravenous

infusions. For the first time in 50 years, the incidence of sleeping sickness slipped below 10,000 new cases per year; it's currently around 2,200, according to the World Health Organization. But the need for infusions, along with the spinal tap required to qualify a patient for the treatment, still present obstacles in regions where sterile equipment, electricity and doctors are in short supply.

The group that developed NECT — a non-profit research organization based in Geneva, Switzerland, called the Drugs for Neglected Diseases initiative (DNDi) — continued searching for a better therapy. In 2007, it discovered fexinidazole, a compound that had been shelved by Paris-based pharmaceutical company Sanofi. With the firm's agreement, the DNDi took the drug through clinical trials. It estimates that developing the therapy through to approval will cost a total of around US$50 million — a fraction of what pharmaceutical companies often spend on new drugs.

Just the beginning

Sanofi will soon submit an application for drug approval through the European Medicines Agency, whose sign-off could pave the way for regulators in the Democratic Republic of the Congo. The drug might get a green light by the end of next year, says Nathalie Strub Wourgraft, the DNDi's medical director. Because it is a simple oral treatment, she suggests that patients might even be treated at home, which would save them and their families the expense of hospital stays.

However, Büscher argues that home treatments could be dangerous because people who don't respond to fexinidazole could die of the disease if not seen immediately by medical staff. It's imperative that patients follow up with health workers, he says, and he suggests offering people incentives to return to the clinic, such as money or staples including salt or sorghum. "This is a success," he says, "but it is not the end."

DNDi researchers and their colleagues are currently working on what they hope will be an even better oral treatment to cure the disease in a single dose, and more reliably than fexinidazole.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22856

Comments

Commenting is currently unavailable.

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Self-taught AI is best yet at strategy game Go

Artificial-intelligence program AlphaGo Zero trained in just days, without any human input.

18 October 2017

Xavierarnau/Getty

AlphaGo Zero came up with Go strategies that human players haven't invented in thousands of years.

An artificial intelligence (AI) program from Google-owned company DeepMind has reached superhuman level at the strategy game Go — without learning from any human moves.

This ability to self-train without human input is a crucial step towards the dream of creating a general AI that can tackle any task. In the nearer-term, though, it could enable programs to take on scientific challenges such as protein folding or materials research, said DeepMind chief executive Demis Hassabis at a press briefing. “We’re quite excited because we think this is now good enough to make some real progress on some real problems.”

Previous Go-playing computers developed by DeepMind, which is based in London, began by training on more than 100,000 human games played by experts. The latest program, known as AlphaGo Zero, instead starts from scratch using random moves, and learns by playing against itself. After 40 days of training and 30 million games, the AI was able to beat the world's previous best 'player' — another DeepMind AI known as AlphaGo Master. The results are published today in *Nature*[1], with an accompanying commentary[2].

Getting this technique, known as reinforcement learning, to work well is difficult and resource-intensive, says Oren Etzioni, chief executive of the Allen Institute for Artificial Intelligence in Seattle, Washington. That the team could build such an algorithm that surpassed previous versions using less training time and computer power “is nothing short of amazing”, he adds.

Strategy supremo

The ancient Chinese game of Go involves placing black and white stones on a board to control territory. Like its predecessors, AlphaGo Zero uses a deep neural network — a type of AI inspired by the structure of the brain — to learn abstract concepts from the boards. Told only the rules of the game, it learns by trial and error, feeding back information on what worked to improve itself after each game.

At first, AlphaGo Zero’s learning mirrored that of human players. It started off trying greedily to capture stones, as beginners often do, but after three days it had mastered complex tactics used by human experts. “You see it rediscovering the thousands of years of human knowledge,” said Hassabis.

After 40 days, the program had found plays unknown to humans (see 'Discovering new knowledge').

Discovering New Knowledge

Deepmind

Approaches using purely reinforcement learning have struggled in AI because ability does not always progress consistently, said David Silver, a scientist at DeepMind who has been leading the development of AlphaGo, at the briefing. Bots often beat their predecessor, but forget how to beat earlier versions of themselves. This is the project's first "really stable, solid version of reinforcement learning, that’s able to learn completely from scratch," he said.

AlphaGo Zero’s predecessors used two separate neural networks: one to predict the probable best moves, and one to evaluate, out of those moves, which was most likely to win. To do the latter, they used ‘roll outs’ — playing multiple fast and randomized games to test possible outcomes. AlphaGo Zero, however, uses a single neural network. Instead of exploring possible outcomes from each position, it simply asks the network to predict a winner. This is like asking an expert to make a prediction, rather than relying on the games of 100 weak players, said Silver. “We’d much rather trust the predictions of that one strong expert.”

Merging these functions into a single neural network made the algorithm both stronger and much more efficient, said Silver. It still required a huge amount of computing power — four of the specialized chips called tensor processing units, which Hassabis estimated to be US$25 million of hardware. But its predecessors used ten times that number. It also trained itself in days, rather than months. The implication is that “algorithms matter much more than either computing or data available”, said Silver.

Think outside the board

Several DeepMind researchers have already moved from working on AlphaGo to applying similar techniques to practical applications, said Hassabis. One promising area, he suggested, is understanding how proteins fold, an essential tool for drug discovery.

Generating examples of protein folding can involve years of painstaking crystallography, so there are few data to learn from, and there are too many possible solutions to predict structures from amino-acid sequences using a brute-force search. The puzzle shares some key features with Go, however. Both involve well-known rules and have a well-described goal. In the longer term, such algorithms might be applied to similar tasks in quantum chemistry, materials design and robotics.

Silver acknowledged that to apply its approach to real-world tasks more generally, the AI will need the ability to learn from smaller amounts of data and experience. Another essential step will be learning the rules of a game for itself, as another DeepMind bot did in 2015 for arcade games. Hassabis reckons this is something AlphaGo Zero could eventually do: “We’re pretty sure it would work, it would just extend the learning time a lot,” he said.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22858

Comments

Comments

There are currently no comments.

Science must examine the future of work

As automation changes employment, researchers should gather the evidence to help map the implications.

18 October 2017

VCG/Getty

Automation will take away jobs, but a bigger question is how many it will generate.

In 2014, the *Los Angeles Times* began beating its rivals to report earthquakes, using an algorithm to convert announcements from the US Geological Survey

(USGS) to breaking news within a few minutes. This June, it announced that a magnitude-6.8 quake had shaken Santa Barbara, California. That was certainly news to the distinctly unshaken residents of Santa Barbara; the earthquake the newspaper was reporting on had actually happened in 1925. The paper's Quakebot had misinterpreted an update to the USGS seismic database and published its story online without anyone checking. The story was deleted and Santa Barbarans (and human journalists everywhere) could breathe a sigh of relief.

The tale encapsulates many of the issues that surround the intensifying debate about the roles of computers and humans in the workplace of the future — both the very near and the very far. Much of that debate places people and algorithms in direct competition. From lorry drivers threatened by self-driving vehicles to doctors who could be replaced by know-it-all diagnostic devices, many jobs as we know them could be done by artificial intelligence (AI) systems.

In an Editorial last year on the likely role and risks of AI in future society, *Nature* noted that even academic debate on the topic is polarized between sceptics and fanciful futurists (see *Nature* **532,** 413; 2016). In a special issue this week, we try to find and explore some middle ground, by bringing together and assessing the evidence on how automation will affect the future of work.

In a sense, this debate is nothing new. Technology and automation have been putting people out of jobs for hundreds of years, as historian Robert Allen discusses in a Comment. So have other factors — chiefly economic trends and globalization. But the spread of technology has also created new roles. In broad terms, as manufacturing jobs in the West have been transferred to low-wage economies elsewhere, politicians and economists have looked to tech to help fill the gap. These new industries, they argue, both need direct labour to develop them and create employment indirectly through the need for service and support. But will this trend continue? The true debate over the future of work is not whether computers will replace people in many jobs — they surely will — but whether they are team players. For how long will Quakebot and its descendants need a human supervisor?

Both sceptics and fanciful futurists will find something to agree and disagree

with in the articles that follow. In a Comment, Yuval Noah Harari, historian and best-selling author of *Sapiens* (Harper, 2014) and *Homo Deus* (Harvill Secker, 2015), argues: “The challenges posed in the twenty-first century by the merger of infotech and biotech are arguably bigger than those thrown up by steam engines, railways, electricity and fossil fuels.” He also offers reassurance about job prospects for some people, from a perhaps unlikely source. Each US military drone flying over Syria keeps 110 people in a job, he writes — 30 operators and 80 analysts to process the information it sends back. This is not an argument for more drones, the use of which is controversial. But, as Harari writes: “A careful study of the military job market might tell us a lot about potential future developments in the civilian economy.”

Careful study, *Nature* naturally argues, is something that (human) scientists and other academics excel at. As the 2016 editorial put it, “it is crucial that progress in technology is matched by solid, well-funded research to anticipate the scenarios it could bring about”, such as impacts on mental health and management, and how humans interact with robots. It’s important, too, to study possible political and economic reforms that will allow those usurped by machinery to contribute to society.

The Oxford Martin Programme on Technology and Employment at the University of Oxford, UK, is doing just this (see go.nature.com/2xxauvm). Oxford economist Ian Goldin offers his own thoughts.

Among the topics worthy of examination is the future fate of science and scientists. So far, the application of technology and automation to research has fuelled, and not felled, the need for human support. Indeed, fields such as bioinformatics exist only because of the work that computers generate for scientists. But as explored in a Careers Feature, science is not immune from the gig economy — short-term employment on specialist tasks such as writing a literature review or managing a database. The trend towards parcelling off and even publishing science as a series of steps rather than full papers could see demand for freelance services rise. (The breakdown of complex tasks into a series of simpler steps is, of course, also a proven path to automation.)

Still, browse ‘help needed’ adverts for scientific gigs and the future looks less

rosy. As little as US$80 to perform a detailed meta-analysis of published studies? It's hardly worth even plugging in for that.

Journal name:
Nature
Volume:
550,
Pages:
301–302
Date published:
(19 October 2017)
DOI:
doi:10.1038/550301b

Comments

Comments

There are currently no comments.

Blue is in the eye of the bee-holder

Flowers have evolved an ingenious way to attract pollinators.

18 October 2017

Ron Reznick/VW Pics/UIG via Getty Images

Nanostructures on flowers generate a blue halo that attracts bees.

The car maker Lexus announced a new paint job for its LC coupé this month, which it says will appeal to drivers who value the interaction of science and craftsmanship. The car is blue and the science it leans on is the optics of iridescence. Lexus says that it uses several layers of pigment to increase the amount of incoming light that reflects as blue. The finish, it claims, is “more blue” than anything seen before — and more time-consuming to apply. People who buy the model are unlikely to suffer that common psychological

bias experienced by owners of a new car who suddenly notice other vehicles everywhere the same colour as theirs: at present, the company can make just two a day.

Lexus says that its new blue is based on the famous wings of the morpho butterfly. These contain no pigment, but look blue because of how the wing structure physically separates the various components of white light and reflects only certain wavelengths. The company could also have borrowed the idea from the (less PR friendly) tarantula spider, many species of which use the hairs on their legs and body to show off the same blue effect. In fact, such iridescence is fairly common in plants and animals — sometimes deliberate (the shimmer of the peacock tail) and sometimes less so (the same effect from a fresh cut of meat). It's why a blue-cooked steak really does look blue. blue pigments are rare), and this week a paper online in *Nature* explores its role in flowering plants (E. Moyroud *et al. Nature* http://dx.doi.org/10.1038/nature24285; 2017).

Fewer than 10% of the 280,000 species of flowering plant naturally produce blue petals. This presents a problem, because the bees on which many flowers rely for pollination struggle to see any colour other than blue. So how do these flowers attract the insects they need?

The new study shows that they use structural-colour techniques to generate an iridescent blue halo. From the tulip to the golden perennial sweet pea, a dozen different flowering plants of varying colours were found to have surface nanostructures that produced the optical effect. It's visible to the human eye, too, and best seen against dark-coloured petals.

In a series of tests with bumblebees (*Bombus terrestris*), the researchers demonstrate that the insects avoid artificial flowers made to have smooth surfaces that don't produce the blue ring. And they show how the insects see the halo more easily than we do, because bee vision can better distinguish the ultraviolet frequencies into which the structural-colour effect spreads. The findings are discussed in an accompanying News & Views article (D. D. Deheyn *Nature* http://dx.doi.org/10.1038/nature24155; 2017).

Lexus boasts that it took more than a decade to develop its new blue paint. It took the flowers a lot longer: their ability to generate the halo effect has

evolved over millions of years, and perhaps emerged in each species independently. In both cases, the colour is best appreciated at first hand. Photographs do not do it justice. Take a stroll in the garden. And keep one eye on the road.

Journal name:
Nature
Volume:
550,
Pages:
302
Date published:
(19 October 2017)
DOI:
doi:10.1038/550302a

Comments

Comments

There are currently no comments.

Epic star collision, asteroid fly-by and journal resignations

The week in science: 13–19 October 2017.

18 October 2017

Events | People | Research | Facilities | Policy | Awards | Funding | Trend watch

EVENTS

Flames devastate northern California Wildfires have scorched about 890 square kilometres in Northern California, leaving at least 41 people dead as of 17 October, making them the deadliest fires in the state's history. Nearly 100,000 residents of Napa and Sonoma Counties had been evacuated from their homes, although this week officials have started to let people return. At least 88 of the many hundreds of people who were reported missing are still unaccounted for. The exact cause of the flames is unknown, but the area was primed for a conflagration. Vegetation flourished in the region after record rainfall last winter, and heatwaves this summer dried everything out, turning it into kindling. Winds gusting at more than 100 kilometres per hour hindered the efforts of firefighters to bring the blazes under control.

Justin Sullivan/Getty

Journal editors quit Five German scientists said on 12 October that they have resigned their editorial positions at journals published by Elsevier, after negotiations over a national licensing agreement for German institutes ground to a halt. For more than a year, a consortium of German science organizations called Projekt DEAL has been pushing for a new type of nationwide licence with Elsevier that would include open-access options and replace the need for individual institutional subscriptions. About 200 German universities and research institutes have cancelled their individual contracts with the Dutch publisher.

Asteroid buzz A house-sized asteroid whizzed by Earth on 12 October, passing within 44,000 kilometres of the planet — just above the orbits of geostationary satellites — and providing a test of international planetary defences. Telescopes around the globe swivelled to track the body, which is estimated to be 15–30 metres wide and is known as 2012 TC4. NASA, the European Space Agency and other asteroid-hunting groups gathered data to fine-tune orbital calculations and establish its future path. The asteroid's next

close pass will be in 2050, when it will safely fly by Earth. Future Earth impacts after that date have not been ruled out.

PEOPLE

Trump nominations Barry Myers, the chief executive of weather-forecasting firm AccuWeather, is US President Donald Trump's pick to lead the National Oceanic and Atmospheric Administration (NOAA), the White House said on 11 October. Myers, an attorney by training, has led AccuWeather — based in State College, Pennsylvania — since 2007. Some scientists worry that his ties to the company could lead to conflicts of interest, and note that he has no direct experience with NOAA's broader research portfolio, which includes the climate, oceans and fisheries. Two days later, the White House announced that Trump had nominated Kathleen Hartnett White, a former Texas environmental regulator and prominent climate sceptic, for its top environmental post. If confirmed as chair of the Council on Environmental Quality, White would advise the president and coordinate federal policies on energy and the environment. White is a fellow at the Texas Public Policy Foundation, a conservative think tank based in Austin. She has called efforts to shift away from fossil fuels "environmental lunacy".

New Pasteur chief Stewart Cole was appointed on 13 October as the next president of the Pasteur Institute in Paris, replacing Christian Bréchot, who had reached the institute's mandated retirement age. Many of the Pasteur's researchers had wanted Bréchot to stay on, but a campaign to change the age-limit rule was unsuccessful. Cole, a microbial-pathogenesis specialist, has held several posts at the biomedical research institute and will begin his four-year term in January. Last month, Bréchot was appointed president of the Global Virus Network, an international coalition of virologists based in Baltimore, Maryland.

RESEARCH

Epic stellar clash Researchers announced on 16 October that they had for the first time witnessed the collision of two neutron stars — and perhaps the

subsequent formation of a black hole. The event was first spotted on 17 August by gravitational-wave detectors in the United States and Italy and by a NASA γ-ray probe. More than 70 observatories rushed to observe the collision's aftermath; their discoveries are detailed in dozens of papers and solve several cosmic mysteries.

FACILITIES

FAST's first pulsars The world's largest single-dish telescope has observed its first two pulsars. The Five-hundred-meter Aperture Spherical Telescope (FAST) in southern China's Guizhou province detected the neutron stars in August. Researchers at the National Astronomical Observatories of China reported the results on 10 October after they were confirmed by an Australian telescope. The observations suggest FAST is working well, despite its radical design: the dish consists of thousands of panels that move to track radio signals, requiring elaborate coordination. Signals from the two pulsars were captured a year into an estimated three-year debugging phase. FAST, which is expected to find hundreds, possibly thousands, of pulsars, is looking for clues to how the Universe formed, as well as for signs of extraterrestrial life.

China Daily/Reuters

POLICY

Climate-rule repeal On 10 October, the US Environmental Protection Agency moved to repeal former president Barack Obama's landmark regulations to reduce greenhouse-gas emissions from power plants. Agency administrator Scott Pruitt signed a measure to begin the process of rescinding the Obama policy, a move that is expected to spark lawsuits by environmental groups and some states. The power-plant rule would reduce greenhouse-gas emissions to 32% below 2005 levels by 2030. In 2016, the Supreme Court blocked the policy from taking effect; legal challenges from 27 state governments are still pending, although a federal appeals court has put the case on hold while the administration of President Donald Trump reviews the rule.

Measuring impact UK science minister Jo Johnson has announced plans to

assess universities on their economic impact and engagement with wider society. Higher-education bodies will consult on creating a Knowledge Exchange Framework, an evaluation system designed to incentivize activities such as transferring technology into industry, spinning off companies and conducting contract research, training and consultancy, Johnson said on 12 October. If implemented, the framework would become a third strand of UK university assessment, alongside the Teaching Excellence Framework and Research Excellence Framework.

AWARDS

MacArthur grants The philanthropic MacArthur Foundation in Chicago, Illinois, announced its 2017 award recipients on 11 October. Six of the 24 winners — often referred to as MacArthur geniuses — are scientists. They include anthropologist Jason De León of the University of Michigan in Ann Arbor, who uses methods including archaeology and forensic science to study undocumented migrants on the US–Mexican border; computational linguist Regina Barzilay of the Massachusetts Institute of Technology in Cambridge, who deciphers ancient languages using machine learning; and immunologist Gabriel Victora of the Rockefeller University in New York City, who observes how antibodies evolve in the immune system in real time. Each winner gets US$625,000 over 5 years, with no restrictions on how they can spend the money.

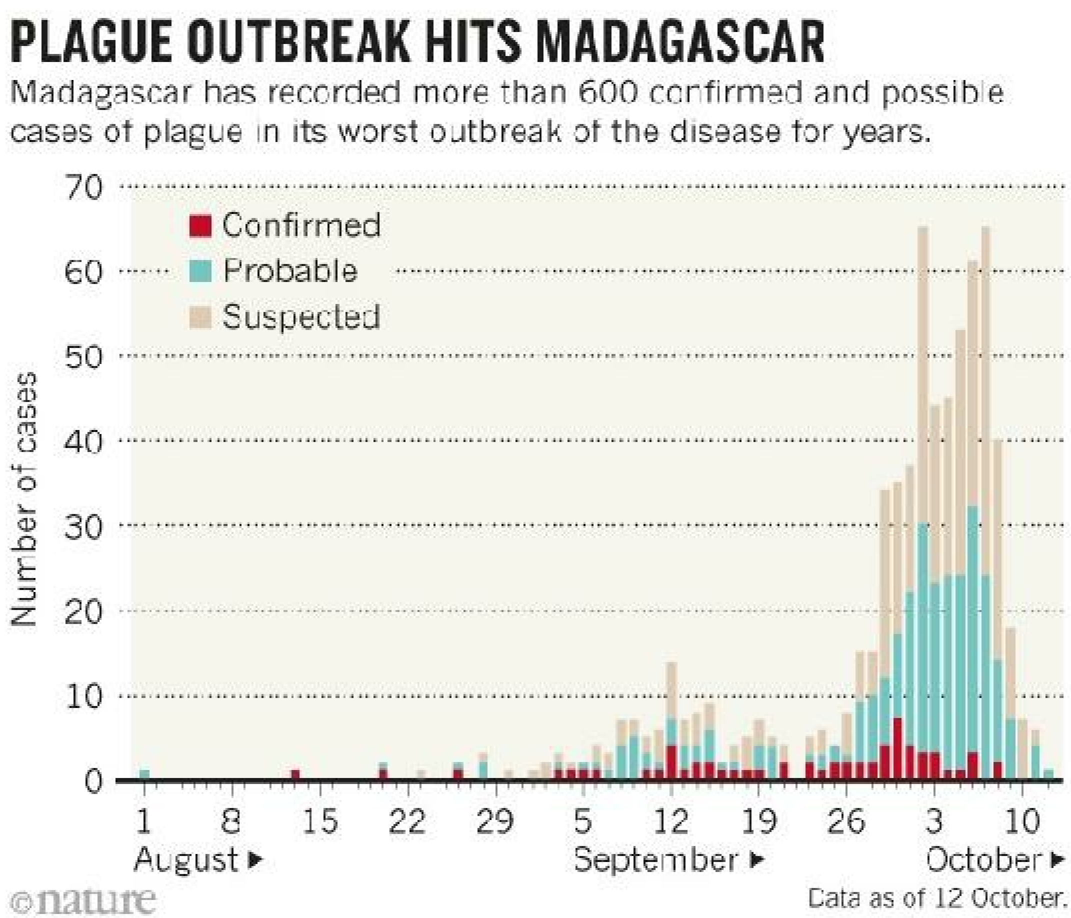
FUNDING

Research boost Online shopping giant Alibaba will set up seven international research laboratories as part of its plan to spend US$15 billion on research and development over the next three years. The company, based in Hangzhou, China, announced the Alibaba DAMO Academy on 11 October. The seven labs will be established in China, the United States, Russia, Israel and Singapore. Research topics will include data intelligence, the ‘Internet of things’, quantum computing and human–machine interfaces. Recruitment of the first 100 researchers is under way. The advisory board of the academy includes prominent scientists from outside China, including

geneticist George Church of Harvard University in Cambridge, Massachusetts.

TREND WATCH

Madagascar is battling an outbreak of plague, with more than 600 cases and at least 57 deaths since 1 August. Plague is endemic to the island and surfaces almost annually. But the current outbreak is unusually large, and cases are mostly of pneumonic plague, which is deadlier and more transmissible than the more usual bubonic form. Untreated, pneumonic plague can kill within 24 hours. On 10 October, the World Health Organization reported a linked case of plague in the Seychelles.



Source: WHO

Journal name:
Nature
Volume:
550,
Pages:
306–307
Date published:
(19 October 2017)
DOI:
doi:10.1038/550306a

Comments

Commenting is currently unavailable.

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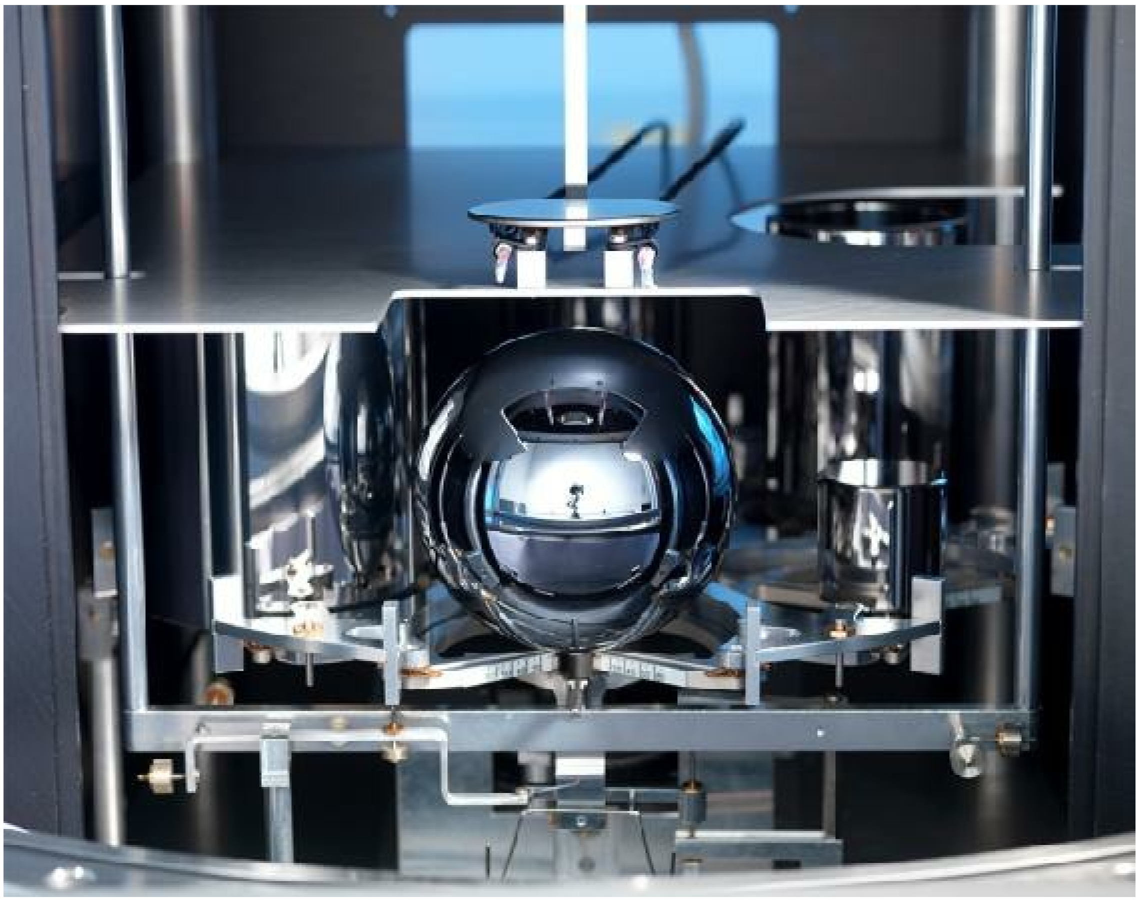
New definitions of scientific units are on the horizon

Metrologists are poised to change how scientists measure the Universe.

18 October 2017



Natl. Phys. Lab., UK

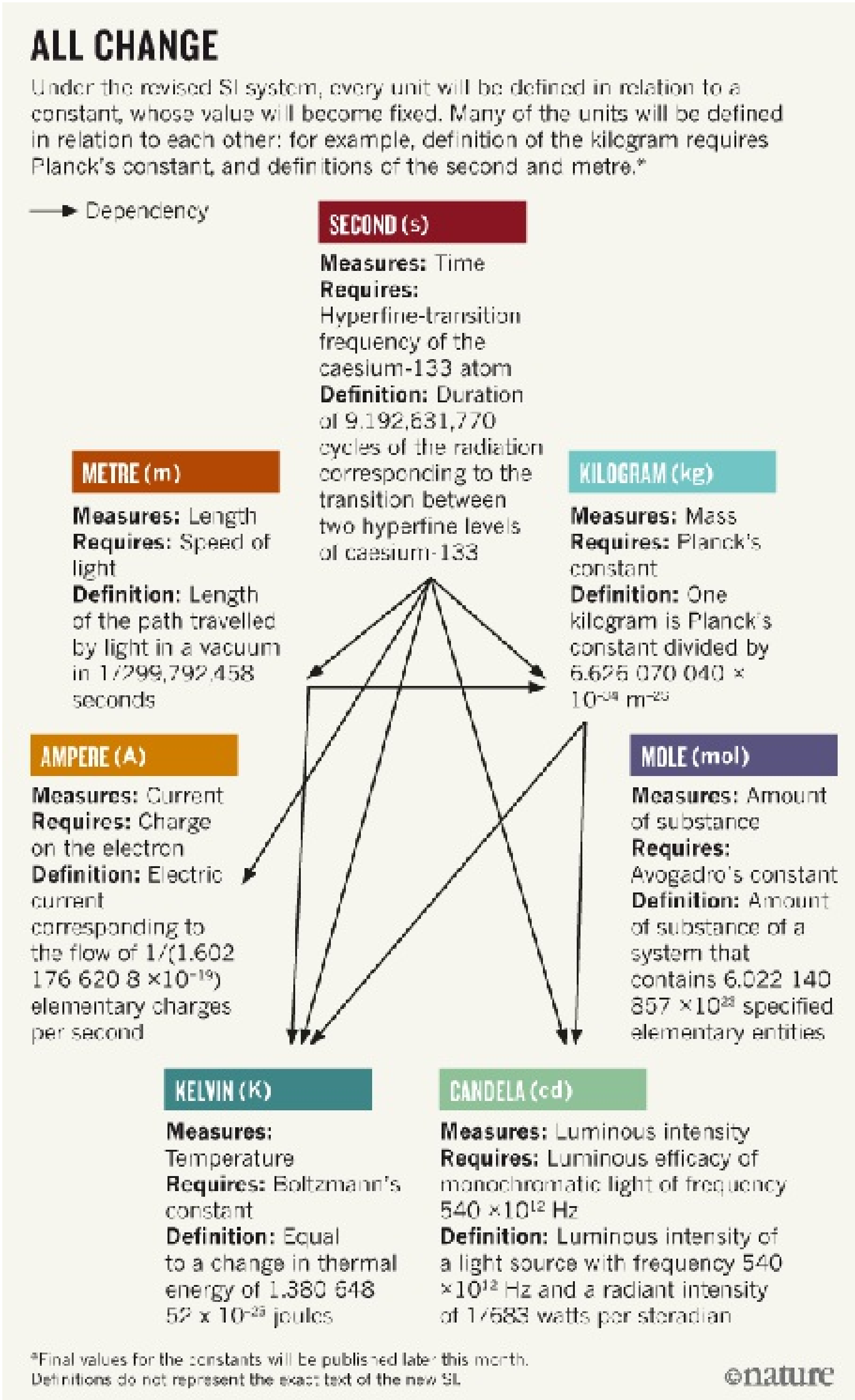
A sphere of pure silicon can be used to define a unit of measurement known as a mole.

Revamped definitions of scientific units are on their way. In the biggest

overhaul of the international system of units (SI) since its inception in 1960, a committee is set to redefine four basic units — the ampere, the kilogram, the kelvin and the mole — using relationships to fundamental constants, rather than abstract or arbitrary definitions. The International Bureau of Weights and Measures is reviewing the plans at a meeting near Paris from 16 to 20 October. Its recommendations will then go before the General Conference on Weights and Measures, which oversees the SI system, in November 2018. The changes would take effect in May 2019.

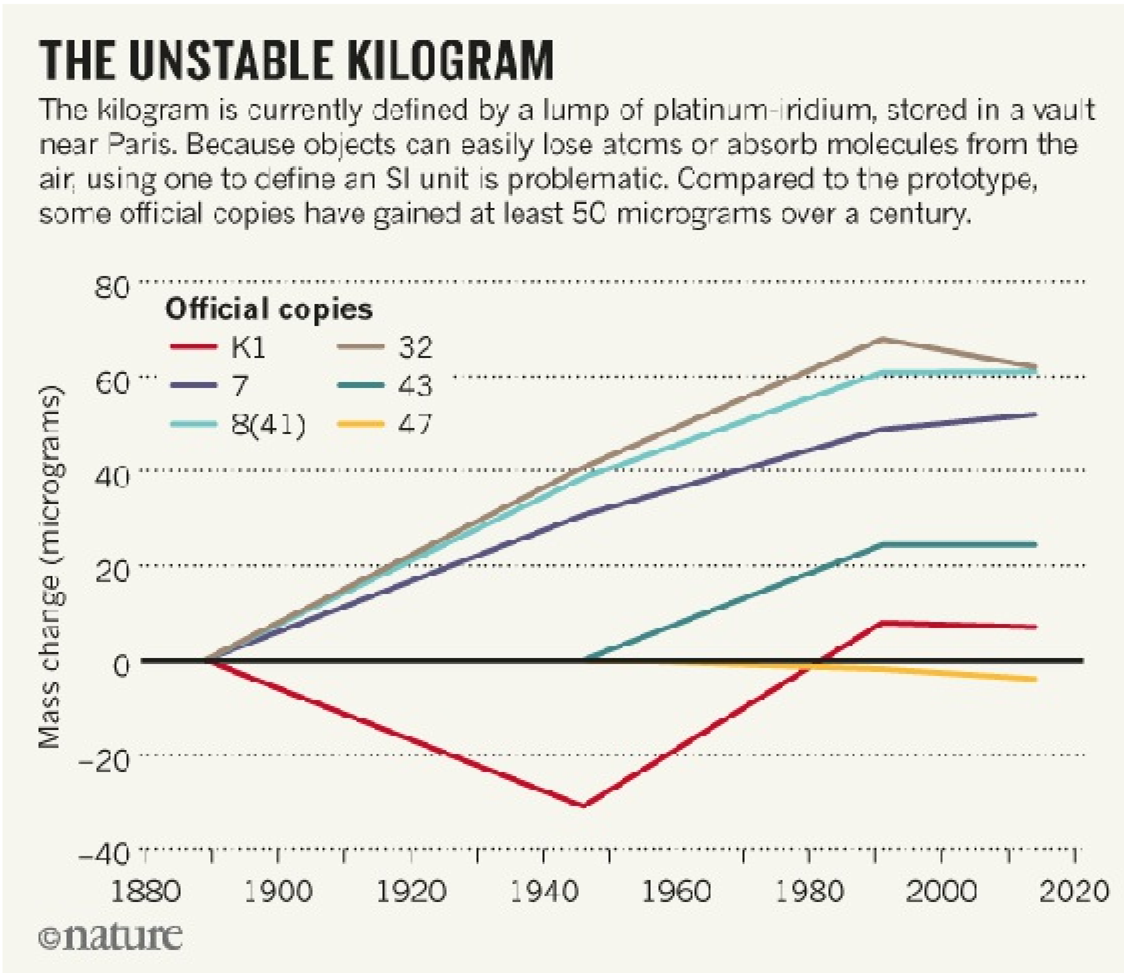
The kilogram is currently defined as the mass of a chunk of metal in a vault in Paris. And an imaginary experiment involving the force between two infinite wires defines the ampere, the unit of electrical current. The mole, meanwhile, is the amount of substance in a system with as many elementary entities as there are atoms in 0.012 kilograms of carbon-12, while the kelvin relates to the temperature and pressure at which water, ice and water vapour co-exist in equilibrium, known as the triple point of water. In the future, these units will be calculated in relation to constants — for example, the ampere will be based on the charge of an electron.

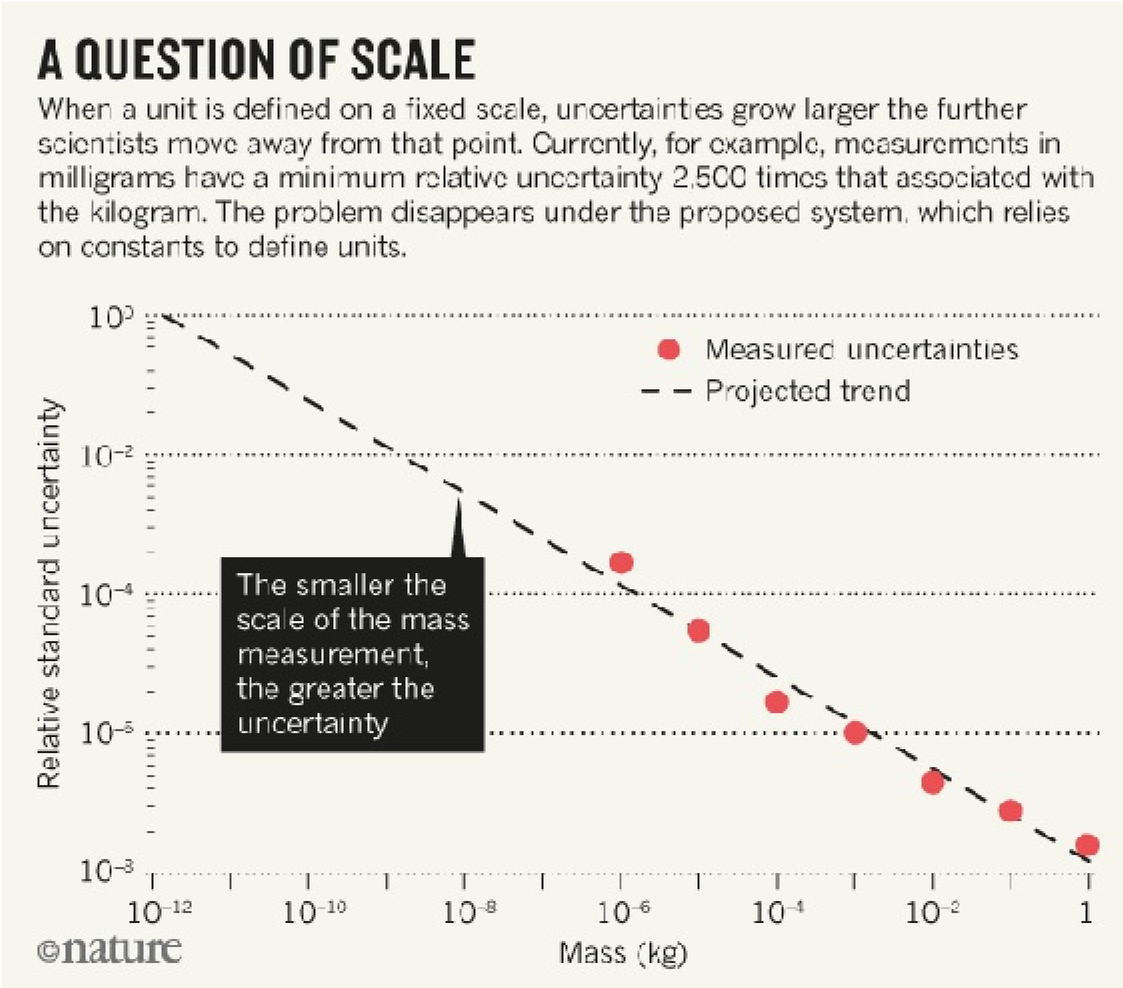
Redefinition might not affect everyday measurements, but it will enable scientists working at the highest level of precision to do so in multiple ways, at any place or time and on any scale, without losing accuracy.


ALL CHANGE
Under the revised SI system, every unit will be defined in relation to a constant, whose value will become fixed. Many of the units will be defined in relation to each other: for example, definition of the kilogram requires Planck's constant, and definitions of the second and metre.*
Dependency
SECOND (s)
Measures: Time
Requires: Hyperfine-transition frequency of the caesium-133 atom
Definition: Duration of 9,192,631,770 cycles of the radiation corresponding to the transition between two hyperfine levels of caesium-133
METRE (m)
Measures: Length
Requires: Speed of light
Definition: Length of the path travelled by light in a vacuum in 1/299,792,458 seconds
KILOGRAM (kg)
Measures: Mass
Requires: Planck's constant
Definition: One kilogram is Planck's constant divided by 6.626 070 040 × 10⁻³⁴ m⁻²s
AMPERE (A)
Measures: Current
Requires: Charge on the electron
Definition: Electric current corresponding to the flow of 1/(1.602 176 620 8 ×10⁻¹⁹) elementary charges per second
MOLE (mol)
Measures: Amount of substance
Requires: Avogadro's constant
Definition: Amount of substance of a system that contains 6.022 140 857 ×10²³ specified elementary entities
KELVIN (K)
Measures: Temperature
Requires: Boltzmann's constant
Definition: Equal to a change in thermal energy of 1.380 648 52 x 10⁻²³ joules
CANDELA (cd)
Measures: Luminous intensity
Requires: Luminous efficacy of monochromatic light of frequency 540 ×10¹² Hz
Definition: Luminous intensity of a light source with frequency 540 ×10¹² Hz and a radiant intensity of 1/683 watts per steradian
*Final values for the constants will be published later this month. Definitions do not represent the exact text of the new SI.
©nature

The problem

For measurements on conventional scales, existing definitions of SI units suffice. But they are poor tools for modern science at the extremes. And basing units on specific points or materials can be troublesome and inelegant, say metrologists.





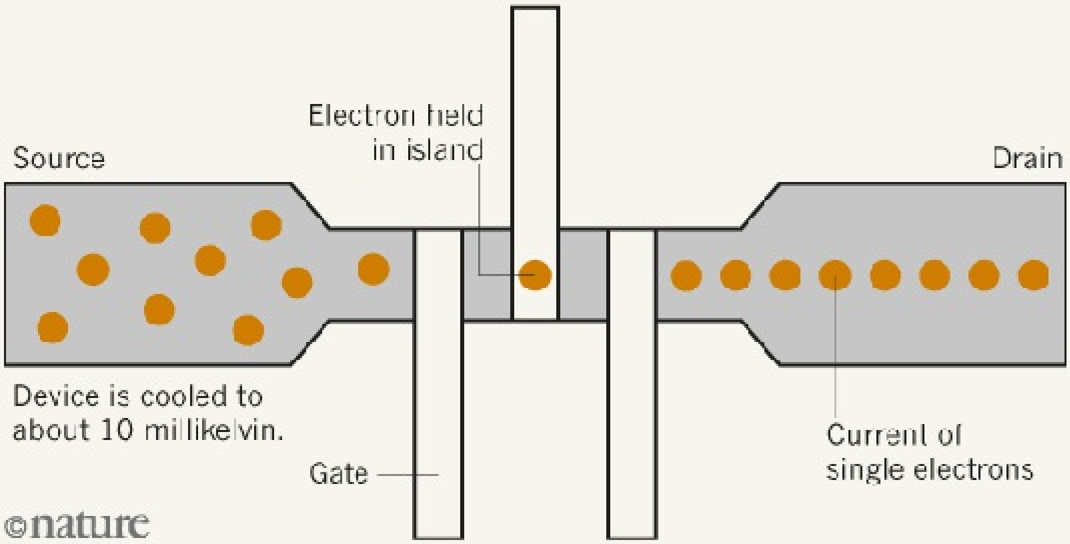
Source: Shaw, G. et al. Metrologia 53, A86–A94 (2016).

The techniques

Under the revamped SI system, researchers will be able to use various experiments to relate constants to each of the units measured.

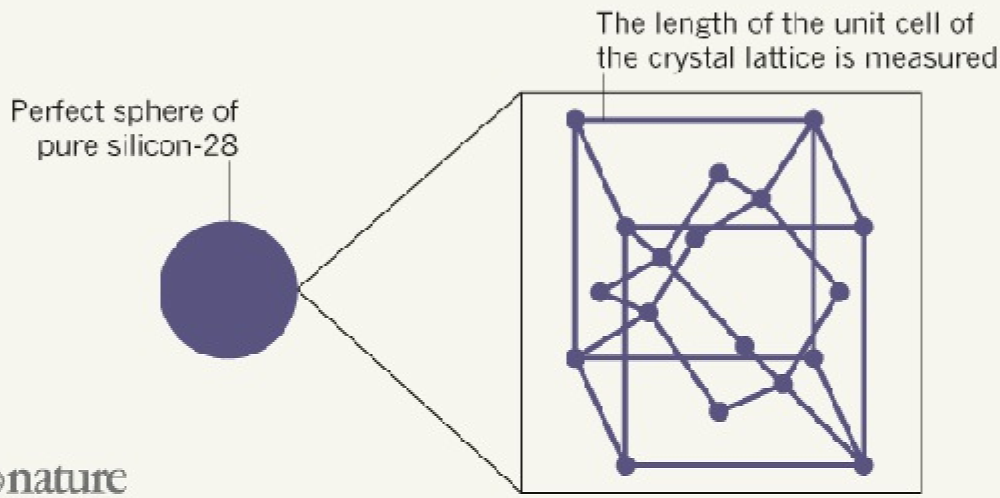
AMPERE: THE SINGLE-ELECTRON PUMP

Used to measure the charge of an electron, an electron pump could become one tool for determining the ampere. By trapping individual electrons as they travel rapidly across a conductor, the pump can generate a measureable current by counting single electrons.



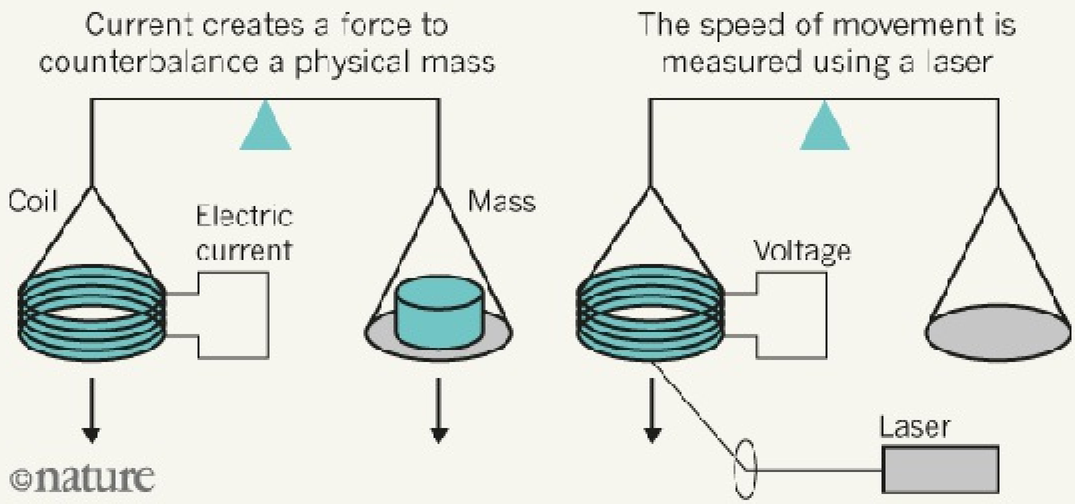
MOLE: THE SILICON SPHERE

As the device that gives scientists Avogadro's constant, this silicon sphere offers a state-of-the-art way to measure a mole. It would determine the precise number of atoms in a perfect sphere of pure silicon-28. Researchers do this by using lasers to measure the length of a unit of the sphere's crystal lattice, and its mean diameter.



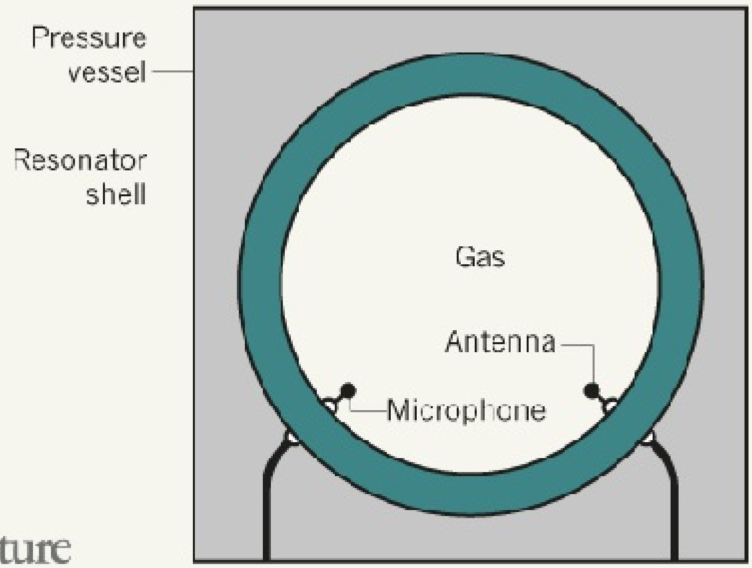
KILOGRAM: THE WATT BALANCE

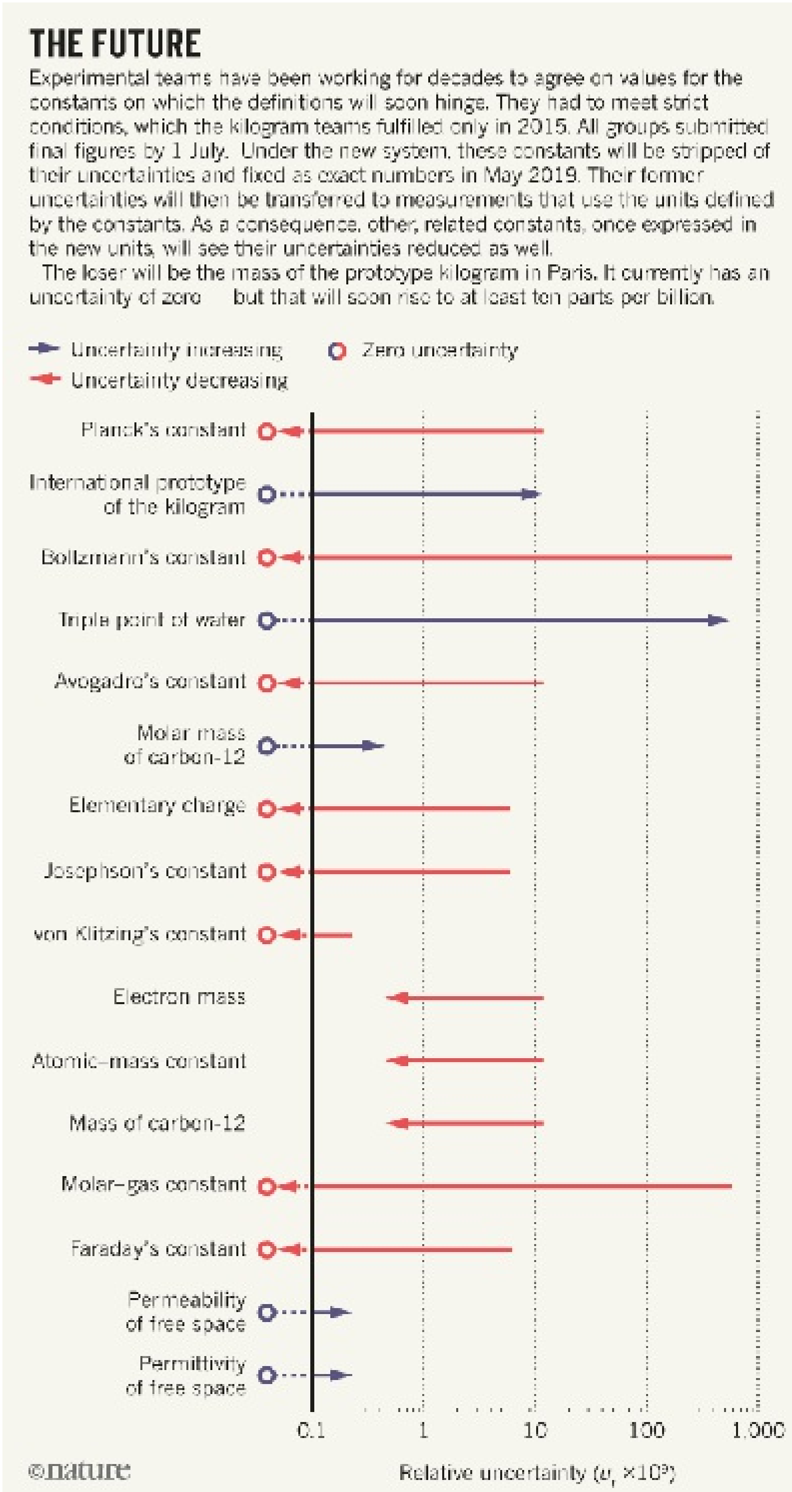
The Watt balance compares mechanical power with electromagnetic power using two separate experiments. First, a current is run through a coil in a magnetic field to create a force that counterbalances a known physical mass. Then, the coil is moved through the field to create a voltage. By measuring the speed as well as experimental values that relate the voltage and current to Planck's constant, scientists can precisely determine the weight of a mass in kilograms.



KELVIN: ACOUSTIC THERMOMETRY

This technique could be used to derive precise temperature measurements. The speed of sound in a gas-filled sphere (which is proportional to the average speed of the atoms in it) can be determined at a fixed temperature, by analysing the frequency of sound waves that resonate within in it and measuring the sphere's volume.





Journal name:

Nature

Volume:

550,
Pages:
312–313
Date published:
(19 October 2017)
DOI:
doi:10.1038/550312a

Comments

Comments

There are currently no comments.

The future of work

Digital technologies are upending the workforce. The right research can tell us how.

18 October 2017

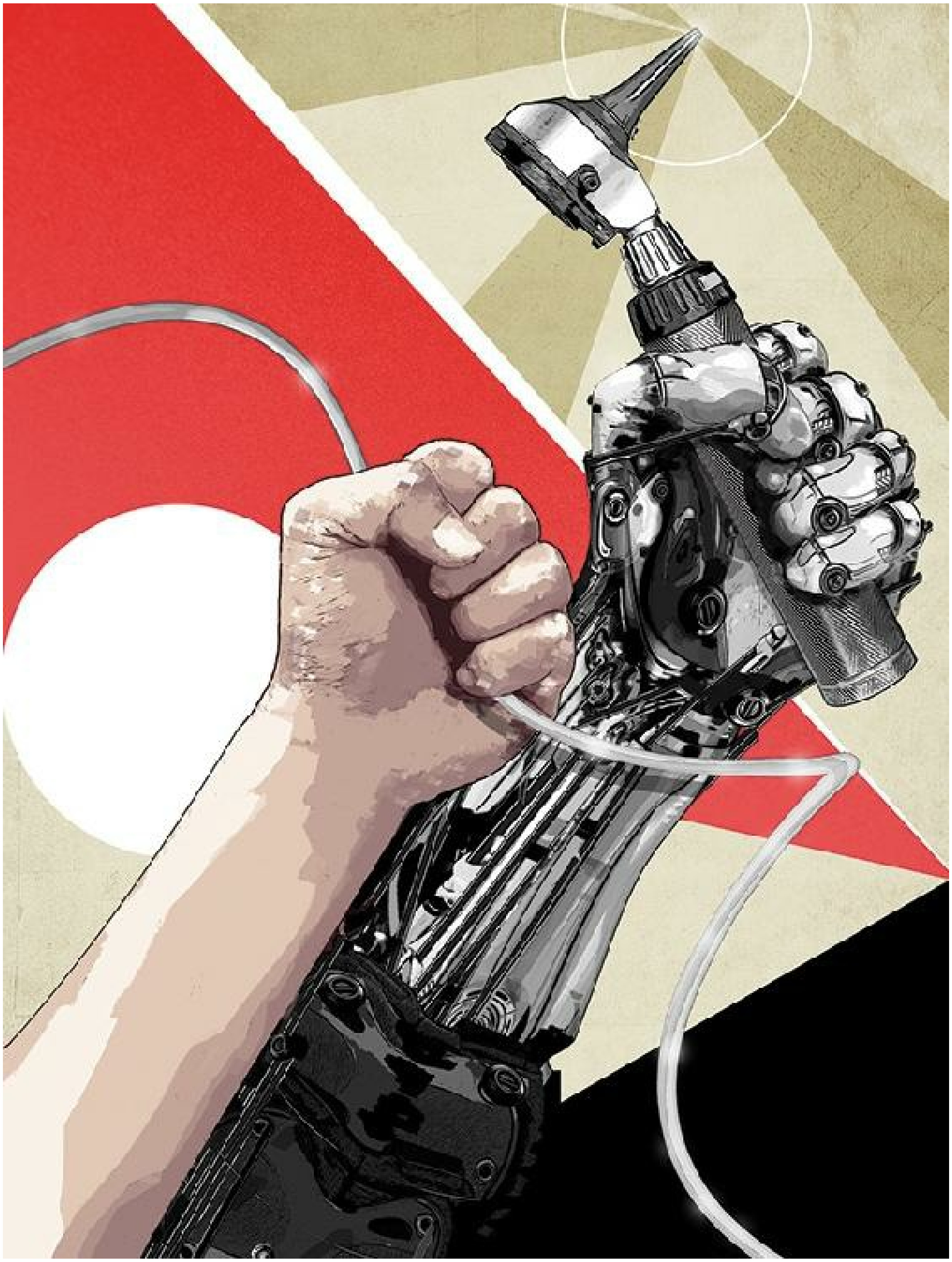


Illustration by Chris Malbon

Robots did not write this sentence, or any other part of *Nature*. But that could

change. Dramatic shifts in labour are reshaping society, the environment and the political landscape. Consider this disorienting estimate from the World Economic Forum: 65% of children entering primary schools now will grow up to work in jobs that do not yet exist. This week, *Nature* asks: what light is research shedding on the future of work, and how will the changes affect scientists' working world?

A News Feature explores which jobs are most at risk of being replaced by artificial intelligence and machine learning; whether a decentralized 'gig economy' will democratize work; and what programmes will best prepare workers. “There's a huge need, a huge opportunity, to study the changes,” says economist Erik Brynjolfsson. And the scientific workforce is feeling these shifts. A Careers Feature reports on people doing research outside the traditional career path. “I love the freedom,” says Cecile Menard, an independent land-surface modeller in Edinburgh, UK, “but for other people, it may be too stressful.”

Important lessons can be drawn from the past. Economic historian Robert Allen synthesizes three centuries of data to see when and where the relationship between wages and productivity was most like today's — and finds that some regions are in uncharted waters. These changes call for new socio-economic models and a revolution in education, concludes historian Yuval Noah Harari. And economist Ian Goldin argues that our era has more parallels with the Renaissance than the Industrial Revolution. This time, he urges, “knowledge and enquiry must find a way to conquer prejudice and ignorance”.

Journal name:
Nature
Volume:
550,
Pages:
315
Date published:
(19 October 2017)
DOI:
doi:10.1038/550315a

Comments

There are currently no comments.

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The shape of work to come

Three ways that the digital revolution is reshaping workforces around the world.

18 October 2017

Illustration by Chris Malbon

Last year, entrepreneur Sebastian Thrun set out to augment his sales force with artificial intelligence. Thrun is the founder and president of Udacity, an education company that provides online courses and employs an armada of salespeople who answer questions from potential students through online chats. Thrun, who also runs a computer-science lab at Stanford University in California, worked with one of his students to collect the transcripts of these chats, noting which resulted in students signing up for a course. The pair fed

the chats into a machine-learning system, which was able to glean the most effective responses to a variety of common questions.

Next, they put this digital sales assistant to work alongside human colleagues. When a query came in, the program would suggest an appropriate response, which a salesperson could tailor if necessary. It was an instantaneously reactive sales script with reams of data supporting every part of the pitch. And it worked; the team was able to handle twice as many prospects at once and convert a higher percentage of them into sales. The system, Thrun says, essentially packaged the skills of the company's best salespeople and bequeathed them to the entire team — a process that he views as potentially revolutionary. “Just as much as the steam engine and the car have amplified our muscle power, this could amplify our brainpower and turn us into superhumans intellectually,” he says.

The past decade has seen remarkable advances in digital technologies, including artificial intelligence (AI), robotics, cloud computing, data analytics and mobile communications. Over the coming decades, these technologies will transform nearly every industry — from agriculture, medicine and manufacturing to sales, finance and transportation — and reshape the nature of work. “Millions of jobs will be eliminated, millions of new jobs will be created and needed, and far more jobs will be transformed,” says Erik Brynjolfsson, who directs the Initiative on the Digital Economy at the Massachusetts Institute of Technology in Cambridge.

But making firm predictions is difficult. “The technology is rushing ahead, which in a way is a good thing, but we have a huge gap in understanding its implications,” Brynjolfsson says. “There's a huge need, a huge opportunity, to study the changes.” Researchers are beginning to do just that, and the emerging evidence resists simple storylines. Advances in digital technologies are likely to change work in complex and nuanced ways, creating both opportunities and risks for workers (see 'More research needed').

More research needed

Illustration by Chris Malbon

Scientists are grappling with how technology could alter workplaces.

The changing world of work presents an almost endless number of topics for

scientists to explore. Here are two other workplace trends and the research questions — as yet mostly unanswered — that they raise.

How will workers respond to new forms of tracking and surveillance?

Although employers have long monitored the performance of their staff, workplace surveillance is entering a new era.

Companies can now log workers' keystrokes and remotely take screenshots of their computers, for example, or use motion sensors, biometrics, radio-frequency identification (RFID) chips and the Global Positioning System to track their movements, even after hours.

But it's not yet clear whether workers will show widespread resistance to the increasing use of surveillance technology, or where they might draw the line. And could new forms of surveillance backfire in less obvious ways, undermining trust, morale or innovation?

How will human-enhancement technologies affect worker health and safety?

Technologies for improving human performance — from cognition-boosting drugs to bionic 'exoskeletons' that are designed to make physical labour safer and easier — are beginning to make their way into the workplace.

In some cases, these technologies could help to protect the health and safety of workers. An alertness-enhancing drug, such as modafinil, might help long-haul drivers avoid accidents, and exoskeletons could reduce joint stress and muscle fatigue. But researchers don't know whether the long-term use of these technologies could harm workers, either directly or indirectly, perhaps by encouraging overwork or increased risk-taking.

Here are three pressing questions about the future of work in a digital world and how researchers are beginning to answer them.

Will machine learning displace skilled workers?

In previous waves of automation, technological advances have allowed machines to take over tasks that were simple, repetitive and routine. Machine learning opens up the possibility of automating more complex, non-routine cognitive tasks. “For most of the last 40 or 50 years, it was impossible to automate a task before we understood it extremely well,” Brynjolfsson says. “That's not true anymore. Now machines can learn on their own.”

Machine-learning systems can translate speech, label images, pick stocks, detect fraud and diagnose disease — rivalling human performance in some new and surprising domains. “A machine can actually look at many, many, many more data samples than a human can handle,” says Thrun. Earlier this year, he led a team that demonstrated that some 129,000 images of skin lesions could be used to train a machine to diagnose skin cancer with a level of accuracy that matches that of qualified dermatologists[1].

LISTEN

Reporter Benjamin Thompson finds out how lessons from the past can help explore the future of work.

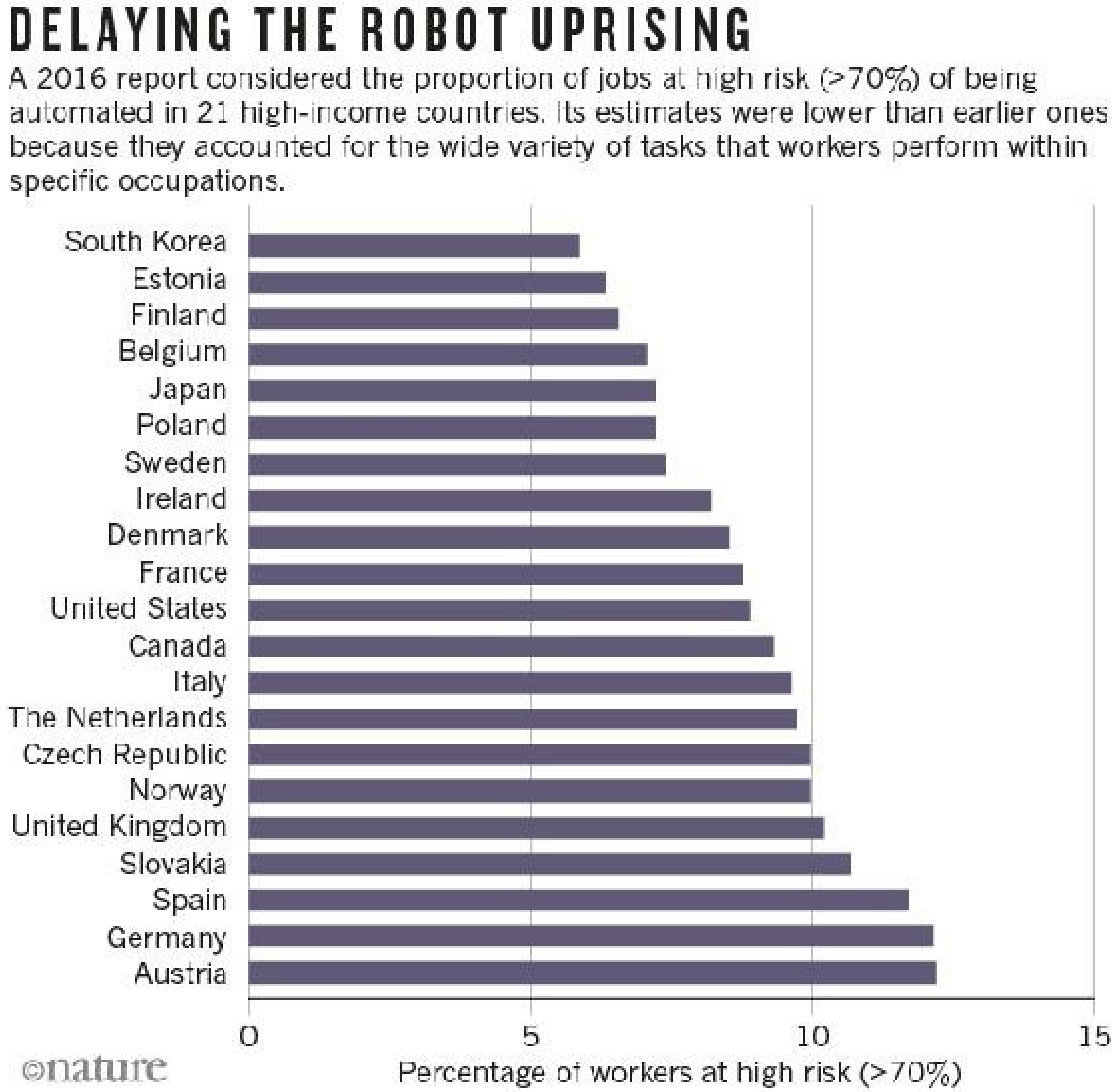
You may need a more recent browser or to install the latest version of the Adobe Flash Plugin.

These advances have raised concerns that such systems could replace human workers in fields that once seemed too complex to be automated. Early estimates seemed dire. In 2013, researchers at the Oxford Martin Programme on Technology and Employment at the University of Oxford, UK, reviewed the advances and lingering challenges in machine learning and mobile robotics to estimate how susceptible 702 different occupations were to automation[2]. Their startling conclusion was that 47% of jobs in the United States were at high risk of computerization, with jobs in transportation, logistics, production and administrative support particularly vulnerable. That spelt trouble for workers such as taxi drivers, legal secretaries and file clerks.

Since then, however, other researchers have argued that the 47% figure is much too high, given the variety of tasks that workers in many occupations

tend to perform. “Once you go deeper, once you look into the task structure of what people really do at work, then you find that the estimates get much lower,” says Ulrich Zierahn, a senior researcher at the Centre for European Economic Research in Mannheim, Germany.

For instance, the Oxford study reported that clerks in bookkeeping, accounting and auditing face an automation risk of 98%. But when Zierahn and his colleagues analysed survey data on what people in those professions actually do, the team found that 76% of them had jobs that required group work or face-to-face interaction. For now at least, such tasks are not easily automated[3]. When the authors extended their approach to other professions, they found less-alarming figures for the number of at-risk jobs in the 21 countries surveyed. In the United States, the share of workers at high risk of automation was just 9%, and the figure ranged from a low of 6% in South Korea and Estonia to a high of 12% in Germany and Austria (see 'Delaying the robot uprising').



Sources: OECD/Ref. [3] (http://go.nature.com/2KK4D4Y)

Brynjolfsson is now working with Tom Mitchell, a computer scientist at Carnegie Mellon University in Pittsburgh, Pennsylvania, to drill deeper into the impact of machine learning. They have developed a rubric outlining the characteristics that make certain tasks especially amenable to this approach. For instance, machine-learning systems are adept at tasks that involve translating one set of inputs — say, images of skin lesions — into another set of outputs, such as cancer diagnoses. They're also most likely to be used for tasks in which the large digital data sets required for training the system are readily available. Brynjolfsson and Mitchell are now going through several

large occupational databases to determine how well a variety of workplace tasks match up with these and other criteria.

Even with these kinds of analysis in hand, determining the consequences for the labour market is complex. Just because a task can be automated doesn't mean that it will be; new technologies often require costly and time-consuming organizational changes. Legal, ethical and societal barriers can also delay or derail their deployment. “AI is not yet an off-the-shelf product,” says Federico Cabitza, who studies health-care informatics at the University of Milano-Bicocca in Italy. Implementing medical machine-learning systems, for instance, requires both technological readiness and willingness to devote the thousands of person-hours necessary to make these systems operational, he says — not to mention buy-in from caregivers and patients.

Research suggests that the workforce is flexible in adapting to new technologies. In the second half of the twentieth century, increasing automation prompted shifts within occupations as employees began performing more complex and non-routine tasks. In some future cases, these shifts could be positive; if automated systems start making routine medical diagnoses, it could free doctors to spend more time interacting with patients and working on complex cases. “The fact that computers are becoming good at medical diagnosis doesn't mean that doctors will disappear as a job category,” Mitchell says. “Maybe it means we'll have better doctors.”

Indeed, many people might find themselves working alongside AI systems, as the Udacity salespeople did, rather than being replaced by them. Self-driving cars, for instance, are not yet able to navigate all situations on their own, so car manufacturer Nissan is developing a human-powered solution. If one of its autonomous cars encounters a situation it doesn't understand, such as roadworks or a traffic accident, it will contact a remote command centre where a human 'mobility manager' can take control until the car has passed the trouble spot. “Machines think in a very different way, fundamentally, than humans do, and each has its strengths,” says Pietro Michelucci, executive director of the Human Computation Institute in Fairfax, Virginia. “So there's a real natural marriage between machines and humans.”

Will the gig economy increase worker

exploitation?

Flexibility, variety and autonomy: these are the promises of the burgeoning gig economy, in which workers use online platforms to find small, short-term jobs. This sort of on-demand, digitally mediated gig work can take a variety of forms, from driving for the taxi service Uber to completing microtasks — including taking surveys, translating a few sentences of text or labelling an image — on a massive crowd-working platform such as Amazon Mechanical Turk.

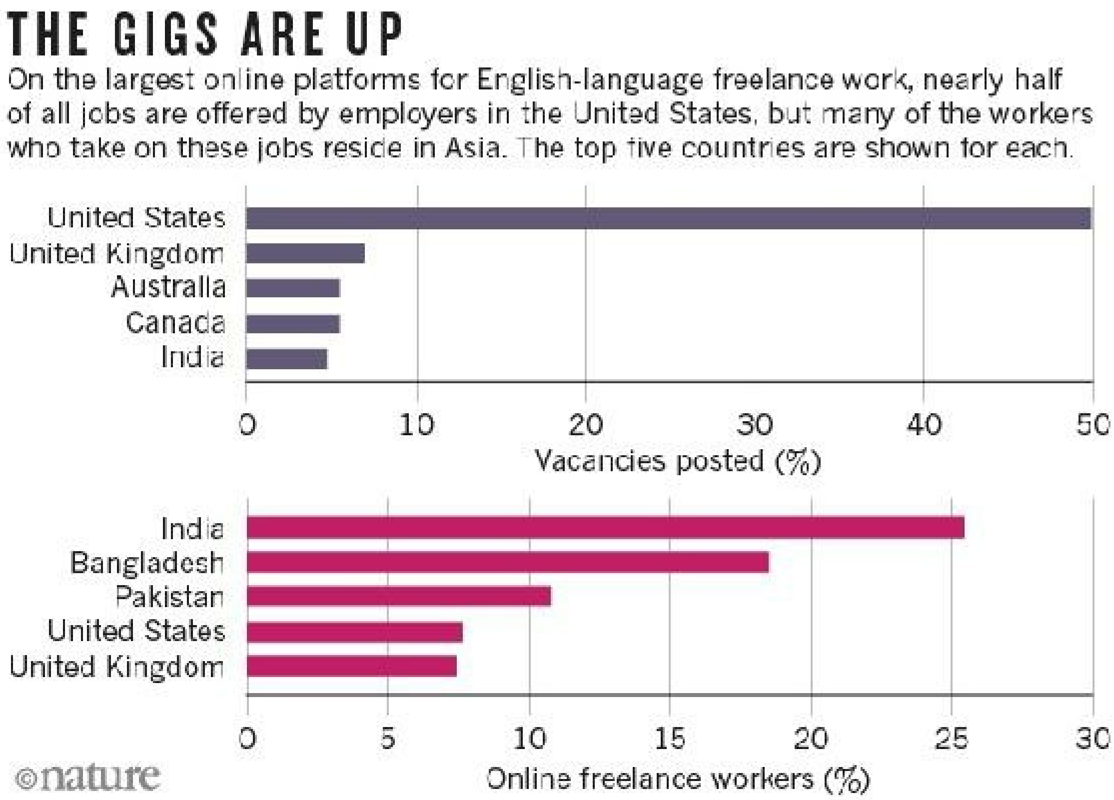
These digital platforms allow workers to complete tasks from anywhere, meaning they could remove some geographical barriers to getting good jobs. “Someone in Nairobi is no longer constrained by the local labour market,” says digital geographer Mark Graham of the University of Oxford.

Graham and his colleagues have spent several years studying the digital, on-demand economy in southeast Asia and sub-Saharan Africa. They have conducted face-to-face interviews with more than 150 gig workers in these regions, surveyed more than 500 people and analysed hundreds of thousands of transactions on online labour platforms.

Their preliminary results show that these jobs do pay off for some gig workers; 68% of the survey respondents said that the work makes up an important part of their household income. And digital platforms provided jobs to a variety of people — including women who were primary caregivers and migrants without work permits — who said that their employment opportunities were otherwise limited. “There are some people who really thrive in this system,” Graham says. “But it's not like that for everyone.”

There is a pronounced oversupply of labour in the gig economy, leading some workers to drop their rates below what they consider fair. Many also work long hours at high speeds and to tight deadlines. “They tend to have a very precarious existence, so they're worried about saying no to jobs that they do get,” Graham says. “We talked to quite a few people who have done things like stay up for 48 hours straight, just working solidly in order to get their contracts done on time.”

Considerable geographical inequities remain. In a 2014 study[4], Graham and several colleagues analysed more than 60,000 transactions on one major platform in March 2013. Most jobs, they found, were listed by employers in high-income countries and completed by workers in low- or middle-income countries (see 'The gigs are up').



Source: Ilabour (http://go.nature.com/2GZE5TZ)

But those who live close to where the jobs are still seem to have an advantage. They win a disproportionate share of jobs and earn significantly more — US$24.13 per hour, on average — than foreign workers, who earned $11.66 per hour for comparable work. And some low- and middle-income nations attracted many more jobs than others; India and the Philippines are the top two recipients in Graham's analysis.

Practical concerns could explain some of these disparities. Language and time-zone differences might make some employers reluctant to hire foreign workers, and the history of outsourcing labour to India and the Philippines

may have helped make workers there more attractive to employers. But discrimination, both conscious and unconscious, could play a part, too; Graham's team found task listings explicitly stating that people from certain countries need not apply. “Even though these technologies have been able to connect different parts of the world, they have not been able to bridge these kinds of differences as much as we hoped,” says Mohammad Amir Anwar, a researcher who works with Graham.

Another large ethnographic study of gig workers is beginning to reveal more about how this work gets done. It also provides some clues about what workers need to succeed. Between 2013 and 2015, two senior researchers at Microsoft Research — anthropologist Mary Gray in Cambridge, Massachusetts, and computational social scientist Siddharth Suri in New York City — surveyed roughly 2,000 gig workers in the United States and India and conducted longer interviews with nearly 200 of them.

One of the first things they discovered was that, although gig workers are often portrayed as independent, autonomous labourers, many of them were in fact communicating and collaborating with each other[5]. Workers helped each other to set up accounts and profiles, shared information about good employers and newly posted jobs, and provided technical and social support. Workers are making a deliberate effort to add human connections back into the system, Suri says, and they're doing it on their own time. “So they clearly must value it.”

In a more quantitative follow-up study[6], in which they mapped the social connections among more than 10,000 Amazon Mechanical Turk workers, Gray, Suri and their colleagues found that this kind of collaboration can have real pay-offs. Workers who had connections to at least one other person on the platform had higher approval rates, were more likely to gain elite 'master' status, and found out about a new task more quickly than unconnected workers. For people to be productive, says Gray, “it turns out that they really need to collaborate. They need each other.”

Can the digital skills gap be closed?

For years, experts have been sounding the alarm about a looming shortage of digital skills. They have warned that there are too few trained workers to fill high-tech jobs, and that a lack of basic digital literacy could prevent workers in certain geographical regions or demographic groups from thriving in the digital economy. In response, various innovative programmes for boosting digital literacy and skills have sprung up worldwide. Research is now starting to provide some clues about what does and doesn't work — and about where skills training might fall short.

There have been some documented successes. More than a decade ago, the US Defense Advanced Research Projects Agency began developing a personalized, interactive and adaptive 'digital tutor' system to train new recruits to the US Navy for jobs as information-systems technology (IT) technicians. Students would work with the tutor one-to-one, completing lessons on different topics and solving related problems. The system prioritized conceptual learning and reflection, regularly prompting students to review what they'd learnt. When the tutoring system judged that a student had mastered the material, it would move on to the next subject.

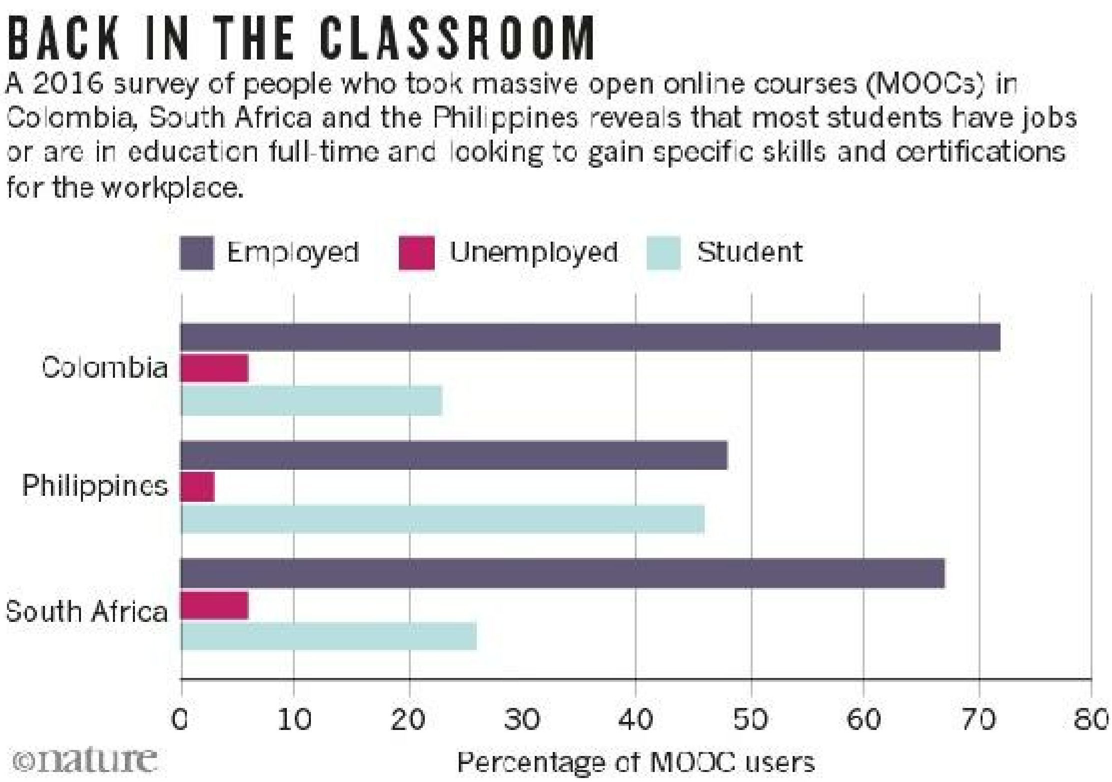
In a 2014 review[7] of the programme, researchers at the Institute for Defense Analyses in Alexandria, Virginia, found that 12 recruits who completed the 16-week course outperformed graduates of conventional, classroom-based US Navy IT training that lasted more than twice as long. The 12 even did better than a group of senior naval IT technicians — who each had an average of nearly ten years' experience — on almost every measure. “If we can do that, why not do more of it?” says Dexter Fletcher, who co-authored the review. “Why not begin to apply this seriously to workforce training?”

In a follow-up study[8], Fletcher found that a slightly modified version of the digital tutor yielded similar results when it was used to train 100 military veterans for civilian jobs in IT. Within six months of completing the programme, 97% of the veterans who wanted IT jobs had landed them, earning an average annual salary roughly equal to that of someone with 3–5 years of experience in the field.

Numerous other strategies have been promoted to improve digital skills and employment, including massive open online courses (MOOCs) — university-

level classes that are delivered over the Internet — and coding bootcamps, which are intensive, short-term training courses that teach the basics of computer programming.

In a 2016 analysis[9] of 1,400 MOOC users in Colombia, the Philippines and South Africa, researchers determined that 80% of students were from low- or middle-income backgrounds and that 41% had only basic computer skills. More than half of the students (56%) were female, and computer science was the most popular MOOC topic. “Women are actually engaging in MOOCs in areas where they are underrepresented,” says Maria Garrido, a co-author of the report at the University of Washington's Information School (see 'Back in the classroom').



Source: Ref. [9] (http://go.nature.com/2YFAPWC)

But the quality of these programmes can vary enormously, and few have been rigorously evaluated. Coding bootcamps can be expensive, require a significant time investment and are located primarily in technology corridors

and urban settings. And achievement gaps remain; in a 2015 study[10] of more than 67,000 MOOC students, two Stanford researchers found that female students and students of both genders from Africa, Asia and Latin America were less likely to reach certain course milestones — such as watching more than 50% of the lectures — and earned lower grades than male students and MOOC students from North America, Europe and Oceania.

Even those who complete digital-skills courses can still face a variety of barriers to employment. When researchers interviewed students in a Kenyan IT programme at Strathmore University in Nairobi in 2004, some of the students said that they were worried about graduating into a local economy that didn't appreciate their expertise or have jobs in which they could put it to use[11]. “And this was especially true for the women,” says Lynette Yarger, an information scientist at Pennsylvania State University in University Park, who was involved in the research. As one student put it: “Because I am a woman, employers may not think that they should give me a job working in IT, so I may never fully get to use all that I have learned to do, work that I want to do.”

One thing the research is already making clear is that even well-designed training programmes might not be sufficient to ensure success in the world of digital work. “The fact that you have better skills and know how to use a computer doesn't necessarily mean that you automatically can get a good job,” Garrido says. “Digital skills are an important piece of the puzzle, but they're not enough.”

Journal name:
Nature
Volume:
550,
Pages:
316–319
Date published:
(19 October 2017)
DOI:
doi:10.1038/550316a

Comments

There are currently no comments.

Lessons from history for the future of work

18 October 2017

Global comparisons of previous social and economic upheavals suggest that what is to come depends on where you are now, argues Robert C. Allen.

Lewis Hine/Pictorial Press Ltd/Alamy

Children working in a cotton mill in Macon, Georgia, in January 1909.

Today is not the first time that people have worried that machines will render

human labour obsolete, making a few very rich and the majority very poor.

Since the Industrial Revolution, mechanization has been controversial. Machines pushed up productivity, raising incomes per capita. But they threatened to put people out of work, to lower their wages and to divert all the gains from growth to the owners of businesses. The stocking-frame operators of Nottingham, UK (the Luddites), wrecked improved knitting machines that threatened their jobs. Mobs burnt down the first mills housing spinning and weaving equipment in the 1760s and 1790s.

Now, it is robots that threaten work, wages and equality[1]. Are the gains of technological progress destined to benefit only the top 1% of earners?

Economists' stock answer to this question is 'no'[2]. Technical progress in the past three centuries has led to incomes in the West (that is, the developed nations of today) that are much higher than they were in 1700 in real terms, and the fraction of the adult population employed in these countries is at record levels. Despite mechanization, automation and computerization, people have found jobs. Somehow the economy has always adjusted; somehow in the future it always will.

I think this answer is too simplistic.

Phase shift

There have been long periods of economic history in which things did not work out well, and we must wonder whether we are in another. Also, the 'future of work' depends very much on where you are in the world. Most discussions in the West focus on how technological evolution in the West affects jobs in the West. This frame is too narrow for the twenty-first century: we must investigate the effect of technological change on work everywhere. For the past three centuries, the global economy has been sufficiently integrated that new technology in one place affects work in others.

LISTEN

Reporter Benjamin Thompson finds out how lessons from the past can help explore the future of work.

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Rather than ask (unanswerable) questions about how machines will affect work over the next centuries, we can ask what the invention of the textile mill meant for a girl growing up in Manchester, UK, in 1800 or the wife of a subsistence rice farmer in China's Yangtze Delta at the same time. Technological change affected their futures of work very differently and often detrimentally. Similar things are happening now.

We need to divide the past into periods defined by trends. The periods I suggest here reflect Western history, which is not as limiting as it sounds: globalization means that developments in one region affect others.

The three phases are: the Industrial Revolution (1750–1830); the Western ascent to affluence (1830–1970); and the problem-ridden present (since 1970). Each holds lessons and pressing research questions for today.

The industrial revolution

The Industrial Revolution was Britain's creative response to the globalization of the world economy that occurred after Columbus's voyage to America in 1492 and Vasco da Gama's sail around Africa to India in 1498. Britain's colonies in North America, the Caribbean and India formed a large market for Britain's handicraft industries. Exports boomed, and by the mid-eighteenth century about one-third of Britain's workforce was employed in making metal goods and cloth.

Large data sets of wages and prices over this period[3] have been assembled since the 1980s and show that real wages rose as a consequence of this export boom[4]. Inventors designed machines to save expensive labour. Mechanization paid in Britain rather than elsewhere because labour was more expensive relative to capital; that is why the Industrial Revolution was

primarily a British affair.

Textiles were the world's most important manufactured product in terms of employment before the Industrial Revolution, and the first to be mechanized. Indian cotton cloth was imported to Europe, where it was a smash hit. English manufacturers struggled to compete because English wages were so high. The invention in the 1760s and 1770s of spinning machines to speed up cloth-making, including Hargreave's spinning jenny, Arkwright's water frame and Crompton's spinning mule, solved the problem. The first victims of technological unemployment were the British women spinning cotton by hand and, later, the much-larger number spinning wool, once machinery was adapted to that fibre.

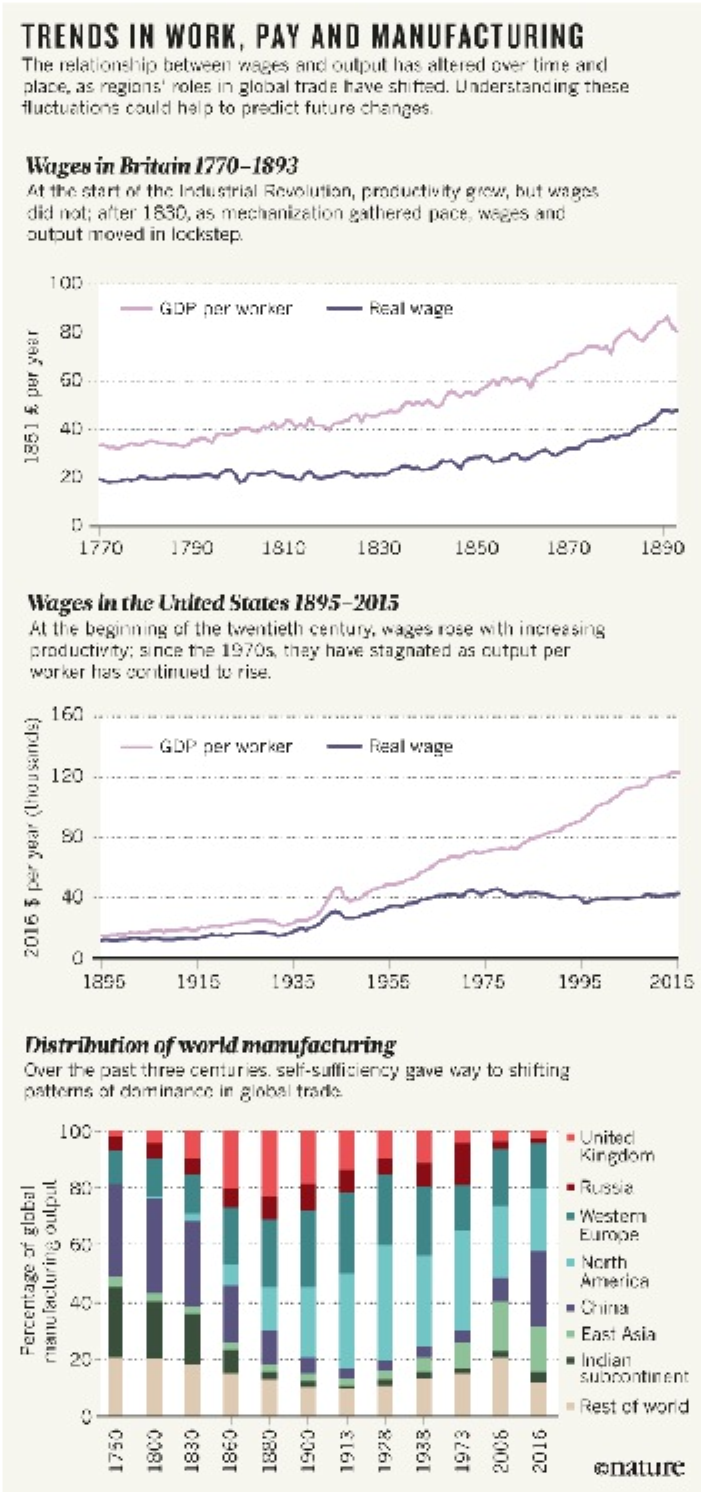
Soon jobs were lost from Casablanca to Canton. Investing in spinning machines made sense only in the high-wage economy of eighteenth-century England, thus they greatly increased English competitiveness without benefiting other nations. As jobs proliferated in the British cotton mills, massive technological unemployment spread across Africa and Asia[5]. The collapse of the Indian cotton trade around the 1830s led the British governor general to remark[6]: “The bones of the cotton-weavers are bleaching the plains of India.”

In 1820, the future of work for the wife of a farm labourer in England was an unhappy one. She had lost the opportunity to increase her family's income by spinning part-time, as her mother had done. The same impoverished fate befell a farmer's wife in the Ganges or Yangtze deltas. Some British women found work in the cotton mills (but a smaller number than had been employed to spin cotton by hand). By contrast, the future of work was auspicious for railway engineers, bricklayers and metal workers, to say nothing of the vast number of middle-class entrepreneurs and professionals who directed and serviced the industrial economy.

Machines were invented to save labour in most sectors of the economy in the first half of the nineteenth century. As one trade after another was eliminated in Britain, earnings collapsed in the affected trade, and that, in itself, lowered average national earnings. The displaced workers shifted into other trades, pushing down those wages. The Luddites and other opponents of

mechanization are often portrayed as irrational enemies of progress, but they were not the people set to benefit from the new machinery, so their opposition makes sense.

The implications were stark (see 'Trends in work, pay and manufacturing'). Although output per worker grew from 1770 to 1890, there was little growth in the real wage from 1770 to about 1830. During the Industrial Revolution (phase one) the 'normal' relationship was booming productivity and constant average wages — rather like the past 40 years.



Sources: See Supplementary Information

The western ascent to affluence

The average real wage only began to rise in the middle of the nineteenth century, when higher-productivity factory work replaced the hand trades. By 1850 Britain was the 'workshop of the world'. Comprising only around 3% of the world's population, the United Kingdom produced about half of the world's iron, for instance.

Industrial pre-eminence saw in the next phase of history. The new normal in the West was productivity and wages advancing together, as the Industrial Revolution spread across Europe and North America. Although there were shocks along the way owing to the depression of the 1930s and the Second World War, the period from the mid-nineteenth century to 1970 was one in which the working class benefited from the growth in productivity. Incomes became more equal. This is the economic performance that many have come to regard as normal.

How this favourable situation arose is a fundamental question. It seems that a positive-feedback system was in operation. Rising incomes led to the demand for fancier manufactured goods (for example, bicycles then cars) and more services (such as travel, retail trade and medical care). These created markets that encouraged technological change and led to jobs that were performed more effectively by educated people[7].

The need for educated workers led to the expansion of state provision of education. The increasing number of educated people prompted the invention of technologies that took advantage of education[8]. Those technologies led to further demand for education. At the same time, the public provision of infrastructure — roads and airports, for instance — was crucial for the development of industries involving cars and aircraft. Public support for research in medicine, agriculture and technologies with military applications, such as electronics and aircraft, underlaid many advances. The welfare state helped to spread the benefits of this economic development across the population.

The upshot was a pattern of economic growth in which technical progress benefited most people in the West.

The same was not true in Asia and Africa. Before the Industrial Revolution, China and India had the largest manufacturing sectors in the world because they had the largest populations, and nations were mostly self-sufficient in the pre-globalization era. As the Industrial Revolution gathered pace, Britain's share of goods manufactured worldwide increased, reaching a peak of about one-quarter in the late nineteenth century. Western Europe's share and that of North America also increased. In the same period, the shares of India and China collapsed. This drop represented absolute de-industrialization and not simply shifting percentages.

The technological revolution that spread prosperity in the West created modern 'underdeveloped countries' in the East (that is, Asia, Africa and South America). It converted them into economies that exported solely primary products — wheat, rice, bauxite, oil — rather than secondary ones such as cloth and porcelain.

By the 1830s, technological progress in the West meant a bleak future of work elsewhere.

The problem-ridden present

The past four decades have seen many job losses in the manufacturing sector in Western countries, static or falling real wages, and rising inequality as the gains from growth accrue to the top 1%. Did the 'new normal' end in 1970, or are the recent trends just a blip? Might what was 'normal' in 1850–1970 return soon — that is, the concurrent advance of productivity and wages?

Some people believe that the feedback loops between education and technology will kick in again, generating new knowledge-based, high-income jobs in the West to replace lost manufacturing jobs. Computers and robots will save us.

I am more pessimistic. The rise in real wages that began in the mid-nineteenth century and tracked the rise in output per worker ended in the 1970s (see 'Trends in work, pay and manufacturing'). Real wages rose at a slower rate than productivity in the 1980s and 1990s — or stagnated

altogether, as in the United States. In some cases (for example, the United Kingdom) wages have actually been falling in real terms over the past decade. A deviation of this magnitude from the trend suggests that the new pattern may not be transitory.

Similarly, the rebound in overall inequality in mature economies, such as the United States, over the past 40 years is unprecedented. Inequality rose in many countries as they industrialized and fell thereafter — this trend is called a Kuznets curve (after the Nobel laureate Simon Kuznets)[9]. The rise in inequality since 1970 has shown that this is a reversible feature of economic history.

Inequality is an area that has seen much recent research, with large data sets assembled and interrogated. Some scholars have focused on the share of total income going to the top 1% or 5%[10]. Others use indices that incorporate information from every level of the income distribution[11]. How we interpret the results depends on our breadth of vision. A common pattern in many countries is a fall in inequality from the early twentieth century to the 1970s and then a rise. This is true of the United States, the United Kingdom and China, for instance. At the global level, inequality increased steadily from 1820 to 1990 and then declined slightly. This pattern takes into account inequality between countries as well as within. Rising per capita incomes in the West in phase two increased global inequality. In phase three, global inequality fell even though inequality increased in many rich and poor countries[12].

Why are the feedback loops that led to general prosperity in the West between 1850 and 1970 seemingly inoperative now[13, 14, 15]? A big change is the industrialization of Asia — first Japan starting in the 1870s, then South Korea and Taiwan since the Second World War, and now China (see 'Trends in work, pay and manufacturing'). These countries have supplanted Western nations as the low-cost producers of manufactured goods. Trade flows have reversed, with Asia shipping textiles and steel to Europe rather than the other way around. Technological progress in Asia has raised incomes and levels of employment dramatically in the region.

The future of work to someone born in China in 1990 is bright indeed —

provided that the country can avoid environmental crises and resource depletion.

Globalization means that Asia's bright future causes havoc elsewhere. Imports of cheap Japanese steel and vehicles caused the collapse of the rust belt in the United States and its counterparts in Western Europe (with Germany as something of an exception). Western de-industrialization was the flip side of the East Asian miracles. And cheap Chinese imports may benefit Africans as consumers, but could blight their employment prospects as African industries struggle to compete. Indeed, China is now purchasing large areas of land in Africa to guarantee access to food and minerals. It is hard to believe that manufacturing or information technology will ever recover in the West, no matter how many robots are installed, visas rescinded, trade agreements ripped up or walls built.

We cannot forecast the future without an understanding of the relationships between science, technology and the economy, because technical change is such an important determinant of the future. I have studied these questions for the Industrial Revolution using business accounts and histories of inventions. The steam engine, for instance, was an application of seventeenth-century science (the discoveries that the atmosphere has weight and that condensing steam creates a vacuum). By contrast, the cotton mills owed little to science and much to attempts to cut costs of relatively expensive employment[16].

How has the balance between knowledge and incentives evolved? The more technology advances in response to economic incentives rather than 'random' scientific discoveries, the more feasible it is to direct the course of technical progress to benefit more people. Furthermore, the cotton mills of the Industrial Revolution increased the demand for workers without education, whereas more-recent technology requires more education. Why the difference? Will the recent trend of needing educated workers persist? If not, then the hope that a knowledge-based future will make everyone better off is doomed.

Journal name:
Nature
Volume:

550,
Pages:
321–324
Date published:
(19 October 2017)
DOI:
doi:10.1038/550321a

Supplementary information

PDF files

1. Supplementary Information 550321a (49K)

Comments

Commenting is currently unavailable.

The second Renaissance

18 October 2017

Ian Goldin calls on scientists to help society to weather the disruptive transformations afoot.

Jay Shaw Baker/NurPhoto/Getty

Workers protest in London in February.

The Renaissance that began in Europe in the mid-1400s and ended in the early 1500s brought a radical transformation of the sciences, the humanities and politics. Building on the invention of the printing press and cheap paper, information was democratized, there was a hunger for literacy and the Catholic Church's near-monopoly on knowledge was challenged. The

resulting breakthroughs took Europe from being one of the more backward regions of the world to being the most advanced by far, within just 80 years.

But it ended in tears. Extremists, pointing to growing inequalities and the corruption of the elite, called for a return to spiritual values. In Italy, thousands of artworks and books were burned, branded as irreverent. Across Europe, rising intolerance of scientists, intellectuals, foreigners and ethnic minorities became the norm, with religious wars and inquisitions playing out over the following centuries.

In my view, many parts of the world are now in the middle of a second Renaissance. This one is seeing even faster change than the last, and across the entire globe. History tells us that it will be disruptive. It will bring immense benefits and it will be highly destabilizing. We should expect more extremism and the rise of potentially catastrophic risks.

Innovation today is happening faster than ever, driven by the unlocking of individual and collective abilities in a booming population. On average, literacy levels, life expectancy and incomes have soared. Flows of goods, services, money, people and, most importantly, ideas across national borders — globalization — has unleashed unprecedented progress and a scientific and broader renaissance. They have also brought growing interdependence and new risks[1, 2].

The Internet helps to harness the global capacity for connectivity and innovation, but also brings us malware, cybercrime and the sacrifice of privacy. Airports are crucial to international integration of science and commerce, but they can also be super-spreaders of pandemics — just as explorers to the new world brought with them fatal diseases. Financial hubs create fresh opportunities for economies to prosper, but they simultaneously allow a financial crisis in one country to destroy jobs and pensions in distant parts of the world[3].

The tension between individual success and collective collapse is growing. As more people escape poverty and climb the energy curve, climate change and biodiversity loss accelerate. As more people benefit from better nutrition, ocean fisheries are at risk of collapse and forests are destroyed for cattle. Improvements in global health could soon be threatened by rapidly rising

antibiotic resistance.

Accelerating technological change will provide solutions for many challenges, from cancer to cleaner sources of energy. But our politics and our institutions are locked in past models that are increasingly unfit for purpose. Deep ethical issues arising from genomics research and the potential dangers of biological pathogens are not being adequately addressed. Improvements in computing and artificial intelligence will kill off many jobs. Breakthroughs in nanotechnology and materials science, augmented and virtual reality, 3D printing and other applications will also radically disrupt society. All are barely understood by politicians and most citizens.

Growing gap

Inequality is rising in almost all countries that are experiencing rapid change. The faster the pace of change, the more rapidly people are being left behind. The share of wealth enjoyed by the top 1% of citizens in the advanced economies has risen from an average of 17% in the late 1980s to more than 23% today (it is 39% in the United States). Countries starting from a more equal distribution of wealth, such as China and the nations of the former Soviet Union, have seen the most rapid rise in inequality[4].

John MacDougall/AFP/Getty

A robot sweeps food towards two dairy cows at an 'automated farm' exhibit at a food and agriculture fair.

Far from levelling the playing field and making the world more 'flat', as is alleged, globalization is making it more mountainous. Place matters more than ever. Cities hold a growing share of wealth and job opportunities, but it is increasingly difficult to afford to live in them. In dynamic ones, such as London, San Francisco, Paris, Berlin, Shanghai and Mumbai, house prices relative to average incomes are at an all-time high.

Technological change is already a key contributor to the growing inequality[5]. This is likely to be exacerbated as machine intelligence and automation take over a growing share of routine tasks in manufacturing and services, including retail, administration and call centres. Over the next 20 years, up to half of US jobs, one-third of jobs in the United Kingdom and the European Union and two-thirds of jobs in China and Mexico may be replaced by computers and robotics[6].

The future will bring new jobs, but their number will be small relative to those lost. And the quality of many of these new jobs will be inferior, in terms of the conditions of work and pay. Although it is tempting to imagine a world in which machines do dangerous and routine jobs, leaving more creative, stimulating and well-paid jobs for humans, this may not come to pass. The pace and scale of technological disruption, which far exceeds that of any previous industrial revolution, raises doubts about our capacity to keep up. We may not be able to redistribute enough funds from the wealthy, or come up with sufficiently creative changes to our systems of work and social safety, to prevent a further rise in inequality[6, 7]. Although this is a major issue for advanced economies, it is even more so for developing countries, because automation may remove key rungs of semi-skilled tasks from the development ladder.

Growing interdependence and complexity also mean that our politicians are increasingly unable to protect or shape our futures. Rather than pursue more cooperative politics, which enhance the benefits of connectivity and mitigate the risks, politicians increasingly blame foreigners and immigrants for the ills. This is profoundly misguided. Immigrants contribute disproportionately to the dynamism of our societies, as can be seen in the talent pool of leading universities, Silicon Valley firms, Nobel prizewinners and patent holders[8].

Those living in the fast-changing cosmopolitan cities of the world are embracing globalization and change: most Londoners did not support Britain's decision to exit from the European Union; people living in dynamic cities tended not to support US President Trump. The populist call for protectionism is driven by those in the United States who fear being left behind. This is not an irrational fear: as is evident from inequality, unemployment and health data, some people are being left behind. There is a correlation, for example, between those who voted for Trump and those whose jobs are vulnerable to having machines take over their jobs[9].

Alongside their anxieties about being left behind by globalization comes a deep mistrust of the 'experts' in charge of the global systems, and a rejection of evidence. Paradoxically, although we know more than ever, rising complexity and speed of change mean that experts are likely to be wrong more often. The financial system, for example, is home to numerous highly

qualified experts, housed in a formidable array of powerful institutions, who are handsomely paid to secure economic stability. Yet, as the 2008 financial crisis demonstrated, they have proved dismally unequal to the task. Similarly, experts in the European Commission seem to have failed to control reporting of emissions from leading car manufacturers. Little wonder that trust in authority has been severely eroded. When the evidence threatens entrenched elites, scepticism regarding expertise becomes particularly poisonous. Trump's dismissal of the science of climate change is an egregious example of this trend.

The flourishing of science was contested in the original Renaissance, too. Printing presses provided the means for experts and intellects to share knowledge, but also allowed fake news to flourish. In Medici Florence, fundamentalist Italian preacher Girolamo Savonarola circumvented the authority of popes and princes with the mass production of one-page pamphlets — the equivalent of today's tweets. Both Savonarola and the clergy denied that Earth went around the Sun, and that the heart was a pump.

Although history does not repeat itself, it does rhyme. In the United Kingdom, campaigners successfully used social media to convince people to support Brexit even when it was against their interests, as in the case of farmers who receive subsidies from the European Union. In the United States, social media that propagated fears rather than facts played a key part in shaping the outcome of the 2016 presidential election[10].

Rapid response

As societies change more rapidly, flexibility becomes more important. For individuals, it becomes more necessary to move to where the jobs are and to reskill. For governments, it is crucial to renew infrastructure and social safety nets. Regulatory frameworks also need to evolve rapidly, to address a widening range of risks — from the genetic enhancement of humans to geoengineering.

Unfortunately, at a time when the need to renew and invest in the future is rising, the ability of governments to keep pace with change is being

undermined. The use of off-shore tax havens — notably by companies at the frontier of technological change — as well as competition by governments to attract increasingly mobile individuals and companies by reducing taxes, together with austerity policies, have reduced the capacity of governments to invest in health, education, infrastructure, social security, research and other expenditures[11]. Lower investment leads to lower growth and political gridlock, as politicians fight over the allocation of fixed or diminishing resources.

Stronger safety nets are necessary to prevent poor and vulnerable individuals and families from being undermined by technological and other changes. If not, social cohesion will be eroded, fanning the flames of populist push-back against change and all things foreign.

Some Silicon Valley billionaires, fearing revolt against the growing wage gap, along with some social activists, have called for the introduction of a Universal Basic Income (UBI) for people working and not. But a UBI is not a panacea. The Organisation for Economic Co-operation and Development has shown that the policy could, perversely, increase inequality and poverty. And, because jobs are so important to our status and self-worth, having money alone does not protect against the increases in morbidity, criminal activity, opioid and alcohol abuse that have been associated with unemployment[12].

Instead, we need a broader change in attitudes towards work. We need to remove the stigmas associated with part-time employment, retirement and volunteer work. We should nurture a greater respect and pay for creative, caring and home-based activities.

There are reasons for optimism. There are more scientists alive today than all those who previously lived; citizen science adds millions more. As well as more minds at work, there are more-diverse collaborations, thanks to greater gender equality and the participation of more nations and peoples. The probability of unlocking mysteries and finding solutions to great challenges is rising, as is the global dissemination of the benefits. Cross-border collaborative projects, from the CERN particle-physics laboratory near Geneva, Switzerland, to the Human Genome Project, highlight the benefits of

cooperative activity, in stark contrast to isolationist politics.

Now, more than ever, scientists must engage and communicate, to ensure that science is not overrun by politics. Renaissance moments are associated with an intensifying battle of ideas. Scientists need to engage in this struggle over the development and application of their expertise and inventions.

In the first Renaissance, extremists won; reason and evidence did not prevail. In our second Renaissance, knowledge and enquiry must find a way to conquer prejudice and ignorance. Scientists know that they can never progress through isolationism or ignorance. Nor can our societies.

Journal name:
Nature
Volume:
550,
Pages:
327–329
Date published:
(19 October 2017)
DOI:
doi:10.1038/550327a

Comments

6 comments

1. *Pentcho Valev* • 2017-10-20 06:53 AM
   Up until recently there was still hope that physics might be resurrected. Scientists had decided to abandon Einstein's absurd spacetime: Nima Arkani-Hamed (06:09): "Almost all of us believe that space-time doesn't really exist, space-time is doomed and has to be replaced by some more primitive building blocks." https://www.youtube.com/watch?v=U47kyV4TMnE Nobel Laureate David Gross observed, "Everyone in string theory is convinced...that spacetime is doomed. But we don't know what it's replaced by." https://www.edge.org/response-detail/26563 What

scientific idea is ready for retirement? Steve Giddings: "Spacetime. Physics has always been regarded as playing out on an underlying stage of space and time. Special relativity joined these into spacetime... [...] The apparent need to retire classical spacetime as a fundamental concept is profound..." https://www.edge.org/response-detail/25477 "Splitting Time from Space - New Quantum Theory Topples Einstein's Spacetime. Buzz about a quantum gravity theory that sends space and time back to their Newtonian roots." https://www.scientificamerican.com/article/splitting-time-from-space/ "And by making the clock's tick relative - what happens simultaneously for one observer might seem sequential to another - Einstein's theory of special relativity not only destroyed any notion of absolute time but made time equivalent to a dimension in space: the future is already out there waiting for us; we just can't see it until we get there. This view is a logical and metaphysical dead end, says Smolin." http://www.guardian.co.uk/books/2013/jun/10/time-reborn-farewell-reality-review Spacetime is a consequence of Einstein's constant-speed-of-light postulate, and since the combination "true postulate, wrong consequence" is forbidden by logic, scientists were actually moving towards the conclusion that the postulate, the "root of all the evil" in fundamental physics, is false: "Special relativity is based on the observation that the speed of light is always the same, independently of who measures it, or how fast the source of the light is moving with respect to the observer. Einstein demonstrated that as an immediate consequence, space and time can no longer be independent, but should rather be considered a new joint entity called "spacetime." http://community.bowdoin.edu/news/2015/04/professor-baumgarte-describes-100-years-of-gravity/ Then extremely dishonest people called LIGO came to power in physics, "discovered" (actually, faked) gravitational waves (ripples in spacetime), and all hope for resurrection of physics died. If you have ripples in spacetime, you cannot claim anymore that "space-time doesn't really exist, space-time is doomed and has to be replaced", can you? Pentcho Valev

2. *Pentcho Valev* • 2017-10-21 06:32 AM

Towards a uniform LIGO science (any theory that in some way contradicts LIGO fakes is doomed): "The simultaneous detection of gravitational waves and light from a cosmic collision has left a few theories of dark matter and dark energy dead in its wake. These theories require gravitational waves - ripples in the fabric of space-time - to travel slower or even faster than the speed of light. But recent observations have proved otherwise. [...] The signals from the smash-up, now named GW170817, show that gravitational waves do indeed travel at the speed of light, to an accuracy of about one in 1 million billion. This seriously undermines some theories that modify Einstein's general relativity to explain the mysterious dark energy thought to be driving the accelerated expansion of our universe, and the invisible dark matter that we detect only through its gravitational pull on ordinary matter." https://www.newscientist.com/article/2151020-dark-energy-survives-neutron-star-crash-test-while-rivals-fail/ Pentcho Valev

3. *Pentcho Valev* • 2017-10-19 06:50 AM

   "Look, my lad, I know a dead parrot when I see one, and I'm looking at one right now." https://www.youtube.com/watch?v=RQhVLHu8HRk Physicists know a dead science when they see one, and they've been looking at one since January 2001: Joao Magueijo, Faster Than the Speed of Light, p. 250: "Lee [Smolin] and I discussed these paradoxes at great length for many months, starting in January 2001. We would meet in cafés in South Kensington or Holland Park to mull over the problem. THE ROOT OF ALL THE EVIL WAS CLEARLY SPECIAL RELATIVITY. All these paradoxes resulted from well known effects such as length contraction, time dilation, or E=mc^2, all basic predictions of special relativity. And all denied the possibility of establishing a well-defined border, common to all observers, capable of containing new quantum gravitational effects." http://www.amazon.com/Faster-Than-Speed-Light-Speculation/dp/0738205257 Neil Turok: "It's the ultimate catastrophe: that theoretical physics has led to this crazy situation where the physicists are utterly confused and seem not to have any predictions at all." http://www2.macleans.ca/2013/09/05/perimeter-institute-and-the-crisis-in-modern-physics/ Frank Close: "In recent

years, however, many physicists have developed theories of great mathematical elegance, but which are beyond the reach of empirical falsification, even in principle. The uncomfortable question that arises is whether they can still be regarded as science. Some scientists are proposing that the definition of what is "scientific" be loosened, while others fear that to do so could open the door for pseudo-scientists or charlatans to mislead the public and claim equal space for their views." http://www.prospectmagazine.co.uk/features/what-happens-when-we-cant-test-scientific-theories Sabine Hossenfelder: "Many of my colleagues believe this forest of theories will eventually be chopped down by data. But in the foundations of physics it has become extremely rare for any model to be ruled out. The accepted practice is instead to adjust the model so that it continues to agree with the lack of empirical support." http://www.nature.com.proxy.readcube.com/nphys/journal/v13/n4/f Sabine Hossenfelder (Bee): "The criticism you raise that there are lots of speculative models that have no known relevance for the description of nature has very little to do with string theory but is a general disease of the research area. Lots of theorists produce lots of models that have no chance of ever being tested or ruled out because that's how they earn a living. The smaller the probability of the model being ruled out in their lifetime, the better. It's basic economics. Survival of the 'fittest' resulting in the natural selection of invincible models that can forever be amended." http://www.math.columbia.edu/~woit/wordpress/?p=9375 Peter Woit: "As far as this stuff goes, we're now not only at John Horgan's "End of Science", but gone past it already and deep into something different." http://www.math.columbia.edu/~woit/wordpress/?p=7266 "But instead of celebrating, physicists are in mourning after a report showed a dramatic decline in the number of pupils studying physics at school. The number taking A-level physics has dropped by 38% over the past 15 years, a catastrophic meltdown that is set to continue over the next few years. The report warns that a shortage of physics teachers and a lack of interest from pupils could mean the end of physics in state schools. Thereafter, physics would be

restricted to only those students who could afford to go to posh schools. Britain was the home of Isaac Newton, Michael Faraday and Paul Dirac, and Brits made world-class contributions to understanding gravity, quantum physics and electromagnetism - and yet the British physicist is now facing extinction. But so what? Physicists are not as cuddly as pandas, so who cares if we disappear?" http://www.guardian.co.uk/science/2005/nov/22/schools.g2 Peter Woit: "If, as seems increasingly all too possible, we're now at an endpoint of fundamental physics, with the field killed off by a pseudo-scientific argument..." http://www.math.columbia.edu/~woit/wordpress/?p=9444 Peter Woit: "I think the worst thing that has happened to theoretical physics over the past 25 years is this descent into ideology, something that has accelerated with the multiverse mania of the last 10-15 years." http://www.math.columbia.edu/~woit/wordpress/?p=9375 The last quotation is correct, except for the number 25 - it should be replaced by 112 (note the "embarrassing question" that will have to be answered soon): "This paper investigates an alternative possibility: that the critics were right and that the success of Einstein's theory in overcoming them was due to its strengths as an ideology rather than as a science. The clock paradox illustrates how relativity theory does indeed contain inconsistencies that make it scientifically problematic. These same inconsistencies, however, make the theory ideologically powerful. [...] The gatekeepers of professional physics in the universities and research institutes are disinclined to support or employ anyone who raises problems over the elementary inconsistencies of relativity. A winnowing out process has made it very difficult for critics of Einstein to achieve or maintain professional status. Relativists are then able to use the argument of authority to discredit these critics. Were relativists to admit that Einstein may have made a series of elementary logical errors, they would be faced with the embarrassing question of why this had not been noticed earlier. Under these circumstances the marginalisation of antirelativists, unjustified on scientific grounds, is eminently justifiable on grounds of realpolitik. Supporters of relativity theory have

protected both the theory and their own reputations by shutting their opponents out of professional discourse. [...] The triumph of relativity theory represents the triumph of ideology not only in the profession of physics bur also in the philosophy of science." Peter Hayes, The Ideology of Relativity: The Case of the Clock Paradox http://www.informaworld.com/smpp/content~content=a909857880 And when ideology replaces science, bureaucrats replace scientists of course: Mike Alder: "It is easy to see the consequences of the takeover by the bureaucrats. Bureaucrats favour uniformity, it simplifies their lives. They want rules to follow. They prefer the dead to the living. They have taken over religions, the universities and now they are taking over Science. And they are killing it in the process. The forms and rituals remain, but the spirit is dead. The cold frozen corpse is so much more appealing to the bureaucratic mind-set than the living spirit of the quest for insight. Bureaucracies put a premium on the old being in charge, which puts a stop to innovation. Something perhaps will remain, but it will no longer attract the best minds. This, essentially, is the Smolin position. He gives details and examples of the death of Physics, although he, being American, is optimistic that it can be reversed. I am not. [...] Developing ideas and applying them is done by a certain kind of temperament in a certain kind of setting, one where there is a good deal of personal freedom and a willingness to take risks. No doubt we still have the people. But the setting is gone and will not come back. Science is a product of the renaissance and an entrepreneurial spirit. It will not survive the triumph of bureacracy. Despite having the infrastructure, China never developed Science. And soon the West won't have it either." https://www.highbeam.com/doc/1G1-172684821.html Pentcho Valev

4. *Pentcho Valev* • 2017-10-18 04:30 PM

   Fundamental physics is paralyzed, even killed, by blind faith in false principles. The falsehood of Einstein's constant-speed-of-light postulate is easy to prove but I'm not going to do this here. Let me just call the attention, by quoting Joao Magueijo, to the validity of the following conditional: If Einstein's constant-speed-of-light postulate is false, fundamental physics is dead. "The speaker Joao

Magueijo, is a Reader in Theoretical Physics at Imperial College, London and author of Faster Than the Speed of Light: The Story of a Scientific Speculation. He opened by explaining how Einstein's theory of relativity is the foundation of every other theory in modern physics and that the assumption that the speed of light is constant is the foundation of that theory. Thus a constant speed of light is embedded in all of modern physics and to propose a varying speed of light (VSL) is worse than swearing! It is like proposing a language without vowels." http://www.thegreatdebate.org.uk/VSLRevPrnt.html "...Dr. Magueijo said. "We need to drop a postulate, perhaps the constancy of the speed of light." http://www.nytimes.com/2002/12/31/science/e-and-mc2-equality-it-seems-is-relative.html "But the researchers said they spent a lot of time working on a theory that wouldn't destabilise our understanding of physics. "The whole of physics is predicated on the constancy of the speed of light," Joao Magueijo told Motherboard. "So we had to find ways to change the speed of light without wrecking the whole thing too much." http://www.telegraph.co.uk/technology/2016/12/06/speed-light-discovered/ Joao Magueijo, Faster Than the Speed of Light, p. 250: "Lee [Smolin] and I discussed these paradoxes at great length for many months, starting in January 2001. We would meet in cafés in South Kensington or Holland Park to mull over the problem. THE ROOT OF ALL THE EVIL WAS CLEARLY SPECIAL RELATIVITY. All these paradoxes resulted from well known effects such as length contraction, time dilation, or E=mc^2, all basic predictions of special relativity. And all denied the possibility of establishing a well-defined border, common to all observers, capable of containing new quantum gravitational effects." http://www.amazon.com/Faster-Than-Speed-Light-Speculation/dp/0738205257 Pentcho Valev

5. *Pentcho Valev* • 2017-10-18 05:19 PM

   Another science killer is the false second law of thermodynamics. Systems violating the second law are commonplace but scientists always turn the blind spot of the eye to them. Here is vigorous motion of water in an electric field, obviously able to produce work

- e.g. by rotating a waterwheel: "The Formation of the Floating Water Bridge including electric breakdowns" https://www.youtube.com/watch?v=17UD1goTFhQ "The water movement is bidirectional, i.e., it simultaneously flows in both directions." https://www.wetsus.nl/home/wetsus-news/more-than-just-a-party-trick-the-floating-water-bridge-holds-insight-into-nature-and-human-innovation/1 The work (rotating a waterwheel) will be done at the expense of what energy? The first hypothesis that comes to mind is: At the expense of electric energy. The system is, essentially, an electric motor. However close inspection would suggest that the hypothesis is untenable. Scientists use triply distilled water to reduce the conductivity and the electric current passing through the system to minimum. If, for some reason, the current is increased, the motion stops - such system cannot be an electric motor. If the system is not an electric motor, then it is a heat engine violating the second law of thermodynamics. Here arguments describing such heat engines as impossible, idiotic, etc. are irrelevant - the following conditional is valid: IF THE SYSTEM IS NOT AN ELECTRIC MOTOR, then it is a a heat engine violating the second law of thermodynamics. In other words, if the work is not done at the expense of electric energy, it is done at the expense of ambient heat. No third source of energy is conceivable. In the electric field between the plates of a capacitor, the same turbulent motion can be seen: " Liquid Dielectric Capacitor" http://www.youtube.com/watch?v=T6KAH1JpdPg In the capacitor system the rising water can repeatedly do work, e.g. by lifting floating weights. The crucial question is: The work (lifting floating weights) will be done at the expense of what energy? Obviously "electric energy" is not the correct answer - the capacitor is not an electric motor. Then the only possible answer remains "ambient heat". The system is a heat engine violating the second law of thermodynamics! Pentcho Valev

6. *Pentcho Valev* • 2017-10-19 07:03 AM

   Why scientists are unable to see the obvious violations of the second law of thermodynamics: Clifford Truesdell, The Tragicomical History of Thermodynamics, 1822-1854, p. 6: "Finally, I confess to a heartfelt hope - very slender but tough - that

even some thermodynamicists of the old tribe will study this book, master the contents, and so share in my discovery: Thermodynamics need never have been the Dismal Swamp of Obscurity that from the first it was and that today in common instruction it is; in consequence, it need not so remain." [...] p. 333: "Clausius' verbal statement of the "Second Law" makes no sense, for "some other change connected therewith" introduces two new and unexplained concepts: "other change" and "connection" of changes. Neither of these finds any place in Clausius' formal structure. All that remains is a Mosaic prohibition. A century of philosophers and journalists have acclaimed this commandment; a century of mathematicians have shuddered and averted their eyes from the unclean." https://www.amazon.com/Tragicomical-Thermodynamics-1822-1854-Mathematics-Physical/dp/1461394465 Jos Uffink, Bluff your way in the Second Law of Thermodynamics: "I therefore argue for the view that the second law has nothing to do with the arrow of time. [...] Before one can claim that acquaintance with the Second Law is as indispensable to a cultural education as Macbeth or Hamlet, it should obviously be clear what this law states. This question is surprisingly difficult. The Second Law made its appearance in physics around 1850, but a half century later it was already surrounded by so much confusion that the British Association for the Advancement of Science decided to appoint a special committee with the task of providing clarity about the meaning of this law. However, its final report (Bryan 1891) did not settle the issue. Half a century later, the physicist/philosopher Bridgman still complained that there are almost as many formulations of the second law as there have been discussions of it. And even today, the Second Law remains so obscure that it continues to attract new efforts at clarification." http://philsci-archive.pitt.edu/313/1/engtot.pdf Pentcho Valev

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Brazilian Amazon still plagued by illegal use of natural resources

Practices such as poaching and illegal logging are concentrated near inhabited areas and along rivers, study finds.

17 October 2017

Jeff Hutchens/Getty

An official with Brazil's environmental enforcement agency arrests poachers caught near Manaus.

Despite Brazil's efforts to safeguard the Amazon rainforest by establishing protected areas and boosting law enforcement, illegal use of the region's natural resources is still widespread, according to a study[1] published on 10

October in *PeerJ*.

The researchers looked at 4,243 law-enforcement records from between 2010 and 2015, across 118 federally protected areas of the Brazilian Amazon. Although the overall number of citations decreased over those five years, illegal activities still occurred in nearly every protected area. The analysis highlighted the need for improved monitoring and enforcement, says study co-author Érico Kauano, a conservation biologist at the Chico Mendes Institute for Biodiversity Conservation (ICMBio), the Brazilian agency responsible for the management of the federal protected areas.

Kauano and his colleagues grouped illegal activities into ten categories, and found that 37% of the infractions fell into the “suppression and degradation of vegetation” group, which included deforestation, logging of endangered tree species and the unauthorized use of fire. Illegal fishing was the next most common citation at 27%, followed by hunting at 18%. Most of the illegal activity occured in more accessible and densely populated areas.

Roads have a major role in opening up the tropics to colonization and exploitation[2]. Deforestation of the Brazilian Amazon increased after the construction of the Belém–Brasília Highway in the 1960s, and continued with the opening of the Trans-Amazonian Highway in 1970s. A 2014 study[2] using satellite images found that around 95% of the deforestation in Brazil’s Amazon occurred within 5.5 kilometres of a road and within 1 kilometre of a navigable river.

Caught in the act

The availability and use of government data are what sets this study apart from others, says Emilio Bruna, a tropical ecologist at the University of Florida in Gainesville, who was not involved in the study. Past studies, including a paper[3] published last month in *Biotropica* (where Bruna is editor-in-chief), struggled to obtain even the most basic information, such as how many staff members were employed by the agency that manages protected areas, and how much they were paid, Bruna says.

Data from efforts on the ground are important because, although remote-sensing instruments such as satellites can detect deforestation, for example, they fail to identify threats present beneath the forest canopy. Law-enforcement records, when available, can complement remote-sensing data sets, the study authors say.

“You can actually tell what it is they’re writing infractions for, and that’s valuable,” says Bruna. But he points out that, without knowing where law-enforcement efforts are being allocated, it’s only a partial picture. “It could be that the reason certain protected areas have the most infractions is because those are the places that are under the greatest threat,” he says. “Or it could be because that’s where the greatest enforcement is being focused.”

Greater enforcement

“We are still far from having adequate staff in the protected areas,” Kauano says. In 2014, a local news outlet reported that the Brazilian Institute of Environment and Renewable Natural Resources had only 47 agents to monitor environmental crimes in Amazonas, the country’s largest state in the Amazon region, which covers an area of about 1.6 million square kilometres.

Hiring more enforcement officials looks unlikely in the short term, however, owing to Brazil’s ongoing political and economic crisis, says Kauano. “What ICMBio seeks to do to overcome this is to prioritize some regions with greater problems.”

Bruna cautions against jumping to conclusions from the study’s results, however. “Not all infractions are created equal,” he says. It’s important to differentiate between a resident fishing out of season and a fishing charter operator. Bruna worries that some may look at this study and think that the people living near protected areas are the problem. But they aren’t the only ones breaking the law, he says. And the demand for the fruits of this illegal labour comes from all over the world.

Local people can, in fact, be part of the solution. There is some evidence that people living in or near protected areas are helping with conservation, says

Kauano. But he adds that the government needs to make a greater effort to work with local communities.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22830

Comments

Commenting is currently unavailable.

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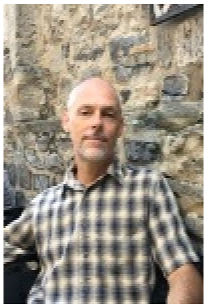


Ellie R. Martinson

Give researchers a lifetime word limit

Brian C. Martinson[1] imagines how rationing the number of publications a scientist could put out might improve the scientific literature.

17 October 2017

A dirty truth pervades academic publishing: we write papers to gain credit in an academic marketplace. Almost a quarter of a century ago, academic worthies lamented that scholarly publications had become “the coins academics must use to get through the tollgates on their way to academic promotion” (D. Rennie and A. Flanagin *J. Am. Med. Assoc.* **271**, 469–471; 1994). In some cases, papers in flashy journals truly do bring in hard cash — reportedly more than US$40,000 at some universities in China. And plenty of people reading this will have felt they’d better squeeze a paper or two out soon to have any chance of getting their next grant proposal funded.

The purpose of authorship has shifted. Once, its primary role was to share knowledge. Now it is to get a publication — ‘pubcoin’ if you will. Authorship has become a valuable commodity. And as with all valuable commodities, it is bought, sold, traded and stolen. Marketplaces allow

unscrupulous researchers to purchase authorship on a paper they had nothing to do with, or even to commission a paper on the topic of their choice. ‘Predatory publishers’ strive to collect fees without ensuring quality.

I have spent much of my career studying how academic and clinical workplaces influence how carefully researchers conduct their studies. The commodification of authorship encourages all manner of corner-cutting, sloppiness in research, and other degradations in the quality of publications, not to mention an obvious motive for plagiarism. A quest for high-profile papers leads researchers to favour a spectacular result, even if it is specious. Authors cite themselves to boost the impact of publications, and cite colleagues to curry favour.

At this point, it is hard even to envisage a world in which the communication of knowledge could return to its rightful place as the focus of academic authorship. But if we cannot imagine something, we cannot attain it. So let me try. Imagine a world in which each scientist is allotted a fixed number of words that they can publish over her or his career. I’m not the first person to suggest this: the Australian writer Michael McGirr has proposed a word limit for every person.

What would happen? Might authorship regain its original purpose?

Lifetime limits would create a natural incentive to do research that matters. Researchers would have to ask themselves, “Is this project I’m pursuing worth the words it will cost me?” I see several articles in my own CV that did not contribute much knowledge to the world. I cannot help but think that I might have pursued better questions had a word limit been in place.

Ideally, limits would encourage researchers to ensure that research is conducted with the utmost care. (Imagine losing part of your allotment of words to a paper that is discredited or even retracted.) This would provide a counterweight to the pressure to publish quickly for priority. It would also lead to increased value being placed on concision and clarity, improving readability and efficiency. Honorary authorship would become much less attractive.

With less time needing to be spent on papers of low quality or containing

little new information, readers and editors would be able to give the smaller number of articles more attention. Editorial workload would be reduced by virtue of the lower volume and the higher quality of material. This might reduce editorial costs, enhance quality, and quite possibly enhance the job satisfaction and quality of life of editors and readers. Predatory publishers would vanish.

With a boost in the quality of scientific papers, the communal work of peer review would get easier. Individual researchers would be asked to carry out fewer reviews. Reviewing invitations would be for work of higher quality, making the job more enjoyable and less aggravating. And knowing the stakes for the authors in expending their precious words, reviewers themselves might be inclined to put more time and effort into their reviews, further improving quality.

The task of evaluating candidates for jobs, advancement and prizes would become less scattershot. With fewer publications per candidate, promotion and tenure committees could become less reliant on tallying counts of first-authored publications, and devote time to reading and critiquing the published work. This, in turn, should reduce their use of journal impact factors as proxies for quality.

Limits would of course bring a new set of problems: if we don’t also address our own cognitive biases and penchant for compelling narratives, word limits could exacerbate tendencies to publish only positive findings, leading researchers to explore blind alleys that others’ negative results could have illuminated. Researchers might skimp on a full description of caveats, previous work and methods. Some subjects and pursuits might be inherently wordier than others. Exceptions might have to be made for experts such as statisticians and bioinformaticians whose skills are required on many papers — but perhaps this would boost the quality of collaborations. Perhaps researchers could apply for word bonuses for careful reproductions, cautious interpretations and meticulously described methods.

Would these drawbacks be worse than the current incentives to publish as much as you can? We have lost sight of information sharing as the primary reason for publishing. Perhaps my flight of fancy is a rose-tinted remembrance of times past. Or perhaps it can serve as a guide to restore the

exchange of ideas to its rightful, pithy, place.

Journal name:
Nature
Volume:
550,
Pages:
303
Date published:
(19 October 2017)
DOI:
doi:10.1038/550303a

Comments

Commenting is currently unavailable.

Japanese research leaders warn about national science decline

Concern mounts over budget cuts and other changes that undermine basic science.

17 October 2017 Corrected:

1. 20 October 2017

Toru Hanai/Reuters

People gather for a rally in Fukushima, Japan, for Prime Minister Shinzo Abe and the Liberal Democratic Party.

As Japan heads towards a national election on 22 October, scientific leaders worry that the outcome will do little to address long-standing concerns about the country's deteriorating research landscape. They say that a decline in funding and a shift away from basic research has undermined Japan's capacity to compete against both established scientific powerhouses and emerging ones such as China.

Since 25 September, when Prime Minister Shinzo Abe called for a snap election, science has barely featured in the campaign. Debate has focused on the government's plan to amend the constitution and increase taxes. The latest polls suggest that Abe's conservative Liberal Democratic Party could lose some seats, but will retain enough to lead a coalition government.

If Abe is re-elected, he says, his government will pursue an innovation agenda. At a meeting of global science leaders in Kyoto on 1 October, Abe reaffirmed his pledge to turn Japan into "a cradle of innovation" by cutting regulations that impede new technologies.

Despite Abe's lofty ambitions, the ruling party coalition has decreased the science and technology budget by more than 5% overall since it came to power in 2012. And the budget for universities has dropped by about 1% a year for a decade. "This has been pointed out as the major cause of the deterioration of research performance and, eventually, the global rank of Japanese universities," says Takashi Onishi, president of Toyohashi University of Technology and a former president of the Science Council of Japan, which advises the government. In the past two decades, the country's share of highly cited papers has stagnated, whereas those of many other leading nations are rising, according to publisher Elsevier's Scopus database.

In an attempt to elevate Japan's top research universities, the government has introduced reforms that categorize institutions according to their research or teaching focus, and that allocate funding on the basis of performance. The government wants leading research institutions to compete globally for the best students and faculty.

Atsushi Sunami, a science-policy specialist at the National Graduate Institute for Policy Studies (GRIPS) in Tokyo, agrees with this aim, but says that to succeed, the government will need to increase its research funding. And

money alone will not be enough, says Hiroshi Nagano, also a science-policy specialist at GRIPS. For universities to become world class, they need autonomy to decide their research and teaching focus, he says. “The current policy is oriented in the opposite direction.”

Basic research left behind

Changes to the university system implemented by Abe’s government are designed to make academia more responsive to the needs of society and industry, in the hope that it will boost low private-sector investment in research. Although scientists broadly encourage this increased collaboration, some say that it has compromised support for basic research. “The government should focus on the development of basic research to supply seeds or ideas to applied sciences,” says Onishi.

Science leaders point to other big concerns about the future of Japanese research. Michinari Hamaguchi, head of the Japan Science and Technology Agency in Tokyo, says that the domestic workforce will be insufficient to keep up with changes in science, technology and innovation, given the country’s rapidly ageing population. He says that policies are urgently needed to encourage more women and foreigners into science and to boost the number of students in doctoral courses, which has dropped by 18% since 2003.

Students who pursue research careers are finding it harder to get jobs. Budget cuts have depleted permanent research positions at universities, and fewer younger researchers are securing permanent posts: the number of research associates on short-term contracts more than doubled from 2007 to 2013.

Biologist and 2016 Nobel prizewinner Yoshinori Ohsumi has warned that the situation for young researchers will jeopardize the country’s chances of winning future Nobel prizes. Japan has the second-highest number of science laureates in the twenty-first century after the United States — but, Ohsumi says, that record is unlikely to hold.

Journal name:

Nature
Volume:
550,
Pages:
310–311
Date published:
(19 October 2017)
DOI:
doi:10.1038/550310a

Corrections

Corrected:

An earlier version of this story misspelled the name of Michinari Hamaguchi. Also, he is based in Tokyo, not in Kawaguchi.

Comments

Comments

There are currently no comments.

Reboot for the AI revolution

17 October 2017

As artificial intelligence puts many out of work, we must forge new economic, social and educational systems, argues Yuval Noah Harari.

Laura Lezza/Getty

A robot conducts the Orchestra Filarmonica di Lucca at Teatro Verdi in Pisa, Italy, this September.

The ongoing artificial-intelligence revolution will change almost every line of work, creating enormous social and economic opportunities — and challenges. Some believe that intelligent computers will push humans out of the job market and create a new 'useless class'; others maintain that

automation will generate a wide range of new human jobs and greater prosperity for all. Almost everybody agrees that we should take action to prevent the worst-case scenarios.

The automation revolution is emerging from the confluence of two scientific tidal waves. Computer scientists are developing artificial intelligence (AI) algorithms that can learn, analyse massive amounts of data and recognize patterns with superhuman efficiency. At the same time, biologists and social scientists are deciphering human emotions, desires and intuitions. The merger of infotech and biotech is giving rise to algorithms that can successfully analyse us and communicate with us, and that may soon outperform human doctors, drivers, soldiers and bankers in such tasks. These algorithms could eventually push hundreds of millions out of the job market.

Governments might decide to deliberately slow down the pace of automation, to lessen the resulting shocks and allow time for readjustments. But it will probably be both impossible and undesirable to prevent automation and job loss completely. That would mean giving up the immense positive potential of AI and robotics. If self-driving vehicles drive more safely and cheaply than humans, it would be counterproductive to ban them just to protect the jobs of taxi and lorry drivers.

A more sensible strategy is to create new jobs. In particular, as routine jobs are automated, opportunities for new non-routine jobs will mushroom. For example, general physicians who focus on diagnosing known diseases and administering familiar treatments will probably be replaced by AI doctors. Precisely because of that, there will be more money to pay human experts to do groundbreaking medical research, develop new medications and pioneer innovative surgical techniques.

This calls for economic entrepreneurship and legal dexterity. Above all, it necessitates a revolution in education.

Lifelong learning

To make use of the new opportunities, people will need radical, lifelong

retraining. The AI revolution won't be a single event after which the job market and the educational system will settle into a new equilibrium. Rather, it will be a cascade of ever-bigger disruptions. Even today, few employees expect to work in the same job for their entire life (see go.nature.com/2ymdvjs). By 2050, not just the idea of 'a job for life', but even the idea of 'a profession for life' might seem antediluvian. It will become increasingly difficult to know what to teach schoolchildren and university students.

Predicting the future was never easy. If you lived in China 1,000 years ago, there were many things you didn't know: the empire might collapse in 50 years; the Khitans might invade, or a new plague might kill millions. Nevertheless, you did know that most people would still work as farmers and weavers, rulers would still need men to fight in their armies and administer their taxes, women would still have few opportunities beyond marriage and life expectancy would still be about 40 years.

LISTEN

Reporter Benjamin Thompson finds out how lessons from the past can help explore the future of work.

You may need a more recent browser or to install the latest version of the Adobe Flash Plugin.

Hence, in 1017, poor Chinese parents taught their children how to plant rice or weave silk, and wealthier parents taught their boys how to read and write, or to fight on horseback, and their girls to be modest and obedient housewives. It was obvious that these skills would still be needed. In 2017, by contrast, we have no such certainties about the future of jobs, gender, economics or even death.

Human psychology, too, might turn out to be a key hurdle. Change is always stressful. Already we face an epidemic of stress and anxiety (see go.nature.com/2z96s57). As the volatility of the job market and of individual careers increases, we may wonder whether everyone will have the emotional

stamina necessary for a life of constant flux. We may need more-effective stress-reduction techniques — ranging from drugs through neurofeedback to meditation — to cope.

Creating new jobs might prove easier than retraining people to fill them. A huge useless class might appear, owing to both an absolute lack of jobs and a lack of relevant education and mental flexibility.

Test cases

It is particularly important to identify as early as possible the potential winners and losers from new technologies. Rosy overall statistics can hide growing gaps between disparate groups. Automation might have a very different impact on men and women, on 40-somethings and 20-somethings, on the university-educated and the illiterate.

The winners and losers are not the usual suspects. In the clinic, for example, automation might prove more of a threat to doctors than to nurses. Many physicians focus almost exclusively on processing information: they absorb medical data, analyse them and produce a diagnosis. Nurses also need good motor and emotional skills, to give a painful injection, replace a bandage and listen with care. We will probably have an AI family doctor on our smartphone years before we have a reliable nurse robot[1].

Exploring the relationship between intelligence and consciousness will also be crucial to understanding the economic, professional and ethical rapport between future computers and humans. We are seeing a tremendous development in computer intelligence, but zero development in computer consciousness. Just as aeroplanes fly faster than birds without ever developing feathers, so computers could come to solve problems and even to analyse human feelings much better than humans, without ever developing feelings. Studying these differences will help us to predict what AI can and cannot do, and to decide what should be kept out of its control.

There are a few areas in which AI has already made significant strides that, in my view, offer test cases for the impact of modern automation on the world

of work.

In chess, it has been 20 years since IBM's Deep Blue computer thrashed Gary Kasparov. Yet humans still play chess, and 'centaur' teams of humans-plus-AIs can outperform both. This seems at first to bode well for the future: the job market could nurture people who can leverage, rather than compete with, AI. Yet the balance of power in centaur teams is constantly shifting. Computers are becoming so good at chess that the humans are gradually losing value, and could soon become irrelevant. The same thing might happen in other human–AI teams[2].

Laura Lezza/Getty

A woman with a robot at an Italian nursing home in 2015.

Self-driving vehicles are another important test case. The race to produce self-driving vehicles now pits old steel giants such as Mercedes-Benz against new silicon giants such as Google. Transport leverages one of the core advantages of AI: connectivity. Even if a single computer-driven car is less

competent than a good human driver, a network of computer-driven cars is still likely to be much safer and more efficient than the chaos of fallible human drivers that currently dominates the roads.

Today, about 1.25 million people are killed annually in car accidents[3], more than 90% of which are estimated to be caused by human errors[4]. When two human drivers approach the same junction, they might miscommunicate and collide. But computer-driven vehicles can be connected — the chances that they might miscommunicate and collide are therefore much smaller. Similarly, it is easier to ensure that automated vehicles comply with rules such as speed limits (not to mention the ban on drink driving), even as those rules change[5, 6, 7].

Self-driving vehicles illustrate two important points. First, that in some fields it might make sense to replace all humans with robots and computers, even if individually some humans do a better job. Second, that when change comes to some realms, it might do so suddenly, not step-wise.

The military is another important bellwether, because armies are early adopters of much technology. Human soldiers carry a very high economic and political price tag, so replacing people with computers on the battlefield has proved attractive. The most advanced armies now increasingly rely on relatively small numbers of experts coupled with sophisticated and autonomous technologies, such as drones, robots, smart bombs, cyberworms and algorithms that sift through a mass of data[8, 9].

This shift has produced new classes of military jobs in maintenance, remote control, programming and cybersecurity. The US armed forces need 30 people to operate every Predator or Reaper drone flying over Syria, and analysing the harvest of information occupies at least 80 more. A careful study of the military job market might tell us a lot about potential future developments in the civilian economy.

New order

With insights gleaned from early warning signs and test cases, scholars

should strive to develop new socio-economic models. The old ones no longer hold. For example, twentieth-century socialism assumed that the working class was crucial to the economy, and socialist thinkers tried to teach the proletariat how to translate its immense economic power into political clout. In the twenty-first century, if the masses lose their economic value they might have to struggle against irrelevance rather than exploitation.

One new model has been gaining increasing attention and popularity: universal basic income (UBI). UBI suggests that the government should tax the rich and big corporations to provide every person with a stipend covering his or her basic needs. This will cushion the poor against job loss and economic dislocation, and protect the rich from populist rage. It will also free the masses to engage in more creative forms of work that might not currently have economic value, or to pursue further education.

In January 2017, Finland began a 2-year experiment, providing 2,000 unemployed citizens with €560 (US$657) per month, irrespective of whether they work. Similar experiments are under way in the Canadian province of Ontario, in the Italian city of Livorno and in several Dutch cities[10].

Of course, such national and municipal schemes might not solve the worst problems. Globalization has made people in one country utterly dependent on markets in others, and automation might unravel large parts of this global trade network with disastrous consequences for the weakest links. AI might generate immense wealth in hi-tech hubs such as Silicon Valley and Bangalore, while devastating the economies of underdeveloped countries that rely on cheap labour, such as Honduras and Bangladesh.

US voters might conceivably agree that taxes paid by tech giants Amazon and Google for their US business should be used to give stipends to unemployed coalminers in Pennsylvania or jobless taxi-drivers in New York. But they are unlikely to send their taxes to Honduras. We are still far from having any feasible models for a post-work economy, society or political system, and we don't have much time to formulate them.

In the nineteenth century, the Industrial Revolution created new conditions and problems that none of the existing social, economic and political models could cope with. Consequently, humankind had to develop completely new

models — liberal democracies, communist dictatorships and fascist regimes. It took more than a century of terrible wars and revolutions to experiment with these, separate the wheat from the chaff and implement the best solutions.

The challenges posed in the twenty-first century by the merger of infotech and biotech are arguably bigger than those thrown up by steam engines, railways, electricity and fossil fuels. Given the immense destructive power of our modern civilization, we cannot afford more failed models, world wars and bloody revolutions. We have to do better this time.

Journal name:
Nature
Volume:
550,
Pages:
324–327
Date published:
(19 October 2017)
DOI:
doi:10.1038/550324a

Comments

Comments

There are currently no comments.

Nature News

周二, 31 10月 2017

Nature News

[周二, 31 10月 2017]

- **Nature News**

Nature News

Nature is a weekly international journal publishing the finest peer-reviewed research in all fields of science and technology on the basis of its originality, importance, interdisciplinary interest, timeliness, accessibility, elegance and surprising conclusions. Nature also provides rapid, authoritative, insightful and arresting news and interpretation of topical and coming trends affecting science, scientists and the wider public.

- **Spanish government takes control of Catalonian universities** [周二, 31 10月 08:00]
  Madrid will oversee the finances of the region's research centres and seven public universities.
- **Frédéric Chopin’s telltale heart** [周二, 31 10月 08:00]
  Scientists have written another chapter in the curious case of the composer’s heart. But it is unlikely to be the end of the story.
- **Geneticists are starting to unravel evolution's role in mental illness** [周一, 30 10月 08:00]
  Hints emerge that past environments could have influenced psychiatric disorders.
- **Huge microwave observatory to search for cosmic inflation** [周一, 30 10月 08:00]
  Multi-telescope project has ambitious goals and a big price tag.
- **Ageing satellites put crucial sea-ice climate record at risk** [周五, 27 10月 08:00]
  Scientists scramble to avert disruption to data set that has tracked polar ice since the late 1970s.
- **3D map of mouse neurons reveals complex connections** [周五, 27 10月 08:00]
  Reconstructions of single cells highlight how far they can reach into the brain.
- **US March for Science group faces growing pains** [周五, 27 10月 08:00]
  A group of volunteers claims that the organization that spearheaded global protests in April has been unduly secretive about its management practices.
- **Genomic studies track early hints of cancer** [周五, 27 10月 08:00]
  Pilot projects aim to pinpoint how benign tumours turn into lung, breast, prostate and pancreatic cancers.
- **Plans rejected for East Antarctic marine park** [周五, 27 10月 08:00]
  Negotiations to conserve unique ecosystems fail for the sixth year running.
- **China announces plans to fast-track drug approval** [周四, 26 10月 08:00]
  Policies are expected to speed up access to medicines and boost the country’s pharmaceutical industry.

- **Bitter CRISPR patent war intensifies** [周四, 26 10月 08:00]
  Gene-editing pioneers prepare for next stage of intellectual-property disputes in the United States and Europe.
- **First living human cells added to brain database** [周三, 25 10月 08:00]
  Measurements show how neurons behave in healthy living tissue.
- **Many junior scientists need to take a hard look at their job prospects** [周三, 25 10月 08:00]
  Permanent jobs in academia are scarce, and someone needs to let PhD students know.
- **Data science can improve aid distribution** [周三, 25 10月 08:00]
  Online platforms can help to steer emergency response and ensure money is well spent.
- **A death sentence, Hawking's thesis and China's ambitions** [周三, 25 10月 08:00]
  The week in science: 20–26 October 2017.
- **CRISPR hacks enable pinpoint repairs to genome** [周三, 25 10月 08:00]
  Precision tools expand the number of ‘base editors’ available for manipulating DNA and RNA.
- **Out of the Syrian crisis, a data revolution takes shape** [周三, 25 10月 08:00]
  Aid organizations have been piloting a nimble approach to cut through the fog of war.
- **History: Science and the Reformation** [周三, 25 10月 08:00]
  The scientific and religious revolutions that began 500 years ago were not causally related, but were both stimulated by printing, argues David Wootton.
- **Disaster preparedness: Risk, rout and ruination** [周三, 25 10月 08:00]
  Anthony King navigates a show on catastrophe, from nuclear apocalypse to γ-ray bursts.
- **Public engagement: Young scientists welcome at IPBES** [周三, 25 10月 08:00]
- **Poaching: Is snow leopard tally underestimated?** [周三, 25 10月 08:00]
- **Construction: limit China's sand mining** [周三, 25 10月 08:00]
- **Construction: use waste for building** [周三, 25 10月 08:00]
- **Science writing: On what's neither clear nor obvious** [周三, 25 10月 08:00]
- **Nicolaas Bloembergen (1920–2017)** [周三, 25 10月 08:00]
  Laser and optics pioneer whose work led to magnetic resonance imaging.
- **The Everywhere Bus** [周三, 25 10月 08:00]
  It's the latest in travel technology.
- **French scientists in uproar over changes to medical-research clusters** [周二, 24 10月 08:00]
  Biomedical-research agency accused of attempting to undermine autonomy of university–

hospital groups.

- **Wait for Trump's science adviser breaks modern-era record** [周二, 24 10月 08:00]
  Top White House science job stays empty more than nine months after president took office.
- **Reclassify waste to shift the nuclear landscape** [周二, 24 10月 08:00]
  The US Department of Energy should classify and dispose of nuclear rubbish according to risk.
- **Cancer biology still needs physicists** [周二, 24 10月 08:00]
  Considering game theory and the role of physical forces could lead to better treatments for cancer, says Robert Austin.
- **India gears up for second Moon mission** [周二, 24 10月 08:00]
  The Chandrayaan-2 orbiter, lander and rover will track how lunar dust might scupper settlement.
- **To stay young, kill zombie cells** [周二, 24 10月 08:00]
  Killing off cells that refuse to die on their own has proved a powerful anti-ageing strategy in mice. Now it's about to be tested in humans.

Spanish government takes control of Catalonian universities

Madrid will oversee the finances of the region's research centres and seven public universities.

31 October 2017

Alain Pitton/NurPhoto/Getty

Supporters of independence for Catalonia.

The Spanish government has taken over responsibility for higher education and research in Catalonia, following the region’s unilateral declaration of independence on 27 October. It will retain control of spending on research centres and universities, which the League of European Research Universities says threatens institutional autonomy.

The Catalonia region of north-east Spain has been in political turmoil ever since a highly controversial vote on independence was taken on 1 October. For the past 32 years the Catalan government has set and financed the budgets of universities, which were allocated €700 million (US$814 million) of the nearly €1-billion Catalan budget for science and universities in 2017. The region is strong in science: between 2007 and 2015, its universities won 210 grants from the European Research Council, totalling €334 million. In the most recent round, 10 of the 22 ERC starting grants awarded to researchers in Spain were won by researchers based at Catalan institutions.

The Ministry of Education, Culture and Sport in Madrid will run Catalan universities and the Ministry of Economy, Industry and Competitiveness will oversee the region's research policy with immediate effect.

The changes mean that the Spanish government will be able to take decision affecting research centres and universities in Catalonia, after it dismissed all the members of the Catalan government.

Carmen Vela, Spain's secretary of state for research, development and innovation, says that the government hopes the difficulties will be resolved shortly. "Today's situation is a bit different, but it has a very clear goal: restoring normality and tranquility. We are going to work to ensure that there are no negative impacts on research and innovation in Catalonia." She says that the Spanish government will manage but not devise science policy in Catalonia ahead of regional elections due in December.

University connections

Santi Vila, minister of business and knowledge in the Catalan government, stepped down a day before the independence declaration. Arcadi Navarro, secretary of state for universities and research in the Catalan government and a geneticist at Pompeu Fabra University in Barcelona, who used to report to Vila, might yet retain a role. "Arcadi is an excellent researcher and someone with whom we have always had an excellent relationship," Vela says. "We want to keep working with him.”

Jaume Casals, rector of Pompeu Fabra University, says that he does not expect the Spanish government to interfere directly in universities’ affairs. “The relationship between Madrid and Barcelona when it comes to science and universities has always been fluid, and I hope that will not change,” says Casals, who also leads the Alliance 4 Universities, a group of research-intensive universities consisting of two based in Madrid and another two in Catalonia.

Enric Banda, senior adviser at the Barcelona Supercomputing Centre and former president of the grass-roots association EuroScience, agrees. “This is the first time these type of measures, stipulated in the Spanish constitution, are applied. The uncertainty is high because nobody knows exactly how they will be implemented. But I don’t expect any additional disruption in the daily activities of the Catalan universities,” he says.

Financial ties

The League of European Research Universities, headquartered in Leuven, Belgium, has criticized the financial arrangements on the grounds that they undermine institutional autonomy. In a statement issued on 23 October, the group’s secretary-general, Kurt Deketelaere, wrote: “Just like academic freedom, institutional autonomy is key for the academic world and society at large. It cannot be limited on the basis of political considerations, or to serve political goals.”

Ahead of the Catalan elections in December, both Casals and Banda are calling on the Spanish government to lift the financial controls and to minimise the impact of the political upheaval on the region's international image. “Catalonia has done very well at attracting international researchers and students and we would like that to continue,” says Casals.

Journal name:
Nature
DOI:

doi:10.1038/nature.2017.22922

Comments

Comments

There are currently no comments.

Frédéric Chopin’s telltale heart

Scientists have written another chapter in the curious case of the composer’s heart. But it is unlikely to be the end of the story.

31 October 2017

De Agostini/A. Dagli Orti/Getty

The composer Frédéric Chopin died in 1849, but the debate about what killed him continues.

Edgar Allen Poe was a master of the macabre. His 1843 *The Tell-Tale Heart* is a classic gothic tale for Halloween with its roots in guilt and fear: a murderer is haunted by the imagined beating of the excised heart of his victim.

The piano works of Frédéric Chopin — one of the greatest composers of the same period — tend more towards the uplifting. But events after his death have puzzled experts for more than a century and are worthy of any horror story. Scientists in Poland now claim to have solved the mystery. As the researchers conclude in a long-awaited report, he almost certainly died of complications caused by tuberculosis (M. Witt *et al. Am. J. Med.*; in the press; available at http://doi.org/cfpt). The evidence? The scientists have examined Chopin's own telltale heart.

The macabre afterlife of Chopin began with his recorded last words: "Swear to make them cut me open, so that I won't be buried alive." Taphephobia, as this fear is called, was a nineteenth-century obsession (shared by Alfred Nobel, among others), and saw some coffins made with alarm systems to be rung from within. Chopin's sister had an autopsy performed on him, during which his heart was removed. So although most of her brother lies in the famous Père Lachaise Cemetery in Paris, the city in which he died, she sealed his heart in a jar of (probably) brandy and took it back to Warsaw, the city closest to where he was born.

This wasn't too unusual. Remote burial of the heart was a fairly common practice, partly because it was too difficult to repatriate the bodies of kings and nobles who fell in foreign fields. (The heart of the English writer Thomas Hardy is said to be buried in his beloved Dorset, UK, although a more gruesome version of the story has the precious organ being eaten by a cat, and that of the offending animal interred instead.) But Chopin's status as a Polish national hero has helped to make sure that his heart never really rested in peace. His sister smuggled it into Poland past Russian border guards and it was later sealed inside a church pillar. Decades afterwards, during the Second World War, it was retrieved and protected by a Nazi SS commander who claimed to love Chopin's music. After the war, the heart was returned to rest in the church — but only until 2014.

Then, scientists were invited to join an official inspection of the jar and its contents. Their examination — and brief comments to journalists months later — focused on how he died. The original autopsy notes are lost, and an entire academic subfield across many disciplines has emerged to discuss whether Chopin had tuberculosis or something much rarer, perhaps an early known case of cystic fibrosis. Those academics now have a Halloween treat: a draft of a paper to appear in *The American Journal of Medicine* offers more details on the state of the heart.

The original autopsy caused significant damage to both atria, but the paper claims “with high probability” that the remains show that Chopin had chronic tuberculosis, and that the immediate cause of death was a life-threatening complication called pericarditis — inflammation of the membrane enclosing the heart.

Chopin is not the only ghost from the past to offer their secrets to scientists. The artist Salvador Dalí was exhumed in July, moustache reportedly intact, to provide samples to decide a paternity case (he was not the father); and 2015 tests on bones of the Communist poet and winner of the Nobel Prize in Literature, Pablo Neruda, have fuelled theories that he was poisoned in Chile after Augusto Pinochet seized power in 1973.

There could yet be a twist in Chopin’s tale. Some scholars are unsure that the heart is the composer’s, and DNA tests to check for cystic fibrosis have so far been refused. The scientists were not allowed to open the jar in 2014, and Michał Witt at the Polish Academy of Sciences’ Institute of Human Genetics in Poznan, who worked on the project, says that they didn’t want to. The next opportunity will be in 50 years, when the heart is again scheduled for inspection. Witt does not expect to be around to see it. Still, he does have something more planned: the team was allowed to take photographs of the embalmed heart, and although none is yet public, he does plan to include them in the final manuscript. The full tale, after all, has not yet been told.

Journal name:
Nature
Volume:
551,
Pages:
5
Date published:

(02 November 2017)
DOI:
doi:10.1038/551005a

Comments

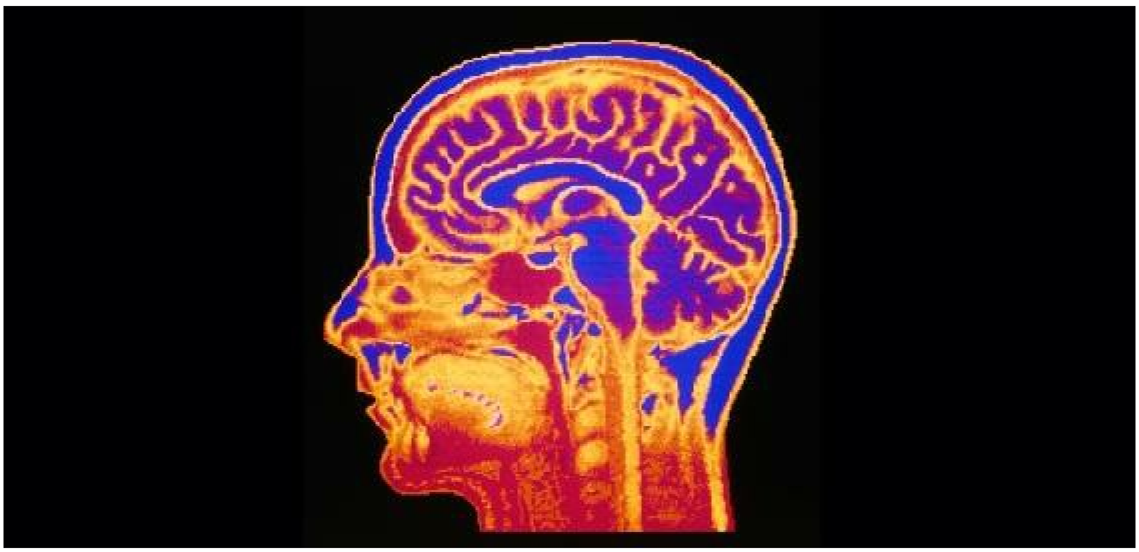
Comments

There are currently no comments.

Geneticists are starting to unravel evolution's role in mental illness

Hints emerge that past environments could have influenced psychiatric disorders.

30 October 2017



Mehau Kulyk/SPL

Human genome databases are enabling researchers to take a deeper dive into the evolution of psychiatric disorders.

Psychiatric disorders can be debilitating and often involve a genetic component, yet, evolution hasn't weeded them out. Now, recent work is beginning to reveal the role of natural selection — offering a peek at how the genetic underpinnings of mental illness has changed over time.

Many psychiatric disorders are polygenic: they can involve hundreds or thousands of genes and DNA mutations. It can be difficult to track how so many genetic regions evolved, and such studies require large genome data sets. But the advent of massive human genome databases is enabling researchers to look for possible connections between mental illnesses and the environmental and societal conditions that might have driven their emergence and development. Others are looking to Neanderthal genetic sequences to help inform the picture of these disorders, as well as cognitive abilities, in humans. Several of these teams presented their findings at the American Society of Human Genetics (ASHG) meeting in Orlando, Florida, in late October.

One project found that evolution selected for DNA variants thought to protect against schizophrenia. The study, led by population geneticist Barbara Stranger of the University of Chicago in Illinois, looked at hundreds of thousands of human genomes using a statistical method that identified signals of selection over the past 2,000 years[1]. There were no signs of selection in genetic regions associated with any other mental illness.

Many of schizophrenia's symptoms, such as auditory hallucinations and jumbling sentences, involve brain regions tied to speech, says Bernard Crespi, an evolutionary biologist at Simon Fraser University in Burnaby, Canada. Over the course of hominid evolution, he says, the ability to speak could have outweighed the small, but unavoidable risk that the genes involved in language could malfunction and result in schizophrenia in a small percentage of the population.

A quest for context

Another team, lead by human geneticist Renato Polimanti at Yale University in New Haven, Connecticut, is trying to tease out links between environmental factors, mental illnesses and behavioural traits. Polimanti and his colleagues looked at 2,455 DNA samples from individuals at 23 sites across Europe and quantified each person’s overall genetic risk for mental disorders, such as autism, and personality traits, such as extraversion. They then calculated whether that risk was associated with certain environmental factors, such as rainfall, winter temperatures or the prevalence of infectious disease — exploring the idea that these factors might have been involved in selecting for the human traits.

People who live in European regions with relatively lower winter temperatures, they found, were slightly more genetically prone to schizophrenia. Polimanti suggests that if genes that helped people tolerate cold were located close to variants that promote schizophrenia in the genome, then the latter could have been inadvertently carried along during evolution as a “fellow traveller”.

“This was a nice first attempt to put some environmental context” on the polygenic variants associated with mental illness, says Tony Capra, an evolutionary geneticist at Vanderbilt University in Nashville, Tennessee. Polimanti now plans to repeat the study in other parts of the world.

For and against

Untangling the roles of genetics and the environment will be difficult, however, because unknown environmental conditions in the past could have selected for traits that were advantageous then, but considered negative today. And other evolutionary factors could contribute to mental illness indirectly. An overactive immune system is thought to be involved in many psychiatric disorders, such as depression[2], but a stronger immune system would have made human ancestors more resistant to diseases, says Stranger.

Some researchers are exploring the evolution of mental illness through a different lens: by looking at possible differences in gene activity in tissues of Neanderthals and humans. A group lead by Capra and Vanderbilt human geneticist Laura Colbran used databases of modern human genomes to find DNA markers that suggest a gene is differently regulated in various tissues in the body. They then looked for these markers in two Neanderthal genomes. The team found that genes associated with neurological development were regulated differently in the Neanderthal brain compared with that of humans.

So while the DNA sequence of a gene such as *FOXP2* — which is associated with language — is identical[3] in humans and Neanderthals, human brains might have produced more of the associated protein, accounting for increased language ability. The results could eventually lead to a better understanding of how Neanderthal brains functioned, if they were similar to human brains and whether they might have suffered from similar psychiatric disorders.

Studying how mental illness evolved is still at an early stage, but the ability to use massive human genome databases is an exciting step forward, says Capra. He and his colleagues plan to take advantage of this with a survey of genetic areas that differ between Neanderthals and humans, searching for differences in how the genes are expressed.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22914

Comments

Comments

There are currently no comments.

Huge microwave observatory to search for cosmic inflation

Multi-telescope project has ambitious goals and a big price tag.

30 October 2017

NSF/Steffen Richter/Harvard Univ./SPL

Telescopes in Antarctica track the cosmic microwave background radiation left over from the Big Bang.

US researchers have drafted plans to study the faint afterglow of the Big Bang using a new facility. They hope it will be sensitive enough to confirm whether or not the infant Universe underwent a brief period of explosive expansion known as inflation.

The Cosmic Microwave Background Stage-4 experiment (CMB-S4) would comprise three 6-metre and 14 half-metre telescopes distributed across two sites in Antarctica and Chile, according to a preliminary design due to be made public this week. Potentially up and running within a decade, the facility would be nearly 100 times as sensitive as existing ground-based CMB experiments.

It won't be cheap, however. Construction will cost a little over US$400 million, according to the expert task force commissioned by the US Department of Energy (DOE) and National Science Foundation (NSF) to produce the design. That is at least twice as much as envisioned in a less-detailed review 3 years ago, and 30 times the cost of existing experiments.

The price tag is "not necessarily" a showstopper, says Richard Barvainis, who directs the NSF's extragalactic astronomy and cosmology programme. But CMB-S4 will have to compete for limited funding with other large proposed facilities.

Primordial ripples

The CMB provides an image of the Universe as it was just 380,000 years after the Big Bang. Discovered in 1964, the radiation has since been observed by experiments on the ground, on balloons and in space, yielding increasingly precise insights into the Universe's geometry, contents and age — currently calculated at a little under 14 billion years.

But physicists think that the CMB has more to offer. In particular, distinctive patterns in its polarization known as B modes could reveal the existence of primordial gravitational waves. Gravitational waves — ripples in space-time — were first observed directly in 2015, but their detection in the very early Universe would be a major breakthrough, providing the strongest evidence yet for inflation, according to Charles Lawrence, an astrophysicist at NASA's Jet Propulsion Laboratory in Pasadena, California, who chairs the CMB-S4 task force.

Current ground-based CMB experiments typically detect microwaves using a few thousand pixels and are based either near the South Pole or in Chile's Atacama Desert, where very dry conditions make the atmosphere nearly transparent to microwave radiation. None of the experiments has so far spotted the telltale B mode. One group did make a well-publicized claim in 2014, but it transpired that the sighting was actually caused by emissions from Galactic dust. Researchers are now building several more experiments that will be ten times as sensitive.

But Lawrence says that detecting the gravitational waves predicted by many of today's models of inflation would require sensitivity boosted by a further order of magnitude. Hence CMB-S4, which would comprise nearly 400,000 pixels. If it, too, came up empty-handed, the task force writes, it might be necessary "to give up on inflation".

Fight for funding

CMB-S4 is too large for any single group to build, so researchers across the US started collaborating on the design in 2013. Their initial plans were approved a year later by a panel advising the DOE on particle physics. But they must wait until 2020 to see how they fare in the next round of the once-per-decade survey of astronomy and astrophysics that the NSF uses to assess funding priorities.

Barvainis says that the agency will support CMB-S4 only if it gets "a very high priority" in the decadal survey, which is also likely to include a proposed upgrade to the National Radio Astronomy Observatory's Very Large Array in New Mexico, along with the development of one or more large optical telescopes. Even if the project does prevail, he adds, further agency reviews could delay the envisaged start of operations — due in 2026 — by at least two years.

The task force suggests that instead, CMB-S4 could be started by adding DOE detectors to existing telescopes in Chile while installing a few of the smaller telescopes at the South Pole. Under that strategy, the NSF would initially fund only operations. However, officials at the DOE also foresee snags. James Siegrist, the agency's associate director for high-energy physics, says budgetary disagreements between the White House and Congress are creating “a lot of uncertainty” in Washington DC. A delay until 2027 or 2028 “could easily happen”, he predicts.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22920

Comments

2 comments

1. *Pentcho Valev* • 2017-10-30 10:41 PM
   Vacuum is not empty, and this makes the Cosmic Microwave Background concept rather silly. It is unreasonable to believe that the vacuum is full of energy and at the same time to claim that the noise known as CMB is not a product of this energy but just traverses it, unchanged. You have vacuum energy, detectors in contact with the vacuum which register strange noise coming from all directions, and you conclude that the noise is not produced by the vacuum energy but comes from the miraculous beginning of space and time. In addition, you implicitly assume that the vacuum energy does not change the noise. Silly, isn't it? Vacuum slows down light - this explains the Hubble redshift (in a STATIC universe): "...explains Liberati. "If spacetime is a kind of fluid, then we must also take into account its viscosity and other dissipative effects, which had never been considered in detail". Liberati and Maccione catalogued these effects and showed that viscosity tends to rapidly dissipate photons and other particles along their path, "And yet we can see photons travelling from astrophysical objects located millions of light years away!" he continues. "If spacetime is a fluid, then according to our calculations it must necessarily be a superfluid. This means that its viscosity value is extremely low, close to zero"." https://phys.org/news/2014-04-liquid-spacetime-slippery-superfluid.html Nature: "As waves travel through a

medium, they lose energy over time. This dampening effect would also happen to photons traveling through spacetime, the researchers found." http://www.nature.com/news/superfluid-spacetime-points-to-unification-of-physics-1.15437 "Some physicists, however, suggest that there might be one other cosmic factor that could influence the speed of light: quantum vacuum fluctuation. This theory holds that so-called empty spaces in the Universe aren't actually empty - they're teeming with particles that are just constantly changing from existent to non-existent states. Quantum fluctuations, therefore, could slow down the speed of light." https://www.sciencealert.com/how-much-do-we-really-know-about-the-speed-of-light?perpetual=yes&limitstart;=1 The transition from expanding to STATIC universe is unavoidable because the implications of the expanding universe theory are absurd: Sabine Hossenfelder: "If The Universe Is Expanding, Then Why Aren't We? The solution of general relativity that describes the expanding universe is a solution on average; it is good only on very large distances. But the solutions that describe galaxies are different - and just don't expand. It's not that galaxies expand unnoticeably, they just don't. The full solution, then, is both stitched together: Expanding space between non-expanding galaxies." https://www.forbes.com/sites/startswithabang/2017/07/28/most-things-dont-actually-expand-in-an-expanding-universe/ "The Multiverse Is Inevitable, And We're Living In It. Alan Guth: "It's hard to build models of inflation that don't lead to a multiverse. It's not impossible, so I think there's still certainly research that needs to be done. But most models of inflation do lead to a multiverse, and evidence for inflation will be pushing us in the direction of taking [it] seriously." The Multiverse itself may not give rise to any observable, testable predictions, but arises as a direct consequences of other physical theories that have already been validated." http://scienceblogs.com/startswithabang/2017/10/12/the-multiverse-is-inevitable-and-were-living-in-it-synopsis/ Pentcho Valev

2. *Pentcho Valev* • 2017-10-31 07:35 AM

   In my view, the following dialog marks the beginning of a sweeping revolution in cosmology: http://backreaction.blogspot.bg/2017/10/space-may-not-be-as-immaterial-as-we.html Sabine Hossenfelder: "Is Space-Time Fluid? We have known at least since Einstein that space and time are inseparable, two hemispheres of the same cosmic brain, joined to a single entity: space-time. Einstein also taught us that space-time isn't flat, like paper, but bent and wiggly, like a rubber sheet. Space-time curves around mass and energy and this gives rise to the effect we call gravity. That's what Einstein said. But turns out... [...] That space itself isn't fundamental but made of other things is one way to approach the problem. Not everyone likes the idea. What irks physicists most about giving substance to space-time is that this breaks Einstein's bond between space and time which has worked dramatically well - so far. Only further experiment will reveal whether Einstein's theory holds up." Arun: "How does a fluid analog of general relativity avoid having a preferred reference frame?" Sabine Hossenfelder: "Arun, it doesn't. It's why I write it breaks the union between space and time." [END OF QUOTATION] Sabine Hossenfelder is on the right track. The "preferred reference frame" does not affect the validity of the principle of relativity in its traditional usage - it is only responsible for the vacuum friction that slows down photons coming from distant stars, in a STATIC universe. So the Hubble redshift is produced, but at the end of their journey photons redshift less vigorously than at the beginning. This has wrongly been interpreted as accelerating expansion: "In the mid 1990s two teams of scientists, one led by Brian Schmidt and Adam Riess, and the other by Saul Perlmutter, independently measured distances to Type 1a supernovae in the distant universe, finding that they appeared to be further way than they should be if the universe's rate of expansion was constant. The observations led to the hypothesis that some kind of dark energy anti-gravitational force has caused the expansion of the universe to accelerate over the past six billion years." https://cosmosmagazine.com/physics/dark-energy-may-not-exist Below I'm showing that the redshifting varies EXPONENTIALLY with time. The "finding that they appeared to be further way than they should be" is an illusion due to using an approximation to the exponential function. Assume that, as the photon travels through space (in a STATIC universe), a factor equivalent to vacuum friction (see relevant references below) slows it down so that the photon loses speed in much the same way that a golf ball loses speed due to the resistance of the air. On this hypothesis the resistive force (Fr) is proportional to the speed of the photon (V): Fr = - KV That is, the speed of light decreases with time in accordance with the equation: dV/dt = - K'V Clearly, at the end of a very long journey of photons (coming from a very distant object), the contribution to the redshift is much smaller than the contribution at the beginning of the journey. Light coming from nearer objects is less subject to this effect, that is, the increase of the redshift with distance is closer to LINEAR for short distances. For distant light sources we have: f' = f(exp(-kt)) where f is the initial and f' the measured (redshifted) frequency. For short distances the following approximations can be made: f' = f(exp(-kt)) ~ f(1-kt) ~ f - kd/λ where d is the distance between the light source and the observer and λ is the wavelength. The approximate equation, f' = f - kd/λ, is only valid for short distances and corresponds to the Hubble law. The original equation, f' = f(exp(-kt)), shows that at the end of a very long journey (in a STATIC universe) photons redshift much less vigorously than at the beginning of the journey. This means that photons coming from very distant objects have undergone some initial "vigorous" redshifting which is unaccounted for by the Hubble law. This explains why the very distant objects "appeared to be further way than they should be if the universe's rate of expansion was constant". Is there "vacuum friction" that slows down photons? Yes there is: "This leads to the prediction of vacuum friction: The quantum vacuum can act in a manner reminiscent of a viscous fluid." http://philpapers.org/rec/DAVQVN New Scientist: "Vacuum has friction after all." https://www.newscientist.com/article/mg20927994.100-vacuum-has-friction-after-all "So how can a vacuum carry force? One of the first things we learn in classical physics is that in a perfect vacuum - a place entirely devoid of matter - friction can't exist, because empty space can't exert a force on objects traveling through it. But,

in recent years, quantum physicists have shown that vacuums are actually filled by tiny electromagnetic fluctuations that can interfere with the activity of photons - particles of light - and produce a measurable force on objects."
http://www.businessinsider.com/casimir-effect-vacuum-space-nanoparticles-2017-4 Pentcho Valev

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Ageing satellites put crucial sea-ice climate record at risk

Scientists scramble to avert disruption to data set that has tracked polar ice since the late 1970s.

27 October 2017

Mario Tama/Getty

The footprint of Arctic sea ice has shrunk dramatically in the last four decades.

One of the most important continuous records of climate change — nearly four decades of satellite measurements of Arctic and Antarctic sea ice — might soon be interrupted.

Scientists all over the world rely on the sea-ice record compiled by the US National Snow and Ice Data Center (NSIDC) in Boulder, Colorado. But the US military satellites that collect the data, by measuring ice extent using microwave sensors, are approaching the end of their lives. Three are still working but ageing, and their intended successor started experiencing glitches in 2016, before conking out for good this month. The next possible replacement won't launch until at least the early 2020s (see 'Seeing ice').

That means the most complete and most scientifically significant sea-ice record is at risk of breaking. Any gap in satellite coverage is not just a short-term problem: it would compromise future research, because scientists would not be able to accurately compare observations made before the gap with those from afterward.

“Sea ice is the canary in the coal mine, and the canary’s about to fall off its perch,” says David Gallaher, an expert in satellite remote sensing at the NSIDC.

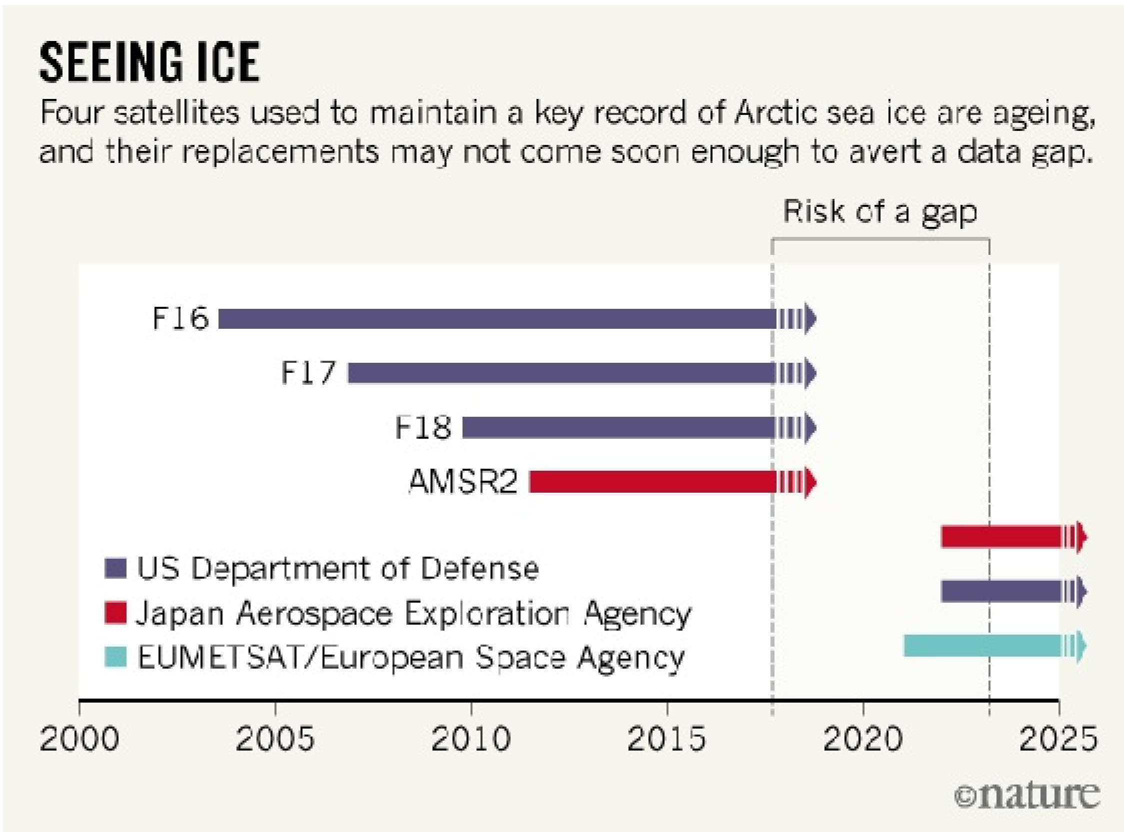
Centre analysts have begun testing the inclusion of sea-ice data from a Japanese satellite, but that spacecraft — designed to last five years — is now five years old. Experts looking to avert the looming gap will gather to debate other options, including the potential use of data from a Chinese satellite, in December, at a meeting of the American Geophysical Union in New Orleans, Louisiana.

Eyes in the sky

In addition to tracking Arctic change, the sea-ice record is also important for climate modellers. Knowing that sea ice formed at a particular location at a particular time gives the air and ocean temperature for that spot, allowing researchers to test simulations of the atmosphere and the ocean.

The data to assess sea-ice coverage come from polar-orbiting satellites carrying passive-microwave sensors that can see through clouds. The sensors detect the brightness of the surface below and translate those measurements into how much ice and water are present.

NASA began taking passive-microwave measurements of sea ice in 1972, using an instrument aboard its Nimbus-5 satellite. That sensor's failure four years later interrupted observations of phenomena such as an Oregon-sized hole that opened in the Antarctic sea ice in successive winters during the mid-1970s. By the time NASA restarted its passive-microwave measurements in 1978, the hole had vanished.



Source: Walt Meier, US National Snow and Ice Data Center

Mysteriously, a large patch of open water appeared in the same region last month — the biggest spotted in four decades. Gallaher says that scientists cannot accurately compare the patch from 2017 to those seen in the 1970s, because the break in the satellite record makes it hard to calibrate Nimbus-5 observations against later ones.

“That’s why it's so critical that you have overlap” from one sea-ice satellite to the next, he says.

NSIDC analysts continued using NASA sea-ice data until 1987, when they switched to information collected by the Defense Meteorological Satellite Program (DMSP). The military uses the microwave information to detect ocean wind speeds to feed into weather models, among other uses, but the data happen to be nearly perfect for sensing sea ice, says Walt Meier, a sea-ice specialist with the NSIDC. The centre has been using DMSP data ever since.

Today, the centre uses data from three DMSP satellites that are more than 8, 11 and 14 years old — and designed to last five. A newer satellite, known as F-19, was launched in 2014 but experienced sensor problems in 2016. It became inoperable this month after tumbling out of control. The final probe in the series, the unlaunched F-20, was dismantled last year after Congress stopped funding the programme.

“Everyone kept saying we got F-20, but then it became obvious 20 wouldn’t go up,” says Gallaher. “The science community was caught kind of flat-footed.”

Tenuous times

The US military is developing another set of weather satellites to replace the DMSP series, but the one carrying a microwave sensor will not launch before 2022. That means that when the current three ageing satellites die, the United States will be without a reliable, long-term source of sea-ice data. “Every day it’s more and more risk,” says Meier. “If one of those goes it will get to be nail-biting time, and certainly if two of them go.”

For now, the centre is preparing for those scenarios by incorporating data from Japan’s AMSR2 microwave sensor into its sea-ice record. Another, more politically fraught option is to pull in data from the China Meteorological Administration’s Fengyun satellite series. Their data are already being incorporated into European weather-prediction modelling, and they carry passive-microwave sensors that are appropriate for studying sea ice. Since 2011 Congress has banned NASA scientists from working with Chinese scientists — but not necessarily from using Chinese data.

One final possibility is finding a way to launch the passive-microwave sensor that scientists at the US Naval Research Laboratory salvaged from the dismantled DMSP satellite. The sensor currently sits at the Aerospace Corporation in El Segundo, California, where researchers are trying to find a way to get it into orbit. “It’s a beautiful instrument,” says Donald Boucher, a principal scientist and engineer with Aerospace. “It must fly.”

But the military might ultimately opt to launch the sensor on something such as the International Space Station, which travels over the Earth’s low and middle latitudes. That would fulfil US troops' weather-prediction needs, but would not provide the polar orbit needed to study sea ice. Other planned military or commercial satellites might be able to provide some information about sea-ice cover, but not with the level of detail and continuity that researchers desire.

“It’s kind of frightening that you can have a record as rich and continuous as what this is, and just not a real good way of continuing it,” says Molly Hardman, a remote-sensing specialist at the NSIDC. “It’s depressing.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22907

Comments

Comments

There are currently no comments.

3D map of mouse neurons reveals complex connections

Reconstructions of single cells highlight how far they can reach into the brain.

27 October 2017

3D map of mouse neurons reveals complex connections

Janelia Research Campus, MouseLight project team

The 70 million neurons in the mouse brain look like a tangled mess, but researchers are beginning to unravel the individual threads that carry messages across the organ. A 3D brain map released on 27 October, called MouseLight, allows researchers to trace the paths of single neurons and could eventually reveal how the mind assembles information.

The map contains 300 neurons and researchers plan to add another 700 in the next year. “A thousand is just beginning to scratch the surface,” says Nelson Spruston, a neuroscientist at the Howard Hughes Medical Institute (HHMI) Janelia Research Campus in Ashburn, Virginia.

To create the maps, Spruston and HHMI neuroscientist Jayaram Chandrashekar injected mouse brains with viruses that infect only a few cells at a time, prompting them to produce fluorescent proteins[1]. The team made the organs transparent using a sugar-alcohol treatment to obtain an unobstructed view of the glowing neurons, and then scanned each brain with a high-resolution microscope. Computer programs created 3D models of the glowing neurons and their projections, called axons, which can be half a metre long and branch like a tree.

MouseLight has already revealed new information, including the surprisingly extensive number of brain regions that a single axon can reach. For instance, four neurons associated with taste stretch into the region that controls movement and another area related to touch. Chandrashekar says the group is now working on identifying which genes each neuron expresses, which will help to pin down their function.

“This is a tremendous project,” says Hongkui Zeng, a molecular biologist at the Allen Institute for Brain Science in Seattle, Washington, who plans to collaborate with the Janelia group on MouseLight. The Janelia technique is similar to one that Zeng and her colleagues developed using a line of mice genetically engineered so that a certain drug activates glowing proteins in a handful of their neurons.

MouseLight is just one of several methods being used to reconstruct individual neurons, says Rafael Yuste, a neurobiologist at Columbia University in New York City. Accurately labelling neurons with markers such as fluorescence, he says, will probably be the key challenge in the eventual goal of creating a “census” of different cell types in the brain.

But to achieve that goal, Zeng says, researchers may need to reconstruct hundreds of thousands of neurons. “Now it’s a numbers game.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22908

Comments

Commenting is currently unavailable.

US March for Science group faces growing pains

A group of volunteers claims that the organization that spearheaded global protests in April has been unduly secretive about its management practices.

27 October 2017 Corrected:

1. 27 October 2017

Aaron P. Bernstein/Reuters

Participants in the March for Science in Washington, DC, on 22 April gather at the Washington Monument.

The US group that sparked the global March for Science movement is facing complaints about its management practices as it files for non-profit status and signals its intent to continue as “a movement to advance science and its role in public life”.

On 23 October, a group of current and former volunteers posted an open letter to the central March for Science organization in New York City, alleging that it is secretive, insensitive to the concerns of its volunteers, and unwilling to share power or information with organizers of its many affiliated ‘satellite’ groups around the world. The volunteers also claim that the organization sidelined and stonewalled experienced activists who wanted the movement to focus on how science can be used in ways that perpetuate racism, sexism and other forms of discrimination.

In a statement to *Nature*, the March for Science said that it welcomed the “concrete feedback and suggestions”. But volunteers have already walked away from the group, and at least one major satellite group, in New York, has severed ties. The turmoil comes at a time of renewed political activism by US scientists, much of it in protest against the policies of US President Donald Trump.

Aaron Huertas, the former communications director for March for Science and an author of the letter, says that the organization is acting in a hierarchical fashion, and not as the grassroots movement that many volunteers wanted. He adds that experienced activists in the group, many of whom focussed on issues of social justice, were the first to raise the alarm about lack of transparency — and with good reason. “Transparency prevents marginalized people from having their work and labour undervalued or thrown away,” Huertas says.

He and his letter co-signatories are concerned that the group has not published a detailed accounting of its finances, including the US$1.3 million it raised between 1 February and 30 April. They are uncomfortable with the group’s decision to ask some volunteers and board members to sign non-disclosure or confidentiality agreements, and to hire one of the group’s original co-chairs, Caroline Weinberg, as its paid interim director without advertising the job.

Weinberg says that the board hired her in August as the part-time interim executive director at a salary of $67,000 per year, with no benefits. She adds that a public search for a permanent director will begin in December, and that the March for Science will release more detailed financial information "at the end of this week or early next." In the meantime, the disclosure on 24 October that Weinberg and her two co-chairs received some money for their services is also coming under scrutiny.

Terry Kush, the March for Science's chief operating officer, revealed the payments in a memo to the March for Science's satellite groups. "In May and June, 12 national team members were paid for their work those months, including the former co-chairs," Kush wrote. She added: "We'd like to reaffirm our commitment to increasing transparency within the org and the larger grassroots movement."

The group's three original co-chairs — Weinberg, Jonathan Berman and Valorie Aquino — resigned their positions in late April and signed a confidential agreement with the organization in late August, Weinberg says. She adds that while she "cannot comment on the clauses therein", that does not prevent her from being open about "the march, our work, accounting, governance, or legal structures". Aquino and Weinberg also signed what Weinberg calls "standard" confidentiality agreements with the board.

In a 25 October post on Twitter, former co-chair Jonathan Berman confirmed that he had been paid $6,500. "I didn't feel great about it at the time, and I'm still not sure accepting it was the right thing to do," he wrote.

Huertas calls these payments "secret", and argues that not disclosing the information publicly undermined the effectives of the March for Science group. Weinberg says that the payments were made in July, but "not publicly released" until now only because they took place in the middle of the fiscal year.

"The accusation that we are in this to enrich ourselves and make money is deeply offensive and something I am sadly not surprised to see aimed at women in leadership as it devalues our work and commitment to the cause," Weinberg says. "Most people do not have the luxury of volunteering full time in perpetuity, and need — and deserve — to be paid for this work."

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22909

Corrections

Corrected:

The original version of this story incorrectly stated Terry Kush's gender. It has been corrected.

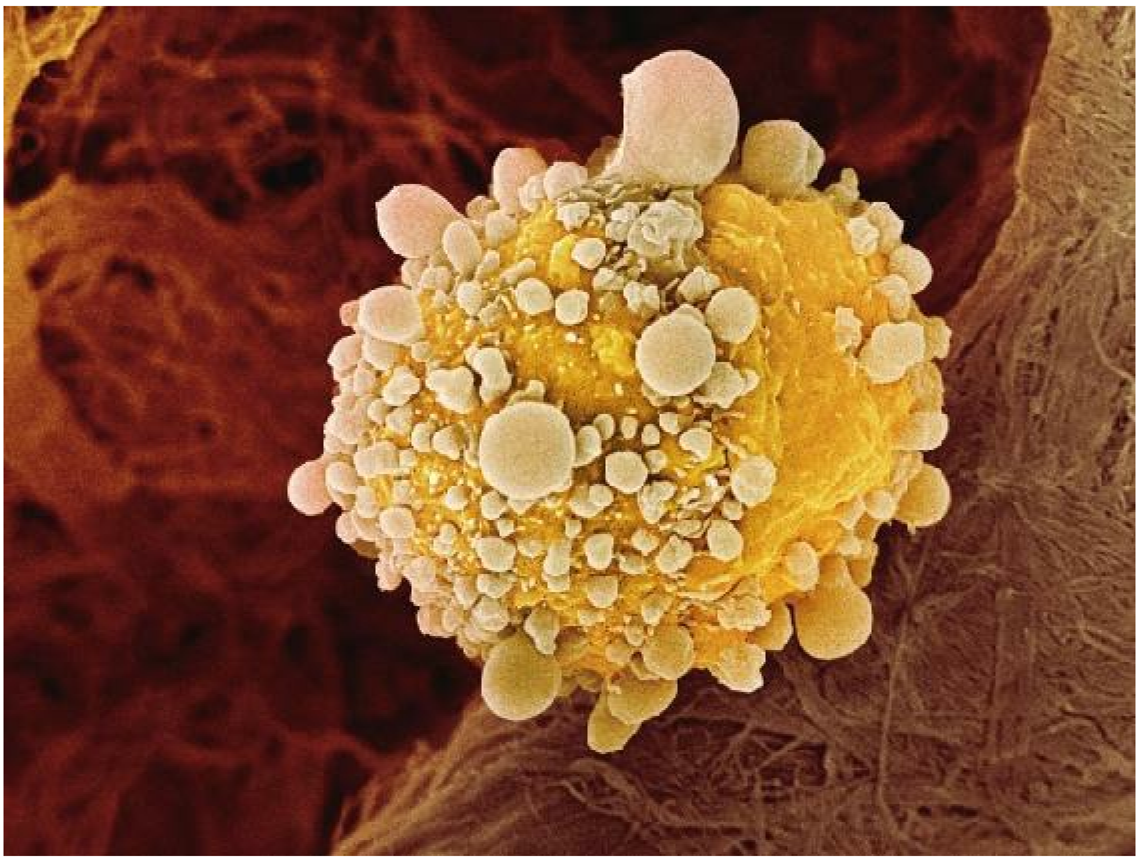
Comments

Commenting is currently unavailable.

Genomic studies track early hints of cancer

Pilot projects aim to pinpoint how benign tumours turn into lung, breast, prostate and pancreatic cancers.

27 October 2017



Steve Gschmeissner/SPL

Researchers are trying to stop tumour cells from turning malignant like this pancreatic cancer cell.

After years of studying advanced cancers, researchers are now training their

DNA sequencers on precancerous growths to learn more about how they develop into the full-blown disease.

A three-year pilot project funded this month by the US National Cancer Institute (NCI) as part of the National Cancer Moonshot Initiative, will take this approach with lung, breast, prostate and pancreatic cancer. Investigators hope to create a 'pre-cancer genome atlas' by sequencing DNA from precancerous growths, in addition to sequencing RNA from individual tumour cells and identifying the immune cells that have infiltrated the lesions.

Another project — a four-year US$5-million effort funded by the charities Stand Up To Cancer, the American Lung Association and LUNGevity announced on 26 October — will bolster the study in lung cancer by sequencing DNA from precancerous growths in the airway. Doctors sometimes monitor such lesions, taking periodic biopsies to determine if and when they become malignant. One component of this project will track the genetic changes in these biopsies over time.

The aim is to find ways to intervene in cancer earlier, when it may be easier to rein in the disease. “There’s a tremendous sense that the rate-limiting step for new approaches for either preventing cancers or detecting them early, is the fundamental lack of knowledge about the earliest molecular events,” says pulmonologist Avrum Spira at Boston University in Massachusetts, a leader on both projects. “We just don’t understand what’s going on very early.”

Making maps

The desire to map those earliest events has been growing, fuelled in part by frustration with the limited success of therapies in patients with advanced cancers. Meanwhile, technological advances in DNA sequencing have made it possible for researchers to glean useful data from tiny tissue samples — a crucial development because physicians tend to take small biopsies of precancerous growths, and there is often little tissue left after the pathologists have analysed them.

However, even with advances in sequencing, sceptics have questioned whether those minuscule amounts of tissue would suffice, says Spira. The Moonshot-funded project is set to last for three years, but Spira and his colleagues have been asked to report back in 12 months so that the NCI can decide whether the approach is feasible and warrants expansion, Spira says. “This is the beginning of a much bigger initiative,” he says.

It’s a short timeline, but the team has a head start, Spira says. Several institutions have already been collecting these small tissue samples in biobanks, so investigators can begin their analyses immediately. This will be particularly important for pancreatic cancer, a relatively rare condition that is often caught only when it has become advanced and difficult to treat, he says.

But it is worth the extra effort to study pancreatic cancer, which is among the most lethal ones, says Elizabeth Jaffee, who studies the disease at Johns Hopkins University in Baltimore, Maryland. Many pancreatic tumours seem to be driven by mutations in the same genes — and that commonality may make the disease more predictable, and therefore easier to detect and target at an early stage.

“You can look at it as, ‘Let’s pick the easiest ones’, but will that have the biggest impact?” Jaffee says. “Or let’s pick some of the harder ones and maybe we can, longer term, have this plan of just preventing them entirely.”

If successful, the projects could herald a change in how researchers approach cancer prevention, says Spira. “The field has been stagnant and people are frustrated,” he says. “People want to really transform that space, and the feeling is that the atlas is the next thing to do to change that.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22911

Comments

Commenting is currently unavailable.

Plans rejected for East Antarctic marine park

Negotiations to conserve unique ecosystems fail for the sixth year running.

27 October 2017

Hobart, Australia

Colin Monteath/Minden/Getty

The proposed East Antarctic marine park would protect species including cold-water corals, krill and Adélie penguins (*Pygoscelis adeliae*).

A huge area off the coast of East Antarctica rich in cold-water corals and penguin foraging grounds will remain unprotected for at least another year. Conservation advocates had hoped that the region, covering one million square kilometres, would become the continent's newest marine protected area (MPA). But the international body that oversees Antarctic waters failed to reach agreement before the end of its annual meeting on 27 October in Hobart, Australia.

At last year's meeting, after years of unsuccessful talks, the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) agreed to create the world's largest marine park, the Ross Sea MPA. Buoyed by that success, representatives from Australia, France and the wider European Union had hoped that East Antarctica would follow this year. But for the sixth year in a row, CCAMLR was unable to agree on the details.

Conservationists did have some good news, however, with a decision to extend protection for waters exposed when a massive iceberg split from the Larsen C ice shelf this year; a new proposal for a marine protected area in the waters around the Antarctic Peninsula; and the approval of a research and monitoring plan for the Ross Sea MPA.

After the move to protect the Ross Sea, "it is disappointing that CCAMLR could not agree to protect more of the vast and biologically diverse Southern Ocean", said Andrea Kavanagh, director of Antarctic and Southern Ocean work at the Pew Charitable Trusts in Washington DC, in a statement issued after the meeting.

"People aren't feeling great," Chris Johnson, senior manager of the Antarctic programme for global wildlife charity WWF, told *Nature* just after the meeting's conclusion close to midnight. "This was a polarizing year. But these things take a long time to get consensus."

Fighting over fishing

The proposal to protect three large blocks of ocean and sea floor along East Antarctica has been endorsed by the commission's scientific committee three times. But opposition from China and Russia has blocked the proposal each year.

Both have current or historical fishing interests in the region. China began fishing in the area last year and trawlers from the Soviet Union once plied East Antarctic waters; Russia has expressed interest in returning. Under CCAMLR rules, all 25 commission members — 24 countries and the European Union — must agree for a proposal to be adopted.

Negotiations in recent years halved the size of the proposed reserve from 1.9 million square kilometres divided into seven areas to one million square kilometres divided into three and added a 30-year expiration date. On the other side of the ledger, the talks also yielded extra protections for underwater recesses in the ice along the coastline that harbour fish.

Fishing for krill, small crustaceans that are a fundamental part of the Antarctic marine food web, would be allowed in much of the reserve. But one area would be completely off limits, in part to provide a control for researchers studying the impacts of fishing on the region.

Neither China's nor Russia's delegates responded to requests for comment on the nature of their opposition to the latest proposal. But the high-level talks between parties including Russia, the United States and China that smoothed the way for the Ross Sea reserve were absent from this year's meeting, according to several attendees interviewed by *Nature*.

Unique ecosystems

Although only two-thirds the size of the Ross Sea MPA, the East Antarctic reserve would protect unique ecosystems and features. Included within its boundaries are sites where Antarctic bottom water is formed; this very cold, dense, oxygen-rich slug of water drives global ocean circulation. Churning on the sea floor creates a range of important habitats on the ice shelf and slope that support marine food webs, a nursery for Antarctic silverfish (*Pleuragramma antarcticum*) and the foraging ranges of marine mammals and birds including Adélie penguins (*Pygoscelis adeliae*) and emperor penguins (*Aptenodytes forsteri*).

Antarctic marine reserves offer a rare opportunity to conserve and study largely untouched natural areas, says Keith Reid, science manager for CCAMLR in Hobart and a former research scientist with the British Antarctic Survey. By contrast, “MPAs in many parts of the world are implemented usually in response to something that’s gone wrong”. And although MPA status does little to ward off the effects of climate change, it can help “ensure the other activities don’t exacerbate the impacts”, he says.

Antarctic marine parks are part of a larger international effort to protect 10% of the world’s oceans in MPAs. Gillian Slocum, who represents the Australian Antarctic Division at CCAMLR, is optimistic that the negotiating challenges can be overcome: “We’re hoping CCAMLR can keep building on the momentum of creating the Ross MPA.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22913

Comments

Comments

There are currently no comments.

China announces plans to fast-track drug approval

Policies are expected to speed up access to medicines and boost the country's pharmaceutical industry.

26 October 2017

Xue Jun/Xinhua via ZUMAPRESS

China is aiming to cut the amount of time people have to wait for new medicines.

China is overhauling its drug-approval system to let companies bring their treatments to market quicker and more easily. On 9 October, the Communist Party of China and the State Council, two of the country's most authoritative

bodies, announced plans to reduce the backlog of medicines awaiting approval by the China Food and Drug Administration (CFDA). Policies will also be introduced to boost the productivity of Chinese drugmakers and spur innovation in health care.

Details of the plans are only just starting to emerge, but industry observers expect them to be in place by the end of 2017. One proposal, released for public comment on 20 October, states that companies will be allowed to use data from clinical trials conducted in other countries when applying for drug approval in China. Currently, companies have to perform extra trials in China to test a drug's efficacy. Under the new guidelines, they will instead need to provide data that show that a drug works in all human populations.

The changes will significantly reduce the time Chinese people have to wait for new medicines, and will save multinational companies time and money, says Angela Yan, senior director of science and regulatory affairs at the R&D-based; Pharmaceutical Association Committee in Beijing, which represents the interests of foreign companies in China**.** A vaccine against the human papillomavirus, for example, was approved in China only in 2016, a decade after it was given the green light in the United States. More than 20 years of efforts to reduce delays are now paying off, says Yan. "This is very positive."

Unblocking the pipeline

The shake-up is the latest in a series of measures to accelerate China's drug-regulation process and make it more rigorous, in line with international standards. In the past two years, the government has dramatically increased the number of application inspectors at the CFDA to reduce the backlog of medicines awaiting approval. It has also threatened to jail manufacturers or researchers caught submitting fraudulent applications.

And in June, China became a member of the International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use, which requires a nation's drug-approval agency to adhere to international standards and guidelines.

As well as reducing the administrative burden of drug registration, the government is eager to expand its pharmaceutical industry, given that China is the world's second largest drug market. Between 2001 and 2016, China approved just over 100 new drugs, whereas developed countries approved 433.

Far-reaching policies

Su Ling, director of the Institute of Drug Regulatory Science at Shenyang Pharmaceutical University and a venture partner for the investment fund Lilly Asia Ventures in Shanghai, says the government will introduce a range of policies that will have broad effects on the industry. "Overall they are in the right direction to become more aligned with international norms and to promote new drug R&D; and access," says Su. "This is really important."

Another policy, announced by the CFDA on 10 October, will end the restriction that prohibits pharmaceutical companies from starting phase I safety trials for a drug in China until its safety has been proved in another country. The ban was designed to protect Chinese people from exploitation by drug companies during early experiments.

Yan says loosening the restriction could plug crucial holes in China's drug-development pipeline, which has lost capacity to translate research from animals to humans. "Now they can do global phase I trials and learn and improve their capabilities," she says.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22888

Comments

Comments

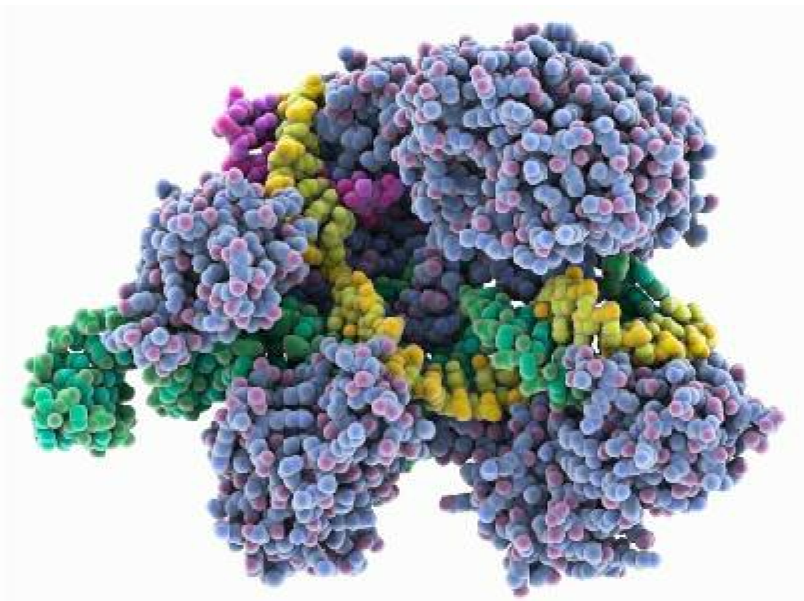
There are currently no comments.

| 章节菜单 | 主菜单 |

Bitter CRISPR patent war intensifies

Gene-editing pioneers prepare for next stage of intellectual-property disputes in the United States and Europe.

26 October 2017



Laguna Design/SPL

The CRISPR–Cas9 system acts as molecular scissors to precisely cut and edit genetic code.

The long-running battle over US patents for CRISPR–Cas9 gene editing continues. On 25 October, the Broad Institute of Cambridge, Massachusetts, filed a fresh set of arguments with the US government to defend a key patent.

That action helps to set the stage for a second round of oral arguments in the unusually vitriolic case, which observers expect to take place in early 2018.

A decision is anticipated to follow shortly thereafter.

In the filing, lawyers for the Broad and its collaborators argued that its opponent, a team that includes the University of California, Berkeley, has failed to provide new evidence that would undermine the legitimacy of the Broad's patent. The lawyers also used the University of California's own press releases as a sign that the case should be thrown out.

At stake are intellectual-property rights to the use of CRISPR–Cas9 gene-editing tools in eukaryotes, organisms such as plants and animals. This would include applications of the technique to treat human genetic diseases — an approach that has recently entered cancer clinical trials in China, and is potentially the most lucrative application of gene editing.

Although non-profit research institutes often reach settlements over such patent disputes, both sides in the CRISPR case have invested heavily in a prolonged patent fight, says Kevin Noonan, a partner at the law firm McDonnell Boehnen Hulbert & Berghoff in Chicago, Illinois. "They really went after each other so vigorously," he says. "You want to say, 'Hey, let's take a breath.'"

Novelty seeking

The fight began when the US patent office granted the Broad a patent covering the use of CRISPR–Cas9 in eukaryotic cells. The California team had filed its patent earlier, but the Broad opted for an expedited review that got its application granted first. The University of California then argued that the Broad's patent interfered with the granting of its own patent, and launched an official proceeding before a board of specialized patent judges.

Throughout that proceeding, the University of California team argued that its patent — which explicitly describes the use of CRISPR–Cas9 gene editing only in non-eukaryotes such as bacteria — rendered applications in eukaryotic cells "obvious" and therefore unpatentable. The Broad countered that the University of California's invention needed significant and non-obvious tweaks before it could be used in eukaryotes.

In February, the patent office sided with the Broad. The University of California team soon filed an appeal to the US Court of Appeals for the Federal Circuit, claiming that the patent board had made “fundamental errors of law” that would allow the Broad to unfairly claim rights to the most important and valuable applications of CRISPR–Cas9 gene editing.

Despite that argument, Noonan expects the court — which generally defers to the patent office — to uphold the patent board’s decision. “For Berkeley to prevail, the Federal Circuit is going to have to say, ‘Yeah, the board got it wrong,’” he says. “I think it’s unlikely that they’ll do that.”

Counter arguments

In the 25 October filing, lawyers for the Broad also pointed to press releases issued by the University of California in the wake of the patent board’s February decision. Those press releases argued that the University of California had come out ahead in the decision, because people who wanted to use CRISPR–Cas9 gene editing in any system — eukaryotic or not — would still need to license its patents. If so, the Broad argued, then the University of California was not harmed by the patent board’s decision and therefore lacks legal standing to appeal it.

Upholding that previous decision could spell trouble for the University of California, notes Jacob Sherkow, a legal scholar at New York Law School. The university’s patent would go back to the patent office for examination. But in May, the patent office issued another key CRISPR patent to Vilnius University in Lithuania. That application was filed earlier than the University of California’s, so patent law could dictate that it takes precedence. The California patent could be crowded out, Sherkow says: “This is a dramatic turn.”

The CRISPR patent landscape elsewhere is also uncertain. In Europe, the Broad has been granted ten patents but is in danger of losing as many as eight of them, notes Catherine Coombes, a patent attorney at intellectual-property specialists HGF in York, UK. In April, the European Patent Office issued a preliminary ruling that threw out the Broad’s earliest filing date for its first

patent, because the institute had later removed an inventor from the patent application.

If that decision — which will be discussed during oral arguments in mid-January — becomes final, it will push the Broad's patent date to a time after the institute's team published its findings in a scientific article[1]. And that would invalidate the patent application altogether.

Overall, there are more than 1,880 families of CRISPR patent, according to IPStudies, a consulting firm near Lausanne, Switzerland. More than 100 new families — each a group of related intellectual-property claims — are published each month.

With those numbers in mind, people looking to commercialize CRISPR–Cas9 gene editing will probably continue to face a daunting patent landscape, notes Coombes. "The situation is going to get a lot more complicated before it gets better."

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22892

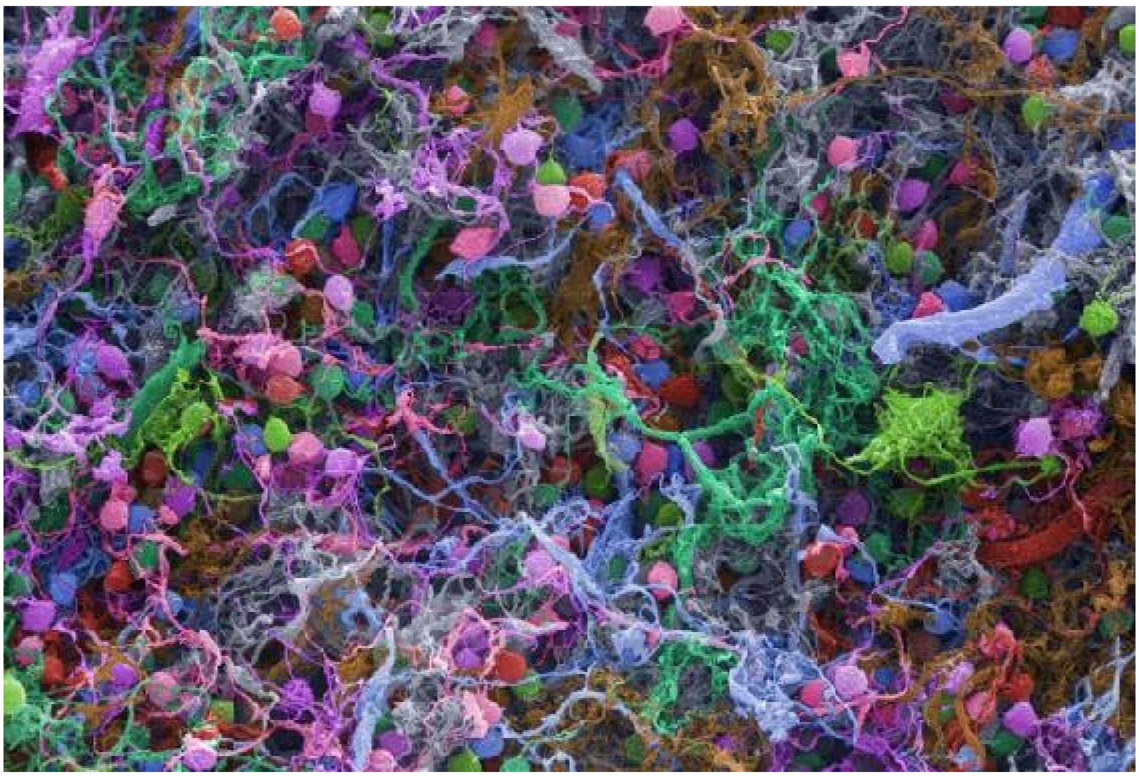
Comments

Commenting is currently unavailable.

First living human cells added to brain database

Measurements show how neurons behave in healthy living tissue.

25 October 2017



Ted Kinsman/SPL

Scanning electron micrograph of human brain cells.

Fresh human brain tissue is a vanishingly rare resource for neuroscientists. Now, data on small bits of live human brain tissue that normally get discarded during surgery are being added to a publicly available database that could help to unravel how cognition works. On 25 October, researchers at the

Allen Institute for Brain Science in Seattle, Washington, who compile neuroscience tools including large-scale databases and brain maps, announced that they had published their first data from living human brain cells.

Most human-brain studies use either images of functioning brains obtained by scanning volunteers or slices of dead organs from cadavers. The images and information now added to the database will let researchers analyse the molecular content of individual living cells, or neurons, and, ultimately, identify the biological basis of their behaviour. Until now, the database had contained information only about mouse brains.

Small studies using surgical human brain samples began very tentatively in the 1970s but the large amount of human data now published by the Allen Institute — the most extensive and systematic effort so far — has been welcomed as a major aid to identifying the uniqueness of the human brain.

Uniquely human

With their patients' consent, neurosurgeons in the Seattle region donated small pieces of brain that they would otherwise have discarded during surgery. The pieces are bits of the outer layer called the cerebral cortex that they needed to snip out to access diseased tissue deeper in the brain.

The cortex processes higher-level activities, including the deep introspection and abstract reasoning that is thought to be specifically human. "Finding out what the detailed differences are between the mouse and human brain will help us understand what makes us unique among species," says Christof Koch, president and chief scientific officer of the Allen Institute.

The first slew of human data includes the electrical properties of 300 different types of neuron from 36 people, along with 3D reconstructions of the spidery shapes of some of them, and computer models that simulate their electrical behaviour. It also includes gene-expression profiles of 16,000 individual cells from the brains of another 3 people. Scientists around the world may now compare these data with those from mice to generate hypotheses about where

key differences lie.

“This database is a major service to the scientific community,” says Huib Mansvelder, a neuroscientist at the Free University of Amsterdam and an early pioneer of research on fresh human brain cells. He and his colleagues have shown[1], for example, that human neurons have a lower capacitance than mouse neurons, which makes them quicker to start firing and quicker to transfer information. They also have more intricate shapes. “But the Allen’s industrial approach takes the endeavour to a whole new level,” he says.

Living tissue

The lumps of donated tissue are each about the size of a sugar lump — typically the same volume as an entire mouse brain. Cut into slices 300–350 micrometres thick, the cells remain alive and active for three days, giving scientists ample time to take measurements. Mouse neurons, by contrast, tend to degenerate within hours.

Only a few research centres worldwide study fresh human brain tissue, partly because until recently few brain surgeons had been inspired to work with it. But rapid developments in biological research tools have increased the scientific rewards for doing so.

The Allen Institute now plans to increase the number of human brain cells in its database and the amount of information available from each of them. It aims eventually to include full RNA profiles to indicate which genes are active in the tissue. The next phase will also analyse the connections between the cells. However, the work cannot be as comprehensive as studies of mouse brains, because only small pieces of living human brains can be removed, whereas the whole brains of mice can be examined.

Cell integrity

There is another concern about the human tissue. Although apparently healthy, the cells come from surgery to remove tumours or treat severe

epilepsy, which provokes concerns that their properties might have been altered by their pathological environment. However, Mansvelder has compared cortical tissue from people with cancer with that from people with epilepsy, and found them to be very similar. The Allen Institute has confirmed these results.

There is another advantage to using human cortical tissue. Neurosurgical teams collect vast information about the brain functions of their patients before and after operations. With appropriate anonymization, this can be correlated with cellular properties. At a meeting of the Federation of European Neuroscience Societies in Pécs, Hungary, on 20–23 September, Mansvelder presented data showing that IQ correlates with the threshold of firing of cells — the higher the IQ, the lower the threshold.

Mansvelder, along with fellow neuroscience pioneer Gábor Tamás of the University of Szeged in Hungary and groups from Israel and Sweden, will collaborate with the Allen Institute to develop the human-brain database further, thanks to a US$19.4-million grant from the US National Institutes of Health, announced on 23 October.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22889

Comments

Comments

There are currently no comments.

Many junior scientists need to take a hard look at their job prospects

Permanent jobs in academia are scarce, and someone needs to let PhD students know.

25 October 2017

David Williams/Corbis/Getty

Most PhD students will have to look beyond academia for a career.

For his 2012 PhD thesis, the sociologist Chris Platts surveyed and interviewed more than 300 young footballers — aged 17 and 18 — at UK club academies who were hoping to pursue a career in the game. He told the newspaper *The Guardian* this month that just four of them currently have

gained a professional contract. That’s a drop-out rate of 99%.

For our Careers section this week, *Nature* surveyed more than 5,700 early-career scientists worldwide who are working on PhDs. Three-quarters of them, they told us, think it’s likely that they will pursue an academic career when they graduate, just like Platts — now a senior lecturer in sport development and sport business management at Sheffield Hallam University, UK. How many will succeed?

Statistics say these young researchers will have a better chance of pursuing their chosen job than the young footballers. But not by much. Global figures are hard to come by, but only three or four in every hundred PhD students in the United Kingdom will land a permanent staff position at a university. It’s only a little better in the United States.

Simply put, most PhD students need to make plans for a life outside academic science. And more universities and PhD supervisors must make this clear.

That might sound like an alarmist and negative attitude for the International Weekly Journal of Science. But it has been evident for years that international science is training many more PhD students than the academic system can support. Most of the keen and talented young scientists who responded to our survey will probably never get a foot in the door. Of those who do, a sizeable number are likely to drift from short-term contract to short-term contract until they become disillusioned and look elsewhere.

As *Nature* has said before, it is good for PhD students and postdocs to pursue careers outside academia. Many will find similar challenges and rewards in industry. And it is surely of benefit to science and society at large that a sizeable number of well-educated and well-trained scientists spread to other sectors, and take with them healthy scepticism and respect for evidence. It is certainly better for young scientists to take a realistic view early in their career path, when they still have time to adjust their ambitions. So why do people in science still see this reality as a dirty secret?

Our survey, for example, shows that one-third of respondents do not have useful conversations about careers with their PhD supervisors. And non-

academic jobs are low on the agenda when future options are discussed. Almost one-third of the students disagreed or strongly disagreed with the statement that their supervisor has useful advice for non-academic careers. That's about the same as was reported in *Nature*'s previous PhD survey, in 2015. If you supervise a PhD student or know someone who does, then please help to shrink that number by the time the next survey goes out, in 2019. Supervisors are busy people but they are often the face of the university and the academic system for students, and so the most obvious place to seek guidance. At the very least, they should be willing to point students towards the university careers service, which should also focus more on options outside academia. It's not just undergraduates who benefit from a variety of possibilities. Indeed, postgraduates arguably need more attention and advice because so many people — including themselves — believe that they are now on a path to a professorship.

Another major point worth making from the 2017 survey is about mental health. More than one-quarter of the students who responded listed mental health as an area of concern, and 45% of those said they had sought help for anxiety or depression caused by their PhD. One-third of those got useful help from their institution (which of course means that two-thirds did not). Still, just 5% said no help was available there or elsewhere, which, given the general difficulty in accessing mental-health support in many countries, suggests that young people in the education system are perhaps better served than many outside it.

If the outlook for junior scientists in academia is mixed, then, luckily for science, most don't seem to let it put them off. Indeed, it's striking to note that nearly eight in ten of the young scientists surveyed said they were satisfied with their decision to start a PhD. That reflects well on the excellent opportunities, facilities and supervision that many receive. Just like the footballers, some will succeed, and they will find a career in academic science to be as thrilling, rewarding and satisfying as they hope. But someone needs to tell the rest what happens next.

Journal name:
Nature
Volume:

550,
Pages:
429
Date published:
(26 October 2017)
DOI:
doi:10.1038/550429a

Comments

Commenting is currently unavailable.

| 章节菜单 | 主菜单 |

Data science can improve aid distribution

Online platforms can help to steer emergency response and ensure money is well spent.

25 October 2017

Delil Souleiman/AFP/Getty

Better data tools could help coordinate aid and relief efforts.

Over the past decade, non-profit organizations have sent millions of small stoves to families in the developing world. These appliances are intended to stop people from cooking over open flames indoors — an activity linked to four million deaths per year, attributable to household air pollution.

But economists and public-health researchers have published studies that question the benefits of this effort. One randomized controlled trial (RCT), reported in 2012 and involving 15,000 households in rural India, found no evidence of improved lung function in women in the first four years after they received a stove (see go.nature.com/2zjgwny).

The RCT suggests that these efforts might be revised. But as useful as RCTs are in development economics and global health, they have limits. Findings in one place might be wildly different in another. And in a crisis, first responders are typically too busy trying to provide shelter, health care and bare necessities to design and carry out a controlled set-up.

But humanitarian groups can still improve their efforts in the short and long term through evidence obtained with new technology. A *Nature* News Feature this week highlights software called the Dharma Platform, which enables workers on the front line of hurricanes, outbreaks or other crises to record, share and analyse useful data — for example, the spread of disease in rural villages. Dharma is being tested by Médecins Sans Frontières (or Doctors Without Borders), the World Health Organization and other groups combating crises in the Middle East. And it is just one of many new technologies that will make data faster to collect and easier to exchange.

The rush to provide food, shelter and health care can be as chaotic as the disaster itself. Hundreds of millions of dollars flood into the world's largest agencies and non-governmental organizations, which often sub-contract delivery to dozens of smaller groups. In such a system, the best source of data is a person on the ground — often someone low in an organization's chain of command. It's this aid worker who listens as a mother describes how she's received four sacks of rice, yet her babies have nothing to eat. This essential feedback is typically recorded on paper. If it makes it into a report, weeks or months will pass by the time it gets to headquarters, where managers then adjust the system.

Platforms such as Dharma that collate real-time data could quicken this response time by informing groups of what people need, and help to reassure donors that their money is being spent wisely. After an acute crisis, researchers can use data collected in the heat of the moment to answer big-picture questions. For example, how might assistance better prevent tragedies

that follow disasters, such as the cholera epidemic in the wake of Haiti's 2010 earthquake, or blindness in survivors of Ebola? As long as data collection is organized, consistent and secure, researchers distanced from those delivering aid can evaluate projects objectively.

Requesting more data and analysing them coldly will make failures more evident. In turn, philanthropists, taxpayers and governments that donate money should evaluate each inefficiency sensibly, and not be unforgiving. For example, a tiny fraction of donated insecticide-treated bednets may be used as fishing nets — but that fact should not negate an intervention that has been shown to reduce cases of malaria caused by *Plasmodium falciparum* by up to 62% (C. Lengeler *Cochrane Database Syst. Rev.* http://doi.org/c4f9c7; 2004). Failures at all scales must be upheld as lessons in the continuing struggle to do what's right — and not as arguments to abandon aid completely.

Journal name:
Nature
Volume:
550,
Pages:
430
Date published:
(26 October 2017)
DOI:
doi:10.1038/550430a

Comments

Comments

There are currently no comments.

A death sentence, Hawking's thesis and China's ambitions

The week in science: 20–26 October 2017.

25 October 2017

Events | Facilities | Politics | Space | Research | Business | Energy | Trend watch

EVENTS

Death sentence for Iranian scientist A judge in Tehran sentenced to death an Iranian researcher accused of “collaboration with a hostile government” on 21 October, according to the researcher’s wife and diplomatic sources in Italy. Ahmadreza Djalali, a disaster-medicine researcher who is affiliated with institutions in Sweden and Italy, was arrested in April 2016 while on an academic visit to Tehran and convicted of espionage following a trial in Iran’s revolutionary court. Close contacts of Djalali’s say he believes that he was arrested for refusing to spy for the Iranian intelligence service and was forced to make false confessions. They say Djalali has 20 days to appeal against the sentence.

Dirk Waem/AFP/Getty

A flyer photographed during a protest outside the Iranian embassy in Brussels for Ahmadreza Djalali.

Hawking's thesis The PhD thesis of physicist Stephen Hawking has been made freely available online for the first time. The University of Cambridge, UK, where Hawking completed his PhD in 1966, posted the work on 23 October to mark Open Access Week 2017. The physicist was 24 years old when he wrote up his thesis, entitled 'Properties of expanding universes'. Demand to view the document temporarily crashed Apollo, the open-access repository on which it was posted. Hawking said that he hoped to inspire people by making his work available.

FACILITIES

Hungary university The US-registered Central European University (CEU) in Budapest faces another year of uncertainty over whether it can continue to

operate in Hungary. In April, the Hungarian government amended its higher-education law to require that all foreign-accredited universities there had to operate as higher-education institutes in their countries of origin. The CEU took steps to comply with the law, but on 17 October the country's parliament voted to delay a decision that would allow the CEU to keep operating. See 'Efforts to save leading Hungarian university hit hurdle' for more.

POLITICS

Travel ban blocked Two federal judges temporarily blocked much of US President Donald Trump's latest iteration of a travel ban that affects eight countries — most of which are Muslim-majority nations — citing unconstitutional religious discrimination. The decisions, announced on 17 and 18 October, allow visa processing to resume as usual for all countries named in the ban, with the exception of Venezuela and North Korea. Eighty-four scientific societies and a university submitted a letter on 17 October contesting the most recent version of the ban, which Trump introduced in late September. The letter says that the ban weakens US science, and cites "serious implications for diplomatic, humanitarian, and national security interests" as motivation for the organizations' disapproval.

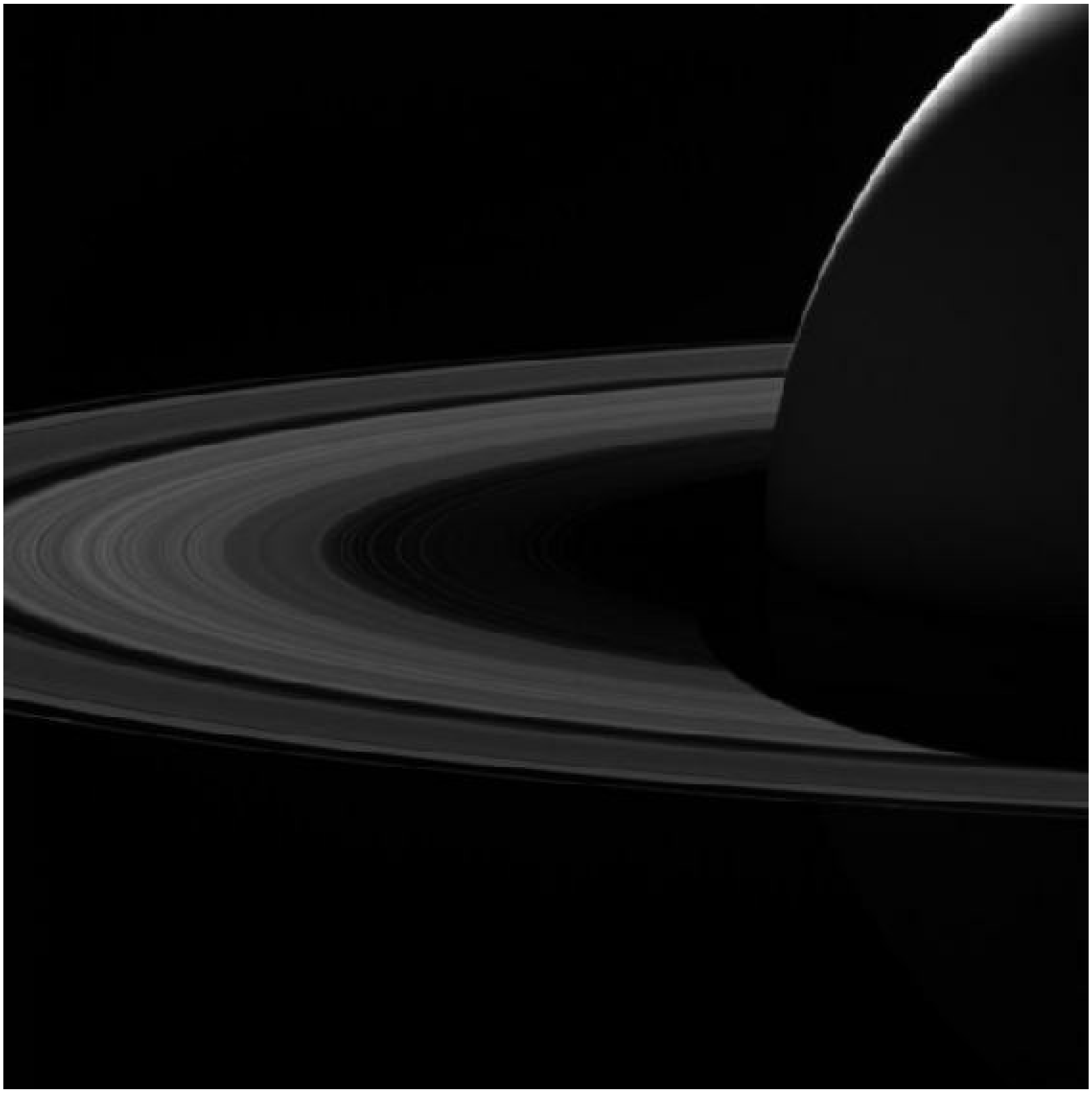
New Zealand leader Jacinda Ardern, New Zealand's newly elected prime minister, has promised to prioritize a number of science-related issues, including climate change and the environment. After a close-run election in which no party won an outright majority, it was announced on 19 October that Ardern would lead a coalition government made up of her own Labour Party and the New Zealand First party. During campaigning, both parties committed to boosting science funding, with New Zealand First saying it would increase investment in research and development (R&D;) to 2% of gross domestic product. The current figure is around 1.2%. The Labour Party plans to introduce tax breaks for companies that invest in R&D;, and to establish an independent climate commission to advise the government on reducing carbon emissions.

Chinese science China will become "a nation of innovators", according to a

speech by the country's president Xi Jinping on 18 October. Xi laid out the vision as he opened the 19th National Congress of the Chinese Communist Party, an event held every 5 years at which the party shuffles its leadership. It was also a chance for Xi to consolidate his power after five years of heading the party. His support for science and technological innovation, which he says is necessary to build the industrial system needed for "socialism with Chinese characteristics", has been welcomed by scientists. Xi also boasted of China's success on environmental issues, and promised to put the country at the forefront of global efforts to combat climate change.

SPACE

Saturn surprise New data from NASA's Cassini probe suggest that Saturn's majestic rings are showering tiny dust particles into the planet's upper atmosphere, where they form a complicated and unexpected chemical mix. The findings were presented on 17 October at a meeting of the American Astronomical Society's Division for Planetary Sciences in Provo, Utah. A mass spectrometer aboard Cassini detected the strange chemistry during the probe's final five months, as it looped between Saturn and its rings. Cassini's mission ended in September, when it burnt up on a controlled dive into Saturn.



NASA/JPL-Caltech/SSI

Telescope cut-back NASA will assess what it can strip off from the planned Wide Field Infrared Survey Telescope (WFIRST), its next major astrophysics mission for the 2020s, to keep the mission's cost below US$3.2 billion. On 19 October, following input from an independent panel of experts, NASA science chief Thomas Zurbuchen directed the agency to consider downsizing the capabilities of WFIRST's coronagraph, an instrument that studies exoplanets, and its wide-field camera. Even with these reductions, NASA says, WFIRST will still enable cutting-edge research into dark energy, exoplanets and other areas of astrophysics. The mission was the top priority

in the most recent US astrophysics decadal survey, but its cost has been creeping up. WFIRST’s current price tag is $3.6 billion.

Euclid delay Officials overseeing the European Space Agency’s (ESA’s) Euclid space telescope will assess whether they need to delay its scheduled 2020 launch because of a problem with infrared detectors developed by NASA. The detectors’ electronics have been failing during tests at cold temperatures, NASA astrophysics head Paul Hertz told an advisory panel on 18 October. Fixing the problem could take 12–18 months. NASA is providing 16 detectors for Euclid, which will study dark energy and dark matter. ESA is trying to minimize the impact of the NASA delay by reshuffling its schedule for integrating parts into the telescope.

RESEARCH

Nuclear-decay hunt On 23 October, physicists in Italy inaugurated a search for a type of nuclear decay that could explain why the Universe seems to contain almost no antimatter. The Cryogenic Underground Observatory for Rare Events (CUORE) at the Gran Sasso underground laboratories in the Apennine Mountains is one of several experiments worldwide that are looking for neutrinoless double-beta decay, a hypothetical reaction that would reveal whether neutrinos are their own antiparticles. In early cosmic history, this reaction could have led to matter becoming prevalent over antimatter. CUORE looks for the reaction in 760 kilograms of tellurium dioxide crystals kept at 10 millikelvin and shielded in part with lead recovered from a Roman shipwreck.

BUSINESS

CRISPR patents Key US patents on a gene-editing tool called CRISPR–Cas9 can be bundled together and licensed for agricultural applications, thanks to an 18 October agreement. The patents are held by the Broad Institute of MIT and Harvard in Cambridge, Massachusetts, and DuPont Pioneer, an agricultural biotechnology company in Johnston, Iowa, which had licensed the patents from the University of California, Berkeley, and

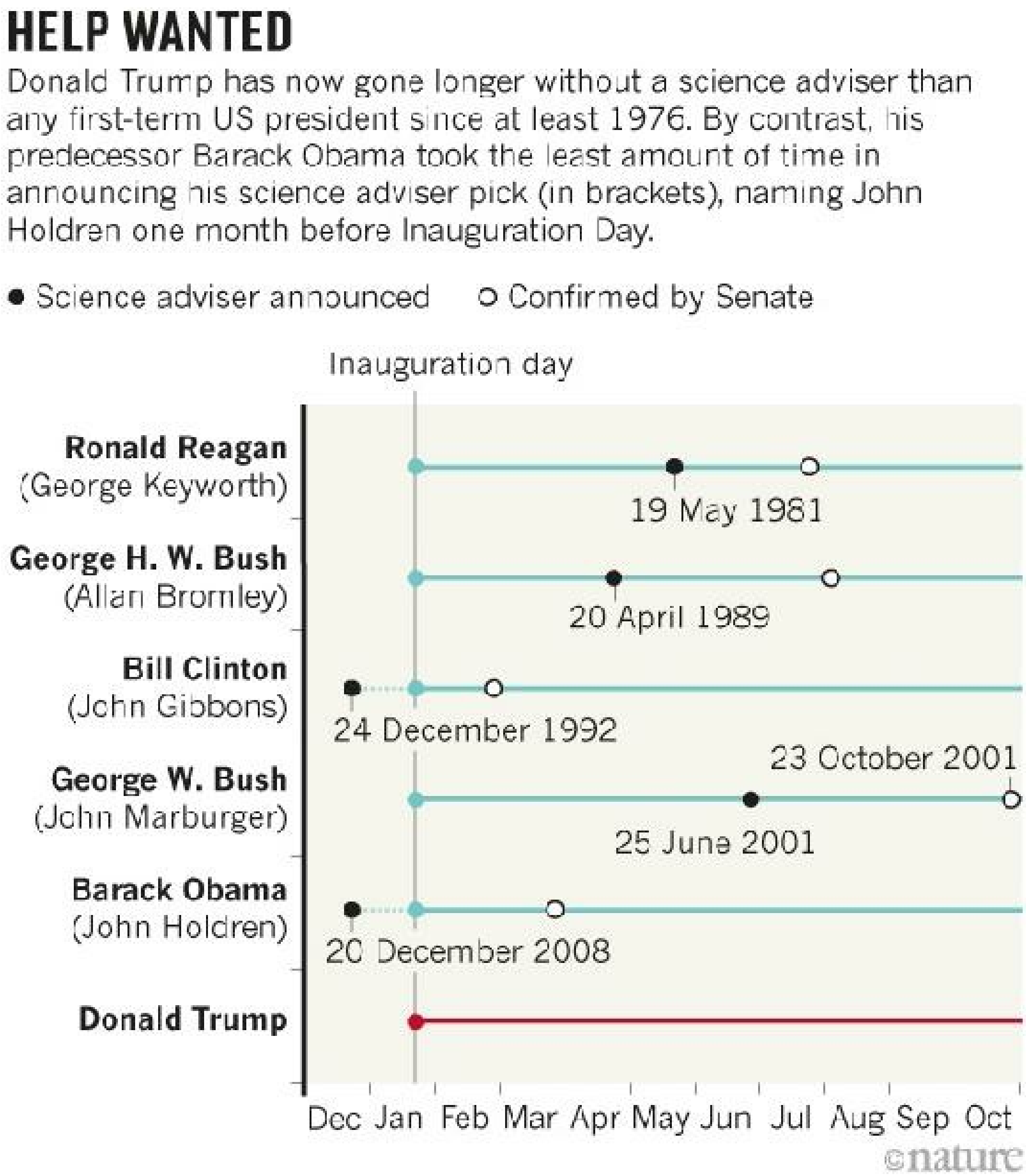
other institutions. Although the Berkeley team is embroiled in a fight with the Broad Institute over CRISPR–Cas9 patents, the new agreement will allow companies to obtain a non-exclusive licence for the patents from the Broad and DuPont. The CRISPR–Cas9 intellectual property will be free for universities and non-profit organizations.

ENERGY

Korean reactors South Korea will resume building two nuclear power plants following the recommendation of a citizens' jury. Although President Moon Jae-in had pledged to cancel construction of the plants when he was elected earlier this year, he agreed to a three-month public debate after his party took power. On 20 October, the government announced that it would accept the jury's decision. Composed of 471 citizens, the jury also recommended that nuclear power eventually be phased out. Moon, who has shut down one old reactor, vowed to continue to pivot the nation towards renewable energy and natural gas. An earthquake last year in the country's southern region has raised fears of possible damage to its nuclear reactors.

TREND WATCH

Donald Trump has now gone longer without a science adviser in place than any first-term US president since at least 1976. On 23 October, Trump broke the record set by former president George W. Bush, whose science adviser was confirmed by the Senate on 23 October 2001 — 276 days after Bush took office, and 120 days after he announced his pick. Trump has yet to name an adviser. By contrast, Barack Obama took the least time of any first-term president in naming his science adviser.



Journal name:
Nature
Volume:
550,
Pages:
434–435
Date published:
(26 October 2017)

DOI:
doi:10.1038/550434a

Comments

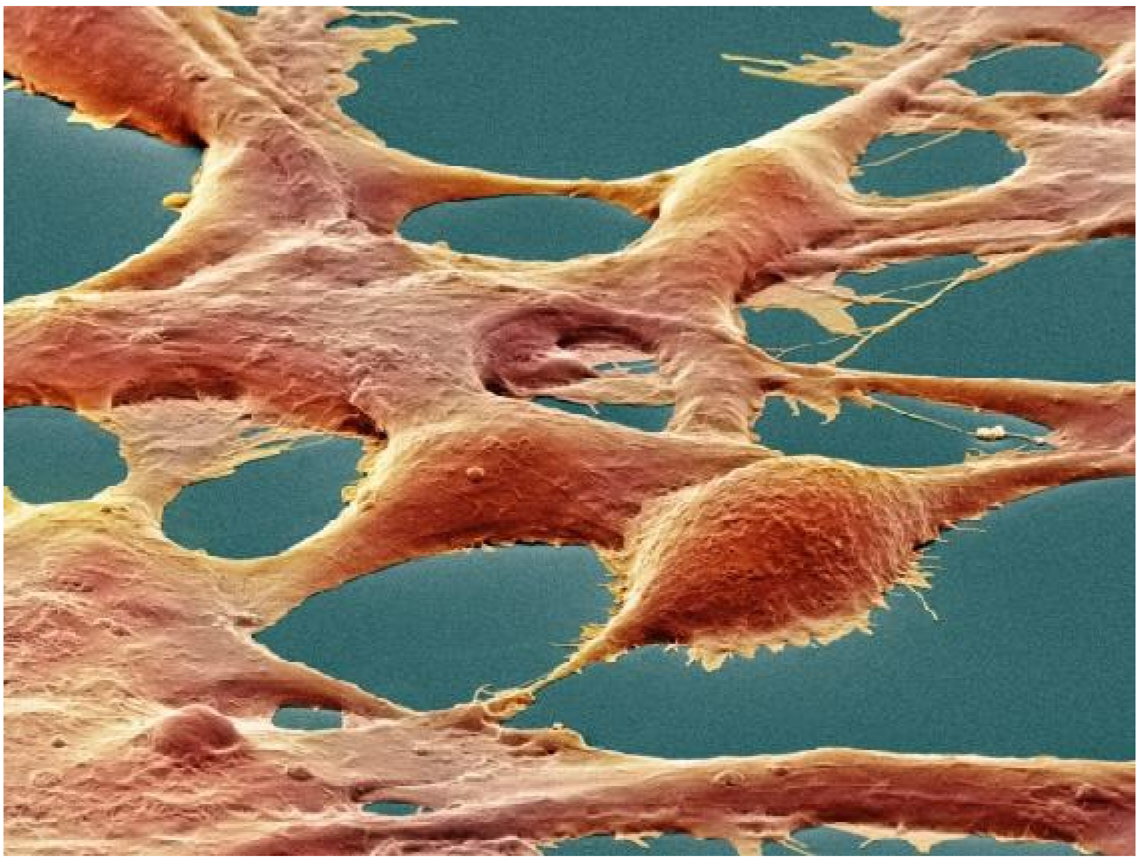
Comments

There are currently no comments.

CRISPR hacks enable pinpoint repairs to genome

Precision tools expand the number of ‘base editors’ available for manipulating DNA and RNA.

25 October 2017



David McCarthy/SPL

Using human embryonic kidney cells, researchers have come up with a way to edit specific letters in the genome.

The toolbox for editing genes expanded this week, as two research groups

announced techniques that enable researchers to make targeted alterations to DNA and RNA. Unlike the original CRISPR gene-editing system — a relatively unpredictable and blunt form of molecular scissors that cut sizeable sections of DNA — the new systems rewrite individual letters, or genetic bases. The ability to alter single bases means that researchers can now attempt to correct more than half of all human genetic diseases[1, 2].

The tools, developed by separate teams at the Broad Institute of MIT and Harvard in Cambridge, Massachusetts, are adaptations of the CRISPR system. Whereas most past attempts to use CRISPR-based methods to fix individual bases have been crude affairs — akin to using a machete to remove a wart — the new techniques are more like "precision chemical surgery", says David Liu, a chemical biologist at the Broad Institute who led one of the studies.

Last year, his group reported[3] the first 'base editing' method for converting one target DNA letter into another without needing to cleave the genome's double helix. It has since been used around the world to correct genes in fungi, plants, fish and mice, and even in human embryos harbouring a defective gene that can cause a blood disorder. But that base editor could achieve only two kinds of chemical conversions: a cytosine (C) into a thymine (T) or a guanine (G) into an adenine (A).

The new base editor — described in a paper published on 25 October in *Nature*[1] — works in the other direction, converting T to C or A to G. It can therefore undo the most common types of 'point mutation', which involve single aberrant bases.

In human embryonic kidney cells and bone-cancer cells, the technique made the desired corrections with about 50% efficiency and almost no detectable by-products. By comparison, a more conventional CRISPR-based method, in which scientists insert a strand of DNA containing the desired base change, fixed the same single-base differences with less than 5% efficiency and often caused undesired insertions or deletions of large chunks of DNA.

"This is a major breakthrough in the field of genome editing," says Jin-Soo Kim, a molecular geneticist at Seoul National University.

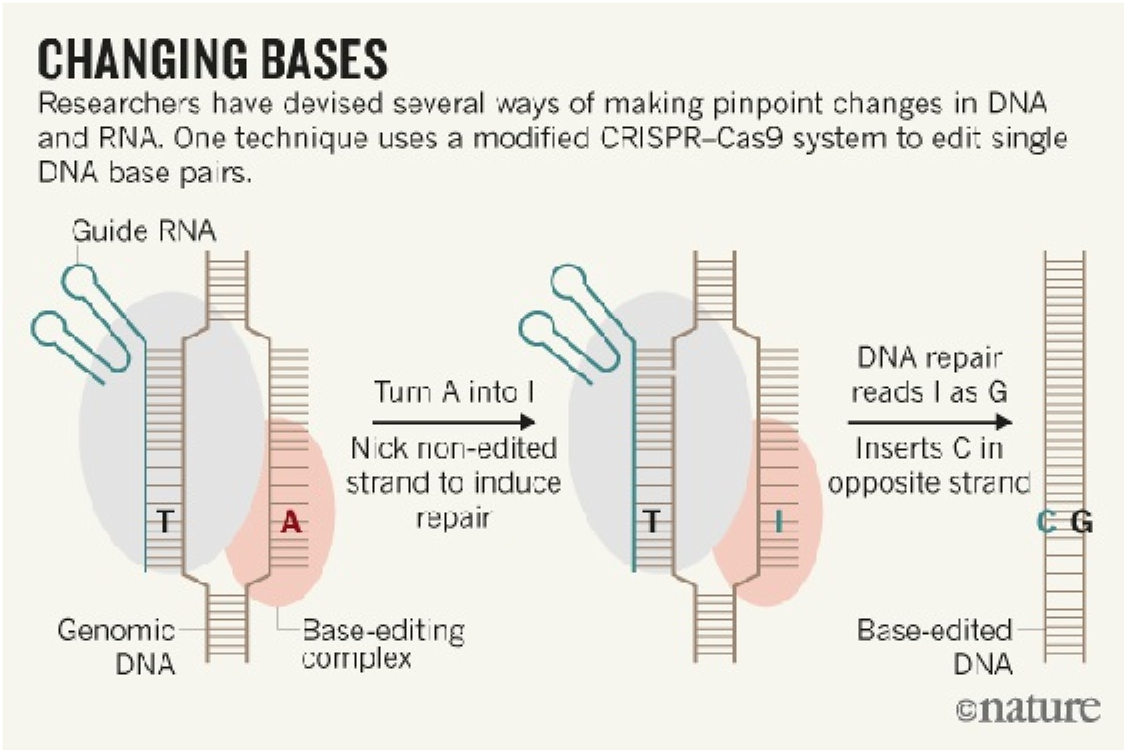
Tricks of the trade

Another method, described in a study published on 25 October in *Science*[2] and led by Broad Institute bioengineer Feng Zhang, performs a similar conversion, but for RNA instead of DNA. It turns an A into inosine (I), which is read as a G by the cell's protein-building machinery. This allows for a temporary correction of a disease-causing mutation without permanent alteration to the genome — a potentially safer option when it comes to gene-fixing therapeutics, although the treatment would need to be administered repeatedly. It would also mean that researchers could alter a treatment as they gain a better understanding of the disease. "If you use RNA therapy," Zhang says, "you can upgrade."

His team's RNA editor is based on a naturally occurring enzyme that rearranges the atoms in A to resemble I instead. The researchers fused the enzyme to a disabled version of the CRISPR system — one involving an RNA-targeted enzyme called Cas13, instead of the usual DNA-binding Cas9. With the help of a sequence-specific guide RNA molecule, they successfully corrected disease-causing mutations 23–35% of the time, with low incidences of off-target activity.

In the base-editing method pioneered by Liu's team last year, the researchers engineered a naturally occurring enzyme and tethered it to a dud Cas9, which allowed them to convert C to T. But there is no equivalent enzyme found in nature for the opposite conversion in DNA. So the researchers started with an RNA-editing enzyme similar to the one Zhang's group used.

The team guided the evolution of bacterial cells through seven generations, and used some protein engineering in the lab, to produce an enzyme that would recognize and manipulate DNA. The enzyme was able to rearrange atoms in adenine to change it into an inosine, which the cell reads as a guanine. The system then tricked the cell into inserting a cytosine into the unmodified DNA strand (see 'Changing bases').



SOURCE: REF. 1

Gutsy move

“It represents a heroic effort,” says Dana Carroll, a genome-engineering researcher at the University of Utah in Salt Lake City, noting that the directed-evolution approach was something of a shot in the dark. “I wouldn’t have had the guts to try what they did,” Carroll says. “My hat’s off to David Liu.”

The ability to make four types of single-base conversion — A to G, G to A, C to T and T to C — “will be extremely valuable for precise therapeutic and agronomic editing”, says Caixia Gao, a plant geneticist at the Chinese Academy of Sciences’ Institute of Genetics and Developmental Biology in Beijing.

It could also prove useful in drug discovery and for DNA-based data storage, says Marcello Maresca, a gene-editing researcher at AstraZeneca in

Gothenburg, Sweden.

The development of any other base editors will require enzymes that do not occur in nature, even for conversions in RNA. But that kind of obstacle has not stopped Liu before. “We’ll keep trying until the community has developed all possible base editors,” he says.

Journal name:
Nature
Volume:
550,
Pages:
439–440
Date published:
(26 October 2017)
DOI:
doi:10.1038/550439a

Comments

Comments

There are currently no comments.

Out of the Syrian crisis, a data revolution takes shape

Aid organizations have been piloting a nimble approach to cut through the fog of war.

25 October 2017

Neil Brandvold for Nature

A doctor and technicians record health data on a Syrian refugee in Jordan.

Shadows shroud Issam Salim's face as he recounts the operations he's performed. Yesterday, he tended to fractures, mangled limbs and intestinal injuries caused by an explosion from an unknown source. “The situation was very tense,” he says. Today, there have been no war-wounded patients, so he

saw people with bladder stones and hernias instead. Salim is deputy director of a hospital in southern Syria, and he's talking to an Iraqi surgeon, Ghassan Aziz, through a flickering Skype video call.

Aziz is not far away — just two hours south by car, in Jordan's capital, Amman. It is from here that the organization Aziz works for, Médecins Sans Frontières (MSF), has been providing medical aid to clinics in southern Syria during a conflict that has become one of the world's worst ongoing humanitarian crises. But Aziz and his colleagues dare not get much closer. After 13 MSF staff members were kidnapped in January 2014, the organization, also known as Doctors without Borders, pulled its international staff out of the country.

Text messages and calls such as the one with Salim provide a glimpse of what is going on, but it is hardly enough to let MSF staff predict what Syrian doctors and nurses will need most to help their communities. An increase in severe burns might mean that C-4 plastic explosives are in heavy rotation, for example, and therefore medics will require extra antibiotics, intravenous lines and surgical equipment, because they won't have time to sterilize between operations. Or an increase in kidney failures could mean that people with diabetes have lost access to regular care. But the fog of war makes tracking such trends next to impossible.

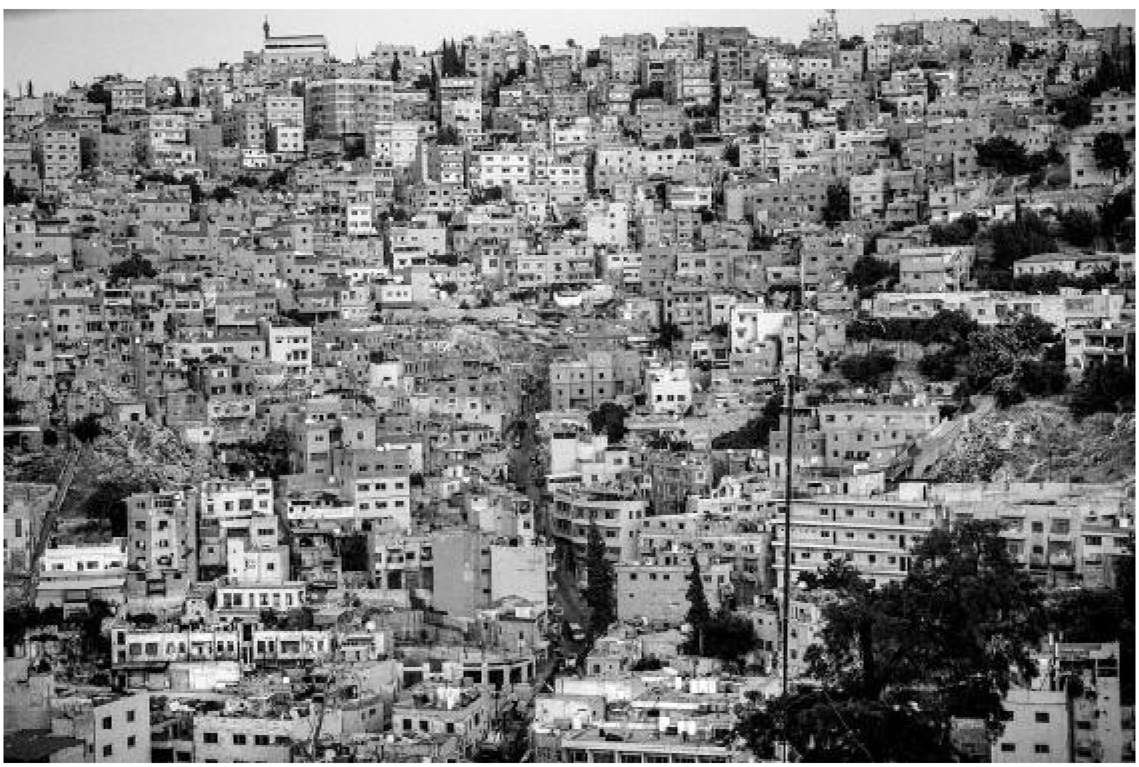
Whenever war, hurricanes or other disasters ravage part of the globe, one of the biggest problems for aid organizations is a lack of reliable data. People die because front-line responders don't have the information they need to act efficiently. Doctors and epidemiologists plod along with paper surveys and rigid databases in crisis situations, watching with envy as tech companies expertly mine big data for comparatively mundane purposes.

Three years ago, one frustrated first-responder decided to do something about it. The result is an innovative piece of software called the Dharma Platform, which almost anyone can use to rapidly collect information and share, analyse and visualize it so that they can act quickly. And although public-health veterans tend to be sceptical of technological fixes, Dharma is winning fans. MSF and other organizations now use it in 22 countries. And so far, the Rise Fund, a 'global impact fund' whose board boasts U2 lead singer Bono, has invested US$14.3 million in the company behind it.

“I think Dharma is special because it has been developed by people who have worked in these chaotic situations,” says Jeremy Farrar, director of biomedical-funding charity the Wellcome Trust in London, “and it's been road-tested and improved in the midst of reality.”

Now, the ultimate trial is in Syria: Salim, whose name has been changed in this story to protect him, started entering patient records into the Dharma Platform in March, and he is looking at health trends even as he shares his data securely with MSF staff in Amman.

It's too soon to say that Dharma has transformed his hospital. And some aid organizations and governments may be reluctant to adopt it. But Aziz, who has deployed Dharma in Iraq, Syria, Jordan and Turkey, is confident that it will usher in a wave of platforms that accelerate evidence-based responses in emergencies, or even in health care generally. “This is like the first version of the iPhone or Yahoo! Messenger,” he says. “Maybe something better will come along, but this is the direction we're going in.”



Neil Brandvold for Nature

Overlooking Amman, where Médecins Sans Frontières remotely supports clinics in southern Syria.

Born of frustration

Jesse Berns dreamt up Dharma after years of first-hand experience with the injured and ill, first as a helicopter paramedic, and then as a field epidemiologist embedded in some of the world's worst disaster zones. “I've worked in pretty much every conflict since 2006,” she says. She became disheartened by the inability to base decisions on data. In 2013, for example, she was surveying the health condition of refugees at the Iraq–Syria border with the World Health Organization. She entered her own hand-written data into an Excel spreadsheet, merged the information with other data, analysed it and generated a report. But the process took five months, and at that point, the results were too old to act on.

In 2015, she worked with MSF during the Ebola crisis in West Africa as the group tried to find a way to track and transmit data on the vital signs of dying patients without a Wi-Fi connection. Berns watched as incredible sums of money were spent. But the outbreak was over before a solution materialized.

She felt broken. “I got burned out after seeing colossal wastes of money and time,” she says. “I'd come home and have Uber and Slack, but in the field I had paper and Excel and it was just the ultimate shitshow for data.”

Berns complained to her friend Michael Roytman, a data scientist working in Chicago, Illinois, and California's Silicon Valley. Roytman suggested that the two join forces and create software to allow an emergency responder to fill the gap in a flash, without having to ask Excel experts, information-technology departments or consultants for help. The platform also had to work offline, store data securely in the cloud and be able to pass information through Bluetooth connections in case bombs, power failures or computer viruses interrupted service. So the pair started a company based in Washington DC to build what was needed in the field.

When they are asked to describe Dharma, Berns and Roytman struggle

because there aren't yet many things like it. “It's not a database,” says Roytman. “It's a platform or framework that lets people with no technical background create the tool they need.”

An early iteration of Dharma caught the attention of Pablo Marco, the head of MSF's Middle East operations, based in Amman, in 2015. His team had been struggling with the complexities of health in the region, which presented challenges MSF was unaccustomed to. For refugees in Africa, he says, the approach is generally straightforward because needs are fairly uniform: provide clean water, food, shelter, antibiotics and vaccines. “We have a checklist,” Marco says, “so we can act fast, fast, fast,” But refugees from Iraq and Syria have a range of different requirements. They might be managing depression, hypertension or diabetes instead of malnutrition. And their needs are in flux as they move and lose assets, and as access to medicine comes and goes.

Marco wanted to see whether new technology could provide faster feedback. So he asked Berns to meet Aziz, who was preparing to survey some 200,000 Iraqis who had fled south from the Islamist terrorist group ISIS in Mosul. Having completed his medical residency in Baghdad amid sectarian violence in 2007, Aziz understood the depth of the challenge before him. Acute traumas would be obvious, but not festering chronic maladies. He readied himself for the undertaking: “You need to train a large number of people to go out to households and fill out paper forms. Then it takes tonnes of time to transfer those forms into Excel, then transfer the data to an analyst and three months go by before they send back findings.”

Aziz, a programme manager at MSF's Center for the Advancement of Humanitarian Medicine in Amman, resembles a Silicon Valley techie with his backpack and worn T-shirt, but he has no computer-science background. Sceptical, but willing to give Dharma a try, he downloaded it onto a tablet and built a form with 145 questions. The survey was designed to move fast, asking only questions made relevant by previous responses. Each person would answer a total of about 25. Women of child-bearing age, for example, were asked whether they were pregnant, and children were asked if they had had diarrhoea or asthma attacks in the past two weeks. Iraqi medical students asking the questions sped through the surveys.

By day 5, the students had collected information from 6,455 people. Then Aziz did something he never could have done before. He merged the information from their devices onto his own and he began to interrogate the data, simply by typing in questions: for example, who identifies as head of household (husband, wife, son-in-law, and so on), and what are the chronic illnesses among these household heads? The answers came back instantly, in graph form.

“Even though I had been up since 5 a.m. that day, I stayed awake until 4 a.m. since it was so interesting,” he says. In one view, a pie chart revealed that people of various ages and backgrounds were complaining of skin irritation. Within minutes, it was obvious that the burrowing mites that cause scabies had infested mosques, motels and flats in which refugees were living. Aziz shared the data with MSF and in less than six weeks the organization was treating people with scabies and their contacts, and spraying shelters to eradicate the pests. A follow-up survey showed that the rate of scabies had dropped from 72% to 23%. Without Dharma, Aziz says, it would have taken several months to realize that something so easily fixed needed attention.

He was sold, and went on to use Dharma to survey refugee health in Turkey and Syria. All the while, he kept in touch with Berns, who tweaked the product in response to feedback. The same evolution occurred as the World Health Organization applied Dharma in Iraq, and as the Paris-based aid agency Médecins du Monde piloted it in Lebanon to assess the mental health of Syrian refugees. Preliminary data from that test suggest that refugee women with children have a lower incidence of suicidal thoughts than those without. Now the group is exploring the connection in a larger survey.

As Dharma's use has spread, public-health experts have taken notice. In April, Farrar told Larry Brilliant to check it out. Brilliant is an epidemiologist and former Google executive who now chairs the Skoll Global Threats Fund, a group in San Francisco, California, that identifies solutions to problems imperilling humanity. He was flabbergasted by how simple it was to use. “I am pitched lots and lots of systems that mechanize emergency and public-health responses, but they take so damn long to learn,” he says. “That is not true for Dharma.” In July, he joined the company's board.

Broken records

In Syria, MSF has been anxious to get access to patients' medical records, which would provide a long-term view of how people are faring and what support Syrian hospitals need. But that has been next to impossible because hospitals have been targeted by the Syrian regime and terrorist groups. Since March 2011, the non-profit group Physicians for Human Rights in New York City has documented 826 deaths of health-care workers in Syria from targeted bombs, assassinations and torture — more than 90% by the government.

Although MSF officially withdrew from the country in 2014, it had avoided some dangerous regions since 2011. One afternoon in 2012, Khalid Ahmad, a tropical-medicine doctor with the charity, got an idea about how the group could provide aid in areas that it was unable to reach itself. He was at an MSF office in Turkey, just across the northern Syrian border, when a young Syrian couple approached him. They showed him videos on their phones of people mangled under rubble. “They were finding the wounded and bringing them to clandestine hospitals,” Ahmad says. “They weren't even doctors, but they were organized, and I was so touched by their commitment.” He gave the couple first-aid kits and training on how to stop bleeding and move the wounded. Then he set out to find doctors said to be operating out of basements, in living rooms and under trees. Underground practices were “mushrooming up everywhere”, he recalls.

In 2015, MSF forged a connection with a hospital serving a large population in southern Syria — the one where Salim now works. At first, MSF asked hospital employees to enter patient data into an electronic database that the organization has long deployed around the world. But the Syrians didn't use it. They did not work for MSF, and they had little to gain from entering data into an unfamiliar system. Trying to get meaningful analyses out of it would take training and time, which the overwhelmed hospital staff didn't have. Plus, MSF's internal system is rigid. Requests for changes have to go through technology departments in European cities, a fact that stood out as a bottleneck.

Early this year, Aziz got the green light to try Dharma at the hospital. He

designed questionnaires on the platform that mimicked the format of the hand-written record books that hospital staff were accustomed to keeping. Two tablets with the program arrived at the hospital on 1 March, and every day since then, hospital staff have transferred data from hard copies into the devices. Anyone with access to the system can use it to search for trends.

For example, in April, Aziz noticed an unusually high number of infections among women who came for post-natal visits. Looking more closely, he saw that these women had not given birth at the hospital, so their infections probably came from stitches administered by midwives after slight rips during birth. “That means the midwife is doing this without sterile tools or in non-sterile conditions,” he says. “By knowing this, we can start to think about how to fix it.”

As of 15 October, the hospital has shared details from 29,469 patient visits. It's an exponential boost in information. “This is the only eye we have,” says Anja Braune, project coordinator for MSF's south Syria operation. “This is the only way we can try to forecast the coming period.” Still, Braune says that Dharma has not suddenly solved an extraordinarily difficult situation. In 2016 alone, MSF-supported facilities in the country were bombed or shelled on 71 separate occasions.

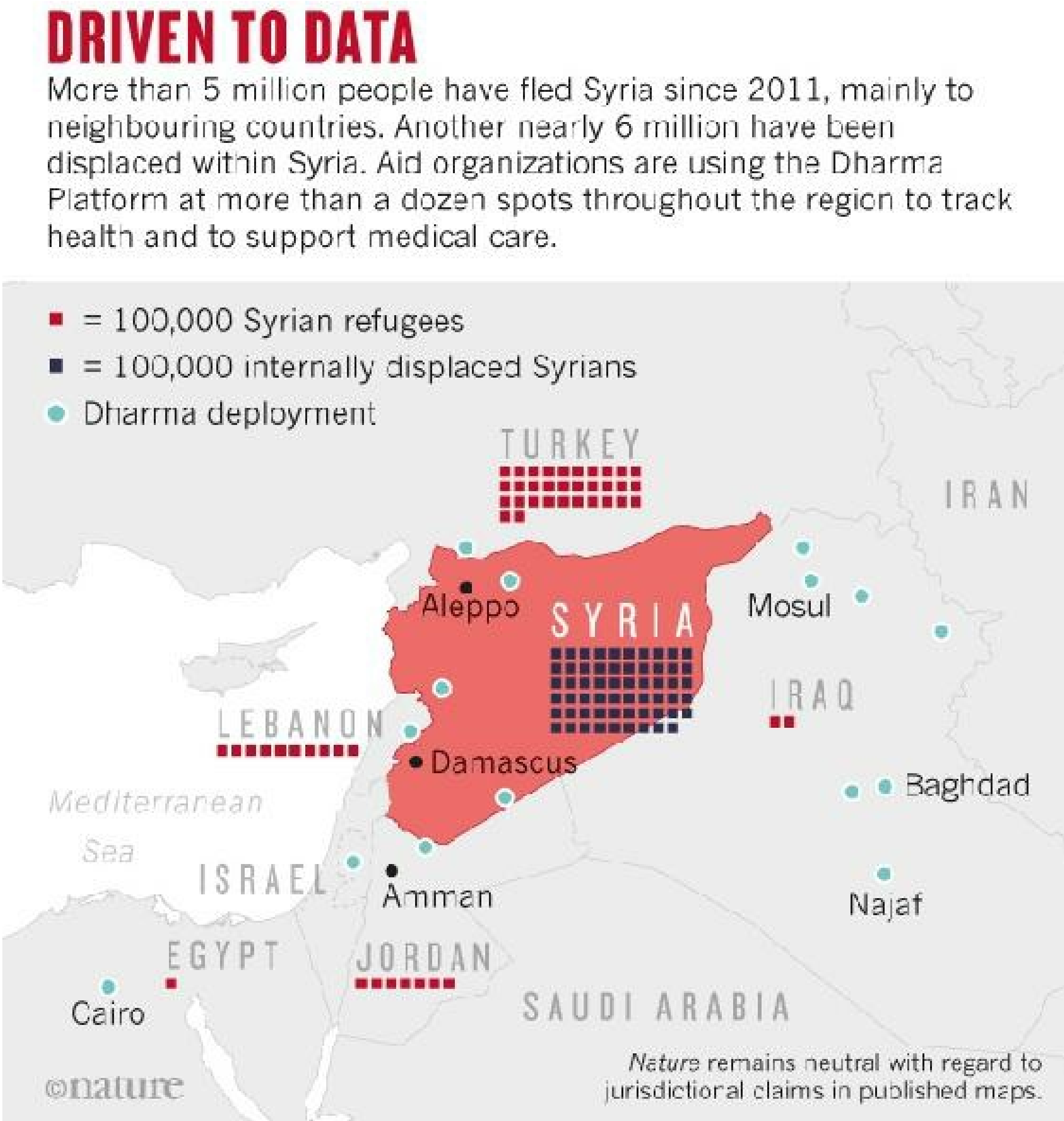
Data diaspora

But the data gap in the Syrian crisis extends outside the country's borders. Since 2011, about 5.3 million Syrians have fled the country, 92% of them to Turkey, Lebanon and Jordan (see 'Driven to data'). Although they are no longer in imminent danger, many continue to deteriorate from chronic health conditions, despite medical care. To understand how to help them, doctors need information.

One sweltering morning in July, Mohammed Manasrah carries a device loaded with Dharma to the houses of his bed-bound patients in Ar Ramtha — a northern district of Jordan where roughly 68,000 Syrian refugees have settled in concrete flats. Manasrah is a physician at an MSF hospital in Ar Ramtha specializing in non-communicable disease. Forms created on Dharma

can be easily amended, and Manasrah inserts variables that might help him discover patterns. “I want to see if some medication we are giving them correlates with depression or if that's tied to refugee status,” he says. “I want to see if we can convince women who cannot walk in the street to exercise in their homes, and to see if this leads to better medical outcomes.” Some answers may lie in patient records maintained by the hospital, but analysing the information requires more expertise and time than he has. On Dharma, he could search for correlations in minutes.

Doctors and other crisis responders have never had access to technology like this before: something that lets them design the tool they need for a job, and that puts analytics at their fingertips. The hope is that this will make them want to participate further and collect more information. That kind of buy-in is important, says Matthew Gee, a data scientist at the University of Chicago. “Whether you are a clinician trying to treat an illness or an academic wanting to understand the propagation of an infection, you rely on the data collector,” Gee says. The same data that help crisis responders react day-to-day can later be used by academics doing long-term research.



Source: UNHCR

Dharma makes it technically easier to share data, too. If a sudden disaster occurs, information obtained on the platform can (pending permission) be passed on to researchers more easily than before. Berns and Roytman have designed the platform to adhere to the security and formatting standards that many scientific-review boards and government agencies recommend. That's a key reason that Dharma is being piloted by scientists monitoring Middle East respiratory syndrome, or MERS, as part of the International Severe Acute

Respiratory and Emerging Infection Consortium. In this way, researchers who arrive at an outbreak much later than first-responders can make use of information gathered at its unpredictable start.

Still, Dharma could fail, like most start-ups. At the moment, many aid groups and governments prefer open-source tools, such as Open Data Kit, says Dykki Settle, director of digital health at PATH, a global-health organization based in Seattle, Washington. Settle explains that cost is not the reason: although open source means that the raw software is free, consultants still charge fees to maintain and modify it, or to link it with other systems for storage or analytics.

Rather, open source has some of the appeal of a vintage car: tinkering is an expectation. Someone who can program computers can alter the code, and weave one component with another. But as with vintage cars, that's unlikely to be the most reliable approach in a crisis. “In an emergency, you may not have the time and money to invest in the extra labour that open source requires,” Settle says.

Berns argues that Dharma is just as useful for long-term health management as for emergencies. And although its code is not accessible, she says, the ease of customization has allowed humanitarian groups to assess data ranging from medical needs to housing damage in Hurricane Harvey. These attributes have caught the attention of powerful players in global health. The US Centers for Disease Control and Prevention (CDC) is planning to pilot Dharma and several other new or updated systems for data management in emergencies. Richard Garfield, an epidemiologist involved with the effort, says that the agency plans to publish a sort of “consumer report” listing the pros and cons of each. New technology and analytics, he hopes, will force aid agencies to base their actions on evidence. “Everyone gets by with good intentions, and that's a serious frustration for those of us who are really concerned about improving people's lives,” Garfield says.

Neil Brandvold for Nature

A Dharma representative shows staff how to use the platform at a Médecins Sans Frontières clinic in Ar Ramtha, Jordan.

With or without Dharma, technological barriers to information exchange are falling. Still, data sharing may remain an aspirational ideal. Organizations often keep information to themselves to save face when their programmes don't deliver; researchers keep it private because they want credit; and many governments like to control access. In this respect, says Farrar, “the technical side is not the challenge; it is a political one”.

Despite being surrounded by war, Salim pushes for data sharing as well. He would like scientists and doctors around the world to learn the details of his cases. “Many websites talk about the war in Syria, but it's very general,” he says. “We need more specialized people talking about our situation so that it can improve — because the situation is bad.” For example, he says, what types of nerve damage are caused by chemical weapons and how do you treat those affected?

Salim admits that he often considers fleeing Syria, but feels responsible

because he knows too well all he leaves behind. “When it's the worst,” he says, “I weigh the risks and the benefits of the services I provide.” And then he decides to stay. At the very least, the world could pay attention.

Journal name:
Nature
Volume:
550,
Pages:
444–447
Date published:
(26 October 2017)
DOI:
doi:10.1038/550444a

Comments

Comments

There are currently no comments.

French scientists in uproar over changes to medical-research clusters

Biomedical-research agency accused of attempting to undermine autonomy of university–hospital groups.

24 October 2017

IRCAD

The Research Institute Against Digestive Cancer is part of a university–hospital research cluster (IHU) in Strasbourg, France.

A group of French scientists is due to meet government officials on 27 October in a bid to resolve a row that has left many of the country's leading biomedical researchers furious.

Scientists were shocked earlier this month when the government

unexpectedly postponed a call for applications to create a new crop of medical-research clusters just days before the closing date, and said that it would slash the budget earmarked for the project.

Government ministers said that they were delaying the project because they wanted to change the way these autonomous clusters are governed. But scientists contacted by *Nature* say they suspect that behind the decision is an effort by INSERM, France's biomedical-research agency, to exert control over the institutes.

The idea of creating the clusters, known as Instituts Hospitalo-Universitaires (IHUs), was introduced in 2009 to boost translational medical research, bringing together universities, teaching hospitals, research agencies and industry.

Based on public–private partnerships, they enjoy much autonomy and are mostly free from government and research-agency bureaucracy. The first six IHUs — in Paris, Bordeaux, Marseilles and Strasbourg — were approved in 2010 and received total funding of €850 million (US$1 billion). The clusters have been widely hailed as a successful model, and a second call for applications — open to any group of institutions that wanted to apply — was due to close on 12 October.

But in a press release on 2 October, the government announced that the deadline for the call would be postponed to an unspecified date. It also said that only two new IHUs would be funded, instead of the three initially planned, and that the total budget would be halved to €100 million. Nineteen applications had been made.

In letters sent to the government last week, and to President Emmanuel Macron on 23 October, 14 applicants said they were "appalled" or "bewildered" by the sudden and drastic changes to the funding and to the terms of the selection process. The health minister and higher-education ministers have invited applicants to discuss the issue this week.

Furious reaction

“None of the changes were discussed with us,” says Richard Frackowiak, who was chair of the international panel that would have assessed the IHU applications, but who resigned from the post on 6 October in protest. “The IHUs are the biggest French medical-research success of the past 10 years.”

The delay “is incomprehensible”, says Jacques Marescaux, a surgeon and chairman of the IHU Institute of Image-Guided Surgery of Strasbourg. The clusters are admired worldwide for their flexibility in being able to raise funds rapidly, and to recruit well-paid, top-flight researchers, says Marescaux. “The model has already been copied in Taiwan and Brazil.”

Despite the clusters' autonomy, INSERM seems to have weighed in on the latest call. In a 9 September letter to the IHU applicants, seen by *Nature*, the agency recommends that the candidate clusters alter their proposed structures to a ‘contract’ or ‘consortium’ model. This would give the agency a direct say in IHU affairs. The ministers’ desire to change the governance models seems to directly reflect INSERM’s recommendations, which were not solicited, say applicants. INSERM did not respond to a request for comment from *Nature*’s news team.

The change of strategy suggests that INSERM wants to get its hands on all the clusters, says Didier Raoult, who heads the infectious-diseases IHU in Marseilles. The institutes largely — or, in some cases, completely — escape the control of the research agencies, he adds, as do the patents that come out of them. “To quarrel with leading French and other medical researchers is very bad news for France and its image in the scientific community.”

A joint report by two French inspectorate agencies — of social affairs, and of education and research — was completed before the latest call was opened, and said that the IHUs were “promising”. The institutes had filed 183 patents and spun out 28 start-up companies. Although the report called for improved IHU governance, including closer researcher involvement, “it said the autonomous foundations should be maintained and strengthened”, notes Philippe Froguel, who is leading an IHU application and is an endocrinology researcher at Lille University Hospital.

Froguel is concerned that at the upcoming meeting, applicants will simply be again told what has been already decided. But he hopes that it will provide an

opportunity for negotiation and some clarity: “They will have to give us a new date for the tender and be more precise about the question of governance, which will be positive,” he says.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22877

Comments

Comments

There are currently no comments.

Wait for Trump's science adviser breaks modern-era record

Top White House science job stays empty more than nine months after president took office.

24 October 2017 Corrected:

1. 24 October 2017

Kevin Lamarque/Reuters

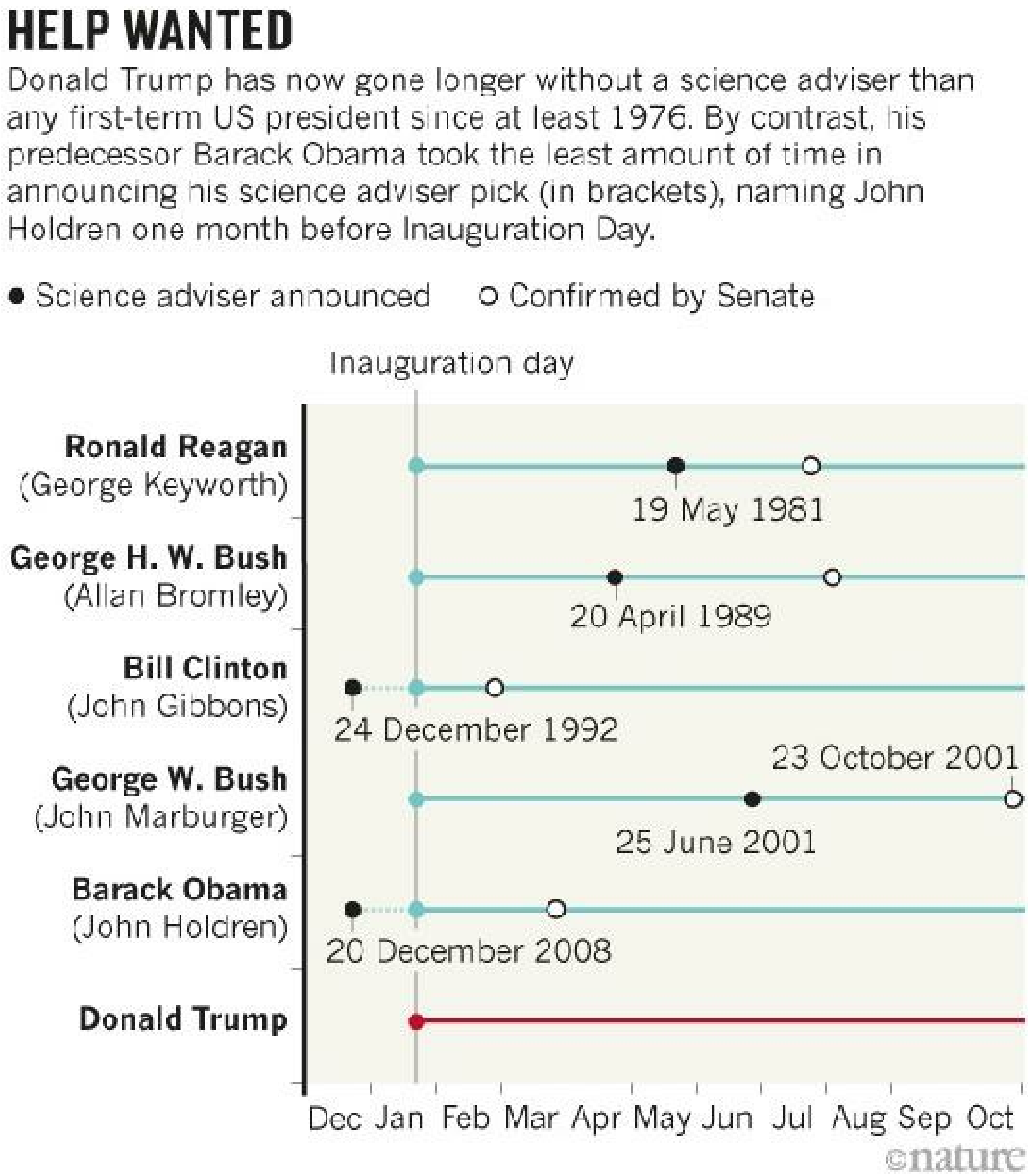
US President Donald Trump still hasn't chosen a White House science adviser

Donald Trump has now gone longer without a science adviser in place than any recent first-term US president — by any measure.

On 23 October, Trump broke the record set by former President George W. Bush. Bush's science adviser, physicist John Marburger, was confirmed by the Senate on 23 October 2001. That was 276 days after Bush took office, and 120 days after he announced that Marburger was his pick for the job.

Trump has also waited longer than any president since at least 1976, when the White House Office of Science and Technology Policy was created, to name his choice for the science-adviser job (see 'Help wanted'). Although rumours have surfaced periodically about scientists who may be in the president's sights, the White House has not made any official announcement.

By contrast, Trump's predecessor Barack Obama took the least time of any first-term president since 1976 in naming his science adviser. Obama revealed his choice of physicist John Holdren on 20 December 2008 — just 47 days after he won the presidency, and exactly one month before he was sworn in. (Holdren was confirmed by the US Senate three months later, on 19 March 2009.)



Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22878

Corrections

Corrected:

> An earlier version of the graphic gave the wrong year for the date that John Marburger was confirmed by the Senate as the science adviser.

Comments

Commenting is currently unavailable.

Reclassify waste to shift the nuclear landscape

The US Department of Energy should classify and dispose of nuclear rubbish according to risk.

24 October 2017

Brian Vander Brug/Los Angeles Times/Getty

Reclassification of nuclear waste could make disposal simpler and cheaper.

The United States has a single deep geological repository for nuclear waste. Since 1999, the Waste Isolation Pilot Plant (WIPP), 655 metres down in a massive salt formation near Carlsbad, New Mexico, has received 12,000-odd shipments of what it calls transuranic waste. This is clothing, tools and other

detritus from the nuclear-weapons programme that are contaminated by elements heavier than uranium. It’s more hazardous than low-level waste, which can be buried closer to the surface, but not as dangerous as high-level waste, for which a disposal site has yet to be found.

WIPP was closed for three years after radiation escaped from a ruptured drum in 2014. It was given the all-clear to reopen only in January; an enquiry determined that the drum had been packed improperly before shipment from the Los Alamos National Laboratory in northern New Mexico. Concerns remain about safety, as well as the long-term risk of human intrusion into a facility that will remain dangerous for thousands of years after its eventual closure. But by and large, WIPP has functioned as designed, and it could do even more to help the US Department of Energy (DOE) address the fallout from the country’s nuclear-weapons programme.

Much high-level waste — produced during the reprocessing of spent nuclear fuel into plutonium — is highly radioactive and dangerous. But the evidence suggests that some of the waste that is labelled ‘high level’ technically qualifies as transuranic. This material is still barred from direct disposal at WIPP, purely because of how it was produced. But labels can be changed. If wastes that meet the transuranic criteria could be shipped to WIPP, it would save considerable time and effort as the DOE continues to struggle with the country’s radioactive legacy.

At present, the high-level waste is scheduled to be encased in glass logs for disposal in a separate repository at Yucca Mountain in Nevada. Despite decades of delays and controversies, there are signs of progress at the DOE’s flagship vitrification facility at the Hanford Site in Washington. But even if current plans hold, that facility will not begin processing high-level waste until 2032. Nor is it clear where the logs will actually go. Yucca Mountain was shut down by former president Barack Obama, only to be revived by President Donald Trump. Its long-term prospects are far from certain.

Reclassifying some high-level waste at Hanford, as well as at two facilities in Idaho and South Carolina, offers an alternative path for some of that waste, and one that would reduce an ongoing threat to workers and the environment. More than one-third of the 177 underground storage tanks at Hanford have leaked and contaminated groundwater.

The problem is inertia, compounded by fear, distrust and politics. The DOE is operating under a complex web of rules, regulations and legal agreements, and shifting course isn't easy. Although the agency has the authority to look through its nuclear-waste inventory and reclassify wastes that meet the WIPP transuranic criteria, it has resisted such a move because it fears that this would spark political uproar — and quite probably legal challenges.

Washington state, which has in place a court-ordered clean-up agreement for Hanford, has been particularly resistant to change. And New Mexico has tied the DOE's hands at WIPP by banning the disposal of tank wastes and any other materials managed as high-level waste — even if they meet the WIPP criteria. Watchdog groups, meanwhile, are concerned that nuclear-waste reclassification is simply a way of changing the rules and lowering the bar for public and environmental safety.

The proposal briefly bubbled up to the surface several years ago, but political attention shifted after the leak at WIPP. Now a coalition of local governments from communities across the nuclear-weapons industry is reviving the idea. In a white paper published last month, the Energy Communities Alliance urged a two-pronged approach involving the DOE as well as Congress, which could clarify the definition of high-level waste legislatively. The alliance estimated that the DOE could save at least US$40 billion over the lifetime of its clean-up programme — more than 15% of the estimated $257-billion price tag.

After spending some $11 billion on the as-yet-unfinished vitrification plant over the past two decades at Hanford, some may hesitate to change course. But as former DOE secretary Steven Chu said, the worst thing you can do in a multi-decade project such as nuclear-waste clean-up is to close the door to alternatives. In this case, the solution is simple enough: nuclear waste should be managed on the basis of the risk it poses and not the process that produced it.

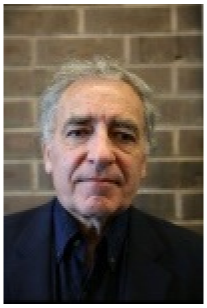
Journal name:
Nature
Volume:
550,
Pages:

429–430
Date published:
(26 October 2017)
DOI:
doi:10.1038/550429b

Comments

Comments

There are currently no comments.



Ted Lewis
III

Cancer biology still needs physicists

Considering game theory and the role of physical forces could lead to better treatments for cancer, says Robert Austin[1].

24 October 2017

Cancer is close to surpassing heart disease as the leading cause of death in the United States. The World Health Organization estimates that worldwide, new cases will rise by 70% in the next two decades. In concert, treatment costs are skyrocketing and could reach US$156 billion by 2020 in the United States alone, according to the US National Cancer Institute (NCI). A modest decline in US cancer mortality rates has been attributed to prevention, such as lower smoking rates, rather than better treatment. Yet, more than 150,000 papers on cancer have been published each year since 2013.

This month, application deadlines closed for several programmes in the US$1.8-billion Cancer Moonshot authorized by the US Congress in 2016. The extra funds to study cancer are badly needed, but we do not have a sufficient fundamental understanding of the disease for these investments to make a near-term difference in treatment.

Comparison of the cancer initiative to former US president John F. Kennedy's lunar challenge is misleading. When, in 1961, Kennedy declared

the goal of landing on the Moon, we understood gravity well enough to be reasonably confident that if we built rockets powerful enough, we could do it. We could predict distant planetary orbits with startling precision. Getting an astronaut to a nearby satellite was an engineering feat. No new basic principles needed to be discovered.

This is not true for cancer. The deepest puzzle we must solve is how groups of cells behave, which networking theories developed in the physical sciences are well equipped to address. Cancer can move from a localized tumour to remote locations — a process called metastasis. Once that happens, individuals with cancer have a poor prognosis. Metastasis drives the costs of treatment skyward, but these therapies are, tragically, largely futile. Without a better way to explain and treat metastases, new clinical methods will do little to improve the situation.

To be sure, there has been progress. A growing appreciation of how the immune system keeps cancer in check has brought a new class of therapies. Patient-specific chemotherapy and more-precise radiotherapy have also led to advances. But cancer needs more big ideas — and those of scientists from other disciplines should be taken more seriously.

In 2008, I attended a series of workshops organized by the NCI in Bethesda, Maryland, to bring together physicists, engineers, mathematicians and computer scientists to look for new ways of tackling the disease. These led to the creation in 2009 of a dozen designated physical-sciences oncology centres; I led the Princeton Physical Sciences–Oncology Center, based in New Jersey, from 2009 to 2015.

Over that time, large cancer-genome sequencing projects revealed millions of cancer-related mutations. The numbers found in individual tumours and types of cancer range widely. Exactly what causes this variation is unclear. In any case, genetically targeted treatments generally buy affected individuals, at most, a few more months of life.

Since the centres launched, there has been greater recognition of the potential contributions of physical forces to cancer-cell responses, such as the number and location of metastases, or how cells stick together. Networking and game theories — mathematical analyses of social and economic interactions that

represent how humans do or don’t cooperate to minimize costs and maximize gains — have also been adapted to model how cells behave during cancer growth and invasion. Particularly promising, in my view, are theories of the evolution of multicellularity, when cells had to develop mechanisms for living in communities — possibly at the cost of their own selfish, local goals of reproduction. I argue that these approaches have not yet had time to show their potential.

The cancer community has been unenthusiastic about the contributions of physical oncologists. When, several years ago, we proposed a special section on the physics of cancer for a high-profile journal, oncology referees were dismissive. One admitted: “I am not a big fan of the topic.” Another reviewer rejected the proposal because genetics “is the Rosetta Stone with respect to treatment”. Wrote another: “I did not recognize any of the proposed authors.”

Too often, biologists see physicists as human calculators. The big ideas, they think, belong to them, with physicists filling in the details by performing quantitative analyses. To counter this attitude, the Francis Crick Institute in London, for instance, is actively searching for physicists with transformative ideas. We need to do more than hire ‘quants’ to crunch ‘big data’.

To develop new conceptual approaches to cancer, scientists of all stripes must reach out. I have sometimes antagonized biologists by saying that their advice stifles creativity. But I am now working, along with medical physicist Robert Jeraj of the University of Wisconsin–Madison, to form groups within the American Physical Society that focus on oncology. These scientists have strong collaborations with biomedical researchers, but have historically been restricted to advancing imaging technologies — important, but far removed from bringing in ideas about the origins and progression of disease. I also serve on the editorial board of two journals designed as outlets for this sort of work. *Convergent Science Physical Oncology* was launched in 2015, by the Institute of Physics in Bristol, UK, and *Cancer Convergence* (published by Springer Nature, which also publishes *Nature*) will publish its first articles in the next few months.

We need to expand our questions — or risk remaining Earth-bound.

Journal name:

Nature
Volume:
550,
Pages:
431
Date published:
(26 October 2017)
DOI:
doi:10.1038/550431a

Comments

Commenting is currently unavailable.

India gears up for second Moon mission

The Chandrayaan-2 orbiter, lander and rover will track how lunar dust might scupper settlement.

24 October 2017

Xinhua/Alamy

India’s Chandrayaan-2 moon mission is scheduled to launch next March from the spaceport of Sriharikota.

In a large shed near the headquarters of the Indian Space Research Organisation (ISRO) in Bangalore, a six-wheeled rover rumbles over dark grey rubble in a landscape designed to mimic the Moon’s rocky surface. This test and others scheduled for the next few weeks are crucial steps in India’s

quest to launch a second mission to the Moon next March.

The country’s much anticipated Chandrayaan-2 comes almost a decade after India began its first journey to the Moon, in 2008. “It is logically an extension of the Chandrayaan-1 mission,” says Mylswamy Annadurai, director of the project at ISRO. The spacecraft comprises an orbiter that will travel around the Moon, a lander that will touch down in a as-yet undecided location near the Moon’s south pole and a rover.

India’s maiden Moon trip was a significant achievement for its space programme, but ended prematurely when ISRO lost contact with the orbiter ten months into the planned two-year mission. However, an instrument on a probe that reached the Moon’s surface did gather enough data for scientists to confirm the presence of traces of water.

Chandrayaan-2 will attempt more ambitious technical manoeuvres that will put Indian space technology to the test. For the first time, ISRO will attempt to give a craft a controlled, or soft, landing. The agency has had to develop advanced systems that can guide the lander to a touch down and successfully deploy the rover.

Lunar conditions

Lunar missions are also being planned by China, Japan and other countries, among others. Like these, India’s explorations are partly driven by the need to improve understanding of the Moon’s environment in the event that governments or private entities decide to establish a human settlement there. One poorly understood phenomenon is floating lunar dust. Without an atmosphere like Earth’s, the surface of the Moon is buffeted by solar wind and ultraviolet radiation, creating a layer of charged ions called a plasma sheath in which dust particles can levitate.

If humans colonize the Moon, this dust will be a significant challenge, says planetary scientist Penny King of the Australian National University (ANU) in Canberra. It gets into everything, from astronauts’ suits to machinery and equipment, where it causes damage, she says. “Understanding how it moves around is pretty critical." ISRO says the Chandrayaan-2 orbiter and lander will carry a first of its kind instrument, called the Radio Anatomy of Moon Bound Hypersensitive ionosphere and Atmosphere (RAMBHA), to measure the density of the near-surface plasma and how it changes over time.

Evolving environment

The rest of the spacecraft's suite of instruments will collect data to help scientists study other aspects of the Moon's present environment and how it has evolved. Chandrayaan-2's lander will take the first on-site thermal measurements on the lunar surface near a polar region. The mission "is expected to further consolidate the findings from the first mission and add new ones with *in situ* analysis of the lunar surface and ionosphere," says Annadurai, who is also director of ISRO's Satellite Centre in Bangalore.

ISRO plans to execute its mission on shoestring budget of just 6.03 billion rupees (US$93 million), including the cost of the rocket and launch. Chandrayaan-2 will be carried into space on one of the agency's three-stage rockets, a Geosynchronous Satellite Launch Vehicle Mark II, taking off from a spaceport on the island of Sriharikota in the Bay of Bengal. "A nice part of the Indian space programme is that they manage to do things so cheaply," says ANU astrobiologist Charles Lineweaver. "If it succeeds, maybe everyone else will see that their mission didn't really need that extra bell or whistle."

In three to four weeks**,** ISRO will begin one of the final and most complex testing phases for Chandrayaan-2, integrating all of its components. With one Moon mission under its belt, ISRO is settling into its role as a moon-faring organisation. "Maybe we were extra anxious with the first child, as parents. But we relax a bit as more children come along," he jokes.

Journal name:
Nature
Volume:
550,
Pages:

440
Date published:
(26 October 2017)
DOI:
doi:10.1038/nature.2017.22870

Comments

Commenting is currently unavailable.

To stay young, kill zombie cells

Killing off cells that refuse to die on their own has proved a powerful anti-ageing strategy in mice. Now it's about to be tested in humans.

24 October 2017 Corrected:

1. 25 October 2017

Illustration by Paweł Jońca

Jan van Deursen was baffled by the decrepit-looking transgenic mice he created in 2000. Instead of developing tumours as expected, the mice experienced a stranger malady. By the time they were three months old, their fur had grown thin and their eyes were glazed with cataracts. It took him years to work out why: the mice were ageing rapidly, their bodies clogged

with a strange type of cell that did not divide, but that wouldn't die[1].

That gave van Deursen and his colleagues at Mayo Clinic in Rochester, Minnesota, an idea: could killing off these 'zombie' cells in the mice delay their premature descent into old age? The answer was yes. In a 2011 study[2], the team found that eliminating these 'senescent' cells forestalled many of the ravages of age. The discovery set off a spate of similar findings. In the seven years since, dozens of experiments have confirmed that senescent cells accumulate in ageing organs, and that eliminating them can alleviate, or even prevent, certain illnesses (see 'Becoming undead'). This year alone, clearing the cells in mice has been shown to restore fitness, fur density and kidney function[3]. It has also improved lung disease[4] and even mended damaged cartilage[5]. And in a 2016 study, it seemed to extend the lifespan of normally ageing mice[6].

“Just by removing senescent cells, you could stimulate new tissue production,” says Jennifer Elisseeff, senior author of the cartilage paper and a biomedical engineer at Johns Hopkins University in Baltimore, Maryland. It jump-starts some of the tissue's natural repair mechanisms, she says.

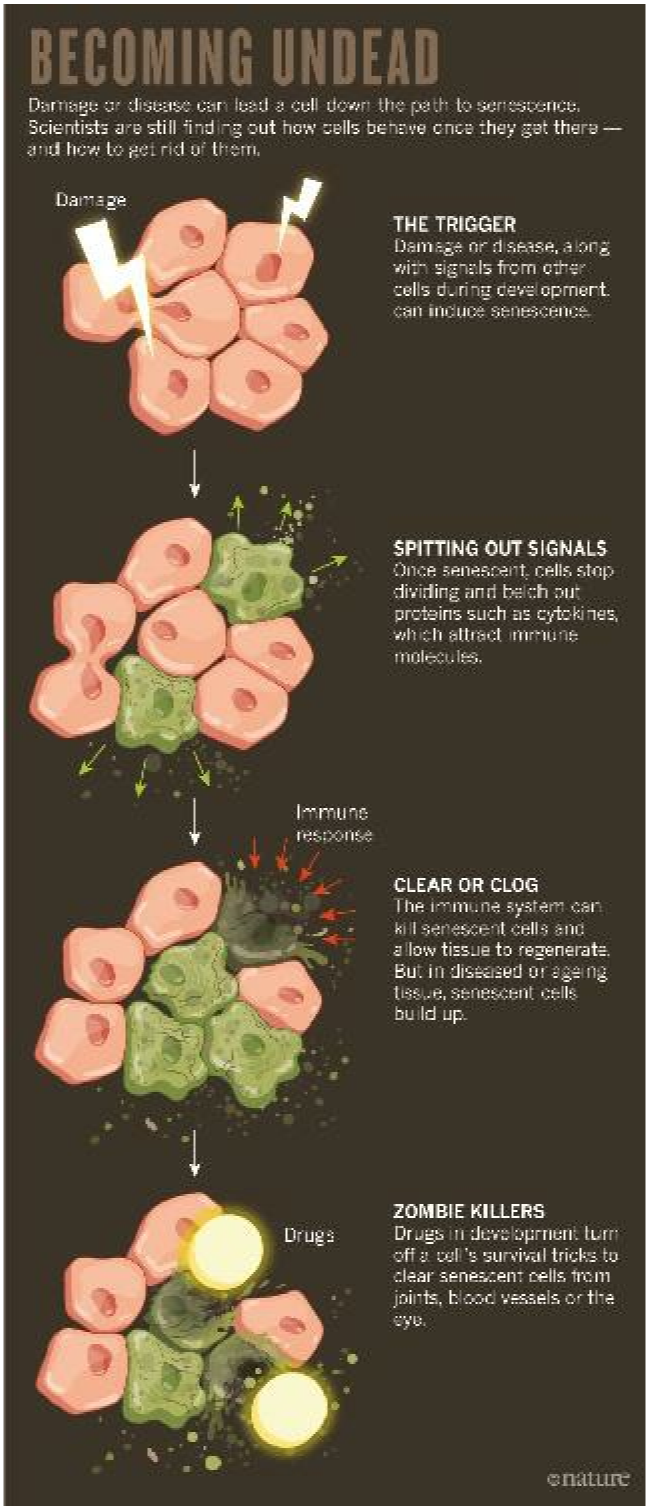
This anti-ageing phenomenon has been an unexpected twist in the study of senescent cells, a common, non-dividing cell type first described more than five decades ago. When a cell enters senescence — and almost all cells have the potential to do so — it stops producing copies of itself, begins to belch out hundreds of proteins, and cranks up anti-death pathways full blast. A senescent cell is in its twilight: not quite dead, but not dividing as it did at its peak.

Now biotechnology and pharmaceutical companies are keen to test drugs — known as senolytics — that kill senescent cells in the hope of rolling back, or at least forestalling, the ravages of age. Unity Biotechnology in San Francisco, California, co-founded by van Deursen, plans to conduct multiple clinical trials over the next two-and-a-half years, treating people with osteoarthritis, eye diseases and pulmonary diseases. At Mayo, gerontologist James Kirkland, who took part in the 2011 study, is cautiously beginning a handful of small, proof-of-concept trials that pit senolytic drugs against a range of age-related ailments. “I lose sleep at night because these things

always look good in mice or rats, but when you get to people you hit a brick wall," says Kirkland.

No other anti-ageing elixir has yet cleared that wall, and for a few good reasons. It's next to impossible to get funding for clinical trials that measure an increase in healthy lifespan. And even as a concept, ageing is slippery. The US Food and Drug Administration has not labelled it a condition in need of treatment.

Still, if any of the trials offer "a whiff of human efficacy", says Unity's president, Ned David, there will be a massive push to develop treatments and to better understand the fundamental process of ageing. Other researchers who study the process are watching closely. Senolytics are "absolutely ready" for clinical trials, says Nir Barzilai, director of the Institute for Aging Research at the Albert Einstein College of Medicine in New York City. "I think senolytics are drugs that could come soon and be effective in the elderly now, even in the next few years."



The dark side

When microbiologists Leonard Hayflick and Paul Moorhead coined the term senescence in 1961, they suggested that it represented ageing on a cellular level. But very little research was done on ageing at the time, and Hayflick recalls people calling him an idiot for making the observation. The idea was ignored for decades.

Although many cells do die on their own, all somatic cells (those other than reproductive ones) that divide have the ability to undergo senescence. But, for a long time, these twilight cells were simply a curiosity, says Manuel Serrano of the Institute for Research in Biomedicine in Barcelona, Spain, who has studied senescence for more than 25 years. “We were not sure if they were doing something important.” Despite self-disabling the ability to replicate, senescent cells stay metabolically active, often continuing to perform basic cellular functions.

By the mid-2000s, senescence was chiefly understood as a way of arresting the growth of damaged cells to suppress tumours. Today, researchers continue to study how senescence arises in development and disease. They know that when a cell becomes mutated or injured, it often stops dividing — to avoid passing that damage to daughter cells. Senescent cells have also been identified in the placenta and embryo, where they seem to guide the formation of temporary structures before being cleared out by other cells.

LISTEN

Hear Judy Campisi and Jan van Deursen discuss why they're excited to be researching senescence.

You may need a more recent browser or to install the latest version of the Adobe Flash Plugin.
Go to full podcast

But it wasn't long before researchers discovered what molecular biologist Judith Campisi calls the “dark side” of senescence. In 2008, three research groups, including Campisi's at the Buck Institute for Research on Aging in Novato, California, revealed that senescent cells excrete a glut of molecules

— including cytokines, growth factors and proteases — that affect the function of nearby cells and incite local inflammation[7, 8, 9]. Campisi's group described this activity as the cell's senescence-associated secretory phenotype, or SASP[7]. In recent unpublished work, her team identified hundreds of proteins involved in SASPs.

In young, healthy tissue, says Serrano, these secretions are probably part of a restorative process, by which damaged cells stimulate repair in nearby tissues and emit a distress signal prompting the immune system to eliminate them. Yet at some point, senescent cells begin to accumulate — a process linked to problems such as osteoarthritis, a chronic inflammation of the joints, and atherosclerosis, a hardening of the arteries. No one is quite sure when or why that happens. It has been suggested that, over time, the immune system stops responding to the cells.

Surprisingly, senescent cells turn out to be slightly different in each tissue. They secrete different cytokines, express different extracellular proteins and use different tactics to avoid death. That incredible variety has made it a challenge for labs to detect and visualize senescent cells. “There is nothing definitive about a senescent cell. Nothing. Period,” says Campisi.

In fact, even the defining feature of a senescent cell — that it does not divide — is not written in stone. After chemotherapy, for example, cells take up to two weeks to become senescent, before reverting at some later point to a proliferating, cancerous state, says Hayley McDaid, a pharmacologist at Albert Einstein College of Medicine. In support of that idea, a large collaboration of researchers found this year that removing senescent cells right after chemotherapy, in mouse models for skin and breast cancer, makes the cancer less likely to spread[10].

The lack of universal features makes it hard to take inventory of senescent cells. Researchers have to use a large panel of markers to search for them in tissue, making the work laborious and expensive, says van Deursen. A universal marker for senescence would make the job much easier — but researchers know of no specific protein to label, or process to identify. “My money would be on us never finding a senescent-specific marker,” Campisi adds. “I would bet a good bottle of wine on that.”

Earlier this year, however, one group did develop a way to count these cells in tissue. Valery Krizhanovsky and his colleagues at the Weizmann Institute of Science in Rehovot, Israel, stained tissues for molecular markers of senescence and imaged them to analyse the number of senescent cells in tumours and aged tissues from mice[11]. “There were quite a few more cells than I actually thought that we would find,” says Krizhanovsky. In young mice, no more than 1% of cells in any given organ were senescent. In two-year-old mice, however, up to 20% of cells were senescent in some organs.

But there's a silver lining to these elusive twilight cells: they might be hard to find, but they're easy to kill.

Out with the old

In November 2011, while on a three-hour flight, David read van Deursen and Kirkland's just-published paper about eliminating zombie cells. Then he read it again, and then a third time. The idea “was so simple and beautiful”, recalls David. “It was almost poetic.” When the flight landed, David, a serial biotech entrepreneur, immediately rang van Deursen, and within 72 hours had convinced him to meet to discuss forming an anti-ageing company.

Kirkland, together with collaborators at the Sanford Burnham Medical Research Institute in La Jolla, California, initially attempted a high-throughput screen to quickly identify a compound that would kill senescent cells. But they found it to be “a monumental task” to tell whether a drug was affecting dividing or non-dividing cells, Kirkland recalls. After several failed attempts, he took another tack.

Senescent cells depend on protective mechanisms to survive in their 'undead' state, so Kirkland, in collaboration with Laura Niedernhofer and others from the Scripps Research Institute in Jupiter, Florida, began seeking out those mechanisms. They identified six signalling pathways that prevent cell death, which senescent cells activate to survive[12, 13].

Then it was just a matter of finding compounds that would disrupt those pathways. In early 2015, the team identified the first senolytics: an FDA-

approved chemotherapy drug, dasatinib, which eliminates human fat-cell progenitors that have turned senescent; and a plant-derived health-food supplement, quercetin, which targets senescent human endothelial cells, among other cell types. The combination of the two — which work better together than apart — alleviates a range of age-related disorders in mice[14].

Ten months later, Daohong Zhou at the University of Arkansas for Medical Sciences in Little Rock and his colleagues identified a senolytic compound now known as navitoclax, which inhibits two proteins in the BCL-2 family that usually help the cells to survive[15]. Similar findings were reported within weeks by Kirkland's lab[16] and Krizhanovsky's lab[17].

By now, 14 senolytics have been described in the literature, including small molecules, antibodies and, in March this year, a peptide that activates a cell-death pathway and can restore lustrous hair and physical fitness to ageing mice[3].

So far, each senolytic kills a particular flavour of senescent cell. Targeting the different diseases of ageing, therefore, will require multiple types of senolytics. “That's what's going to make this difficult: each senescent cell might have a different way to protect itself, so we'll have to find combinations of drugs to wipe them all out,” says Niedernhofer. Unity maintains a large atlas documenting which senescent cells are associated with which disease; any weaknesses unique to given kinds of cell, and how to exploit those flaws; and the chemistry required to build the right drug for a particular tissue. There is no doubt that for different indications, different types of drug will need to be developed, says David. “In a perfect world, you wouldn't have to. But sadly, biology did not get that memo.”

For all the challenges, senolytic drugs have several attractive qualities. Senescent cells will probably need to be cleared only periodically — say, once a year — to prevent or delay disease. So the drug is around for only a short time. This type of 'hit and run' delivery could reduce the chance of side effects, and people could take the drugs during periods of good health. Unity plans to inject the compounds directly into diseased tissue, such as a knee joint in the case of osteoarthritis, or the back of the eye for someone with age-related macular degeneration.

And unlike cancer, in which a single remaining cell can spark a new tumour, there's no need to kill every senescent cell in a tissue: mouse studies suggest that dispatching most of them is enough to make a difference. Finally, senolytic drugs will clear only senescent cells that are already present — they won't prevent the formation of such cells in the future, which means that senescence can continue to perform its original tumour-suppressing role in the body.

Those perks haven't convinced everybody of the power of senolytics. Almost 60 years after his initial discovery, Hayflick now believes that ageing is an inexorable biophysical process that cannot be altered by eliminating senescent cells. “Efforts to interfere with the ageing process have been going on since recorded human history,” says Hayflick. “And we know of nothing — nothing — that has demonstrated to interfere with the ageing process.”

Fans of senolytics are much more optimistic, emboldened by recent results. Last year, van Deursen's lab went beyond its tests on super-aged mice and showed that killing off senescent cells in normally ageing mice delayed the deterioration of organs associated with ageing[6], including the kidney and heart. And — to the joy of anti-ageing enthusiasts everywhere — it extended the animals' median lifespan by about 25%.

Successful results from mouse studies have already lured seven or eight companies into the field, Kirkland estimates. At Mayo, one clinical trial has opened, pitting dasatinib and quercetin in combination against chronic kidney disease. Kirkland plans to try other senolytics against different age-related diseases. “We want to use more than one set of agents across the trials and look at more than one condition,” he says.

If eliminating senescent cells in humans does improve age-related illnesses, researchers will aim to create broader anti-ageing therapies, says David. In the meantime, researchers in the field insist that no one should take these drugs until proper safety tests in humans are complete. In rodents, senolytic compounds have been shown to delay wound healing, and there could be additional side effects. “It's just too dangerous,” says Kirkland.

Van Deursen says that continuing to answer basic biological questions is the field's best shot at success. “Only then will we be able to understand what

ageing really is, and how we can, in an intelligent way, interfere with it.”

Journal name:
Nature
Volume:
550,
Pages:
448–450
Date published:
(26 October 2017)
DOI:
doi:10.1038/550448a

Corrections

Corrected:

Reference 4 in this story originally omitted the journal name. This has now been added.

Comments

Commenting is currently unavailable.

Nature News

周六, 07 10月 2017

Nature News

[周六, 07 10月 2017]

- **Nature News**

Nature News

Nature is a weekly international journal publishing the finest peer-reviewed research in all fields of science and technology on the basis of its originality, importance, interdisciplinary interest, timeliness, accessibility, elegance and surprising conclusions. Nature also provides rapid, authoritative, insightful and arresting news and interpretation of topical and coming trends affecting science, scientists and the wider public.

- **Navajo Nation reconsiders ban on genetic research** [周五, 06 10月 08:00]
  Tribal leaders are developing a policy for genetic research and data sharing, potentially ending a 15-year moratorium.
- **The scientist who spots fake videos** [周五, 06 10月 08:00]
  Hany Farid discusses how to detect image manipulations — and the increasing sophistication of forgers.
- **Proton-size puzzle deepens** [周四, 05 10月 08:00]
  Measurement in ordinary hydrogen agrees with a surprising 2010 result on the element's exotic cousin — but gives a smaller value than virtually every other experiment.
- **Controversial pesticides found in honey samples from six continents** [周四, 05 10月 08:00]
  Neonicotinoids are at the centre of a long-running debate about whether they harm bees.
- **Antikythera shipwreck yields statue pieces and mystery bronze disc** [周三, 04 10月 08:00]
  Archaeologists think that at least seven life-sized sculptures are hidden nearby.
- **Cryo-electron microscopy wins chemistry Nobel** [周三, 04 10月 08:00]
  Jacques Dubochet, Joachim Frank and Richard Henderson share the prize for developing a technique to image biomolecules.
- **Crash in sea-turtle births stumps ecologists** [周三, 04 10月 08:00]
  Leading suspect — climate change — doesn’t fully explain what is happening to leatherback turtles in the US Virgin Islands.
- **Scientists plead with Brazilian government to restore funding** [周三, 04 10月 08:00]
  If officials don't act soon, research institutions could start shutting down next year.
- **Supercomputer redesign of aeroplane wing mirrors bird anatomy** [周三, 04 10月 08:00]
  Bird-bone structures emerge from an evolution-like algorithm.
- **Elite Hungarian university may be saved** [周三, 04 10月 08:00]

Hungary-New York agreement could allow Central European University to sidestep law change.

- **[Science without walls is good for all]** [周三, 04 10月 08:00]
  International mobility and collaboration are linked to stronger research.
- **[Nobel prizes, giant telescope and buried treasure]** [周三, 04 10月 08:00]
  The week in science: 29 September–5 October 2017.
- **[Why fake islands might be a real boon for science]** [周三, 04 10月 08:00]
  The seasteading movement is getting close to building its first prototype, an artificial archipelago where people will live, play and do research.
- **[Scientists have most impact when they're free to move]** [周三, 04 10月 08:00]
  An analysis of researchers' global mobility reveals that limiting the circulation of scholars will damage the scientific system, say Cassidy R. Sugimoto and colleagues.
- **[Open countries have strong science]** [周三, 04 10月 08:00]
  Caroline S. Wagner and Koen Jonkers find a clear correlation between a nation's scientific influence and the links it fosters with foreign researchers.
- **[Neuroscience: The mother lode of invention]** [周三, 04 10月 08:00]
  Dan Jones compares three studies on the origins and fruits of human creativity.
- **[Health: The war on germs]** [周三, 04 10月 08:00]
  Tilli Tansey hails a history of Joseph Lister's drive to vanquish post-operative infection and putrefaction.
- **[New in paperback]** [周三, 04 10月 08:00]
  Highlights of this season's releases
- **[Sustainability: China's path to ecotopia]** [周三, 04 10月 08:00]
  Xuemei Bai critiques a critique of the country's eco-city initiative.
- **[Ornithology: All eyes on the 10,000 species]** [周三, 04 10月 08:00]
  Stuart Pimm considers the obsessive, sometimes dark side to the joyous pursuit of watching birds.
- **[Theoretical physics: When the doer met the dreamer]** [周三, 04 10月 08:00]
  Graham Farmelo applauds a study on the productive friendship of two very different physicists.
- **[Technology: Into cyberia]** [周三, 04 10月 08:00]
  Li Gong weighs up three tomes on Silicon Valley's vast influence, for good or ill.
- **[Fossil fuels: Heed local impact of coal mining]** [周三, 04 10月 08:00]
- **[Hurricanes: rescue natural defences]** [周三, 04 10月 08:00]
- **[Hurricanes: enlist nature's protection]** [周三, 04 10月 08:00]
- **[World Heritage Site: UNESCO honour for Polish mining facility]** [周三, 04 10月 08:00]

- **Collaborative software development made easy** [周三, 04 10月 08:00]
  Save time and protect critical code with 'continuous integration' services.
- **A taste of Toolbox** [周三, 04 10月 08:00]
  Nature 's technology editor, Jeffrey Perkel, started blogging about workplace technology in science in 2016. Here are some highlights.
- **The daughter you've always wanted** [周三, 04 10月 08:00]
  Family matters.
- **South Korea cracks down on dirty air** [周二, 03 10月 08:00]
  Despite huge clean-up effort, scientists say country's pollution problem could get worse over next five years.
- **Xenon view, butterfly wings and a strange squid** [周二, 03 10月 08:00]
  September's sharpest science shots, selected by Nature 's photo team.
- **Europe's Joint Research Centre, although improving, must think bigger** [周二, 03 10月 08:00]
  External report criticizes lack of exploratory research.
- **Make plans to eliminate cholera outbreaks** [周二, 03 10月 08:00]
  Governments must stop denying the occurrence of cholera and unite in long-term prevention strategies, says Anita Zaidi.
- **Ethics of Internet research trigger scrutiny** [周二, 03 10月 08:00]
  Concern over the use of public data spurs guideline update.
- **Gravitational wave detection wins physics Nobel** [周二, 03 10月 08:00]
  Rainer Weiss, Barry Barish and Kip Thorne share the 2017 prize for their work at LIGO to detect ripples in space-time.
- **Risk of human-triggered earthquakes laid out in biggest-ever database** [周一, 02 10月 08:00]
  Geologists track hundreds of quakes caused by people and the projects that set them off.
- **Discoveries have awkward first dates** [周一, 02 10月 08:00]
  Fuzzy timings over a plate-tectonics anniversary highlight the rolling nature of scientific discovery.
- **Chinese scientists fix genetic disorder in cloned human embryos** [周一, 02 10月 08:00]
  A method for precisely editing genes in human embryos hints at a cure for a blood disease.
- **Medicine Nobel awarded for work on circadian clocks** [周一, 02 10月 08:00]
  Jeffrey Hall, Michael Rosbash and Michael Young unpicked molecular workings of cells' daily rhythms.
- **Parakeet invasion of Mexico driven by Europe's ban on**

[bird imports](#) [周五, 29 9月 08:00]
Attempts to stop the spread of bird flu and protect wildlife had unintended consequences.

- ## Time capsule buried to preserve science for the ages [周五, 29 9月 08:00]
  Message in a bottle sums up state of research in 2017.
- ## Tsunami wreckage serves as liferafts for invasive species [周五, 29 9月 08:00]
  Hundreds of species can subsist for years on tsunami debris.
- ## Tropical forests may be carbon sources, not sinks [周五, 29 9月 08:00]
  Combination of satellite images and on-the-ground data enables more complete tracking of forest carbon flows.
- ## French government proposes big science-spending boost [周五, 29 9月 08:00]
  President Emmanuel Macron’s 2018 draft budget would raise research funds by 6%.
- ## Toad tadpoles turn homegrown poisons on each other [周五, 29 9月 08:00]
  Young amphibians are the first animals thought to use toxins against rivals of their own species.
- ## Controversial Thirty Meter Telescope gets go-ahead to build in Hawaii [周五, 29 9月 08:00]
  State board issues construction permit for project, but legal fight over telescope continues.

Navajo Nation reconsiders ban on genetic research

Tribal leaders are developing a policy for genetic research and data sharing, potentially ending a 15-year moratorium.

06 October 2017

Ricky Carioti/The Washington Post/Getty

Children play on the Navajo Nation's vast reservation in the southwestern United States.

When the Navajo Nation opens its first oncology centre next year in Tuba City, Arizona, clinicians there may be able to offer a service that has been banned on tribal lands for 15 years: analyzing the DNA of Navajo tribe

members to guide treatments and study the genetic roots of disease.

That's because the Navajo, the second-largest Native American group in the United States, are considering whether to lift their longstanding moratorium on genetic research. The tribal government banned DNA studies in 2002 to prevent the misuse of its members' genetic material. Although there is still some apprehension about the risk of allowing researchers access to Navajo DNA, the tribe's leaders increasingly see genetic research as a tool to improve medical care for the 174,000 residents of their sprawling reservation, which is roughly the size of Scotland.

As it now stands, Navajo people who live on the reservation must drive hundreds of kilometres to access specialized medical care off tribal lands, in large cities such as Phoenix, Arizona. “We spend millions of dollars outsourcing [care] for cancer and diabetes,” says Walter Phelps, a delegate to the Navajo Nation Council. As the tribe — a nation independent of the United States — tries to expand the health services it offers to its members, he says, “the moratorium could become a barrier when blood and tissue have to be collected”.

Phelps is working on the effort to create a policy by which the Navajo Nation would approve genetic-research projects and maintain control of DNA samples. The research-ethics board run by the tribal government’s department of health is working with tribal officials and traditional leaders and holding a series of public hearings to solicit opinions on the matter from tribe members. The group hopes to deliver a draft proposal by the end of October. Whatever the tribe decides could influence the hundreds of other Native American groups, who have tended to be wary of genetic studies because of a history of scientists conducting research without consent or adequate privacy controls.

The Navajo Nation's new oncology centre provides part of the impetus for revisiting the genetic-research ban. It will be the first such facility on Native American lands outside of Alaska. Allowing some genetic testing at the centre could help physicians to identify the most effective therapies for each patient, says Lynette Bonar, chief executive of the Tuba City Regional Health Care Corporation in Arizona, which will run the facility.

That would match the standard of care that many Navajo people with cancer

have received at medical facilities off the reservation. And creating a repository for such genetic material on Navajo land would enable research into the genetic and environmental factors underlying a broad range of diseases, not just cancer.

So far, Phelps says, the idea of allowing some genetic research has not drawn major opposition. Many tribe members consulted about lifting the moratorium have generally supported the idea after learning how physicians could use genetic data to diagnose disease and tailor treatments. And the number of Navajo tribe members who are geneticists and medical experts has grown since 2002, bolstering the tribe's ability to evaluate proposed protocols and represent its own interests.

Fraught history

Still, some Navajo have lingering questions about whether the tribal government can protect the privacy of their genetic material and maintain control over its use. Such concerns helped to shape the current ban back in the early 2000s, when the Navajo Nation's department of health conducted an outreach campaign about genetics and medical research. "In the absence of a research code and lack of expertise at the time, they decided it was not a good time to move forward with genetic research until they were able to develop a research policy," says Nanibaa' Garrison, a member of the Navajo Nation who is a geneticist and bioethicist at Seattle Children's Hospital in Washington.

The tribe had reason to be cautious. "As Native Americans, we have a problem with trust because we have been violated so much," says David Begay, a pharmaceutical scientist at the University of New Mexico in Albuquerque and a member of the Navajo Nation's human-research review board. "In the past, our data have been misused."

Native Americans in the southwestern United States want to avoid repeating the experience of the region's Havasupai tribe. In 2004, the group sued Arizona State University in Tempe over alleged misuse of tribe members' blood samples. The Havasupai said that the samples, which had been

collected for diabetes research, had later been used in studies of schizophrenia, migration and inbreeding without their consent. The university made a settlement with the tribe in 2010, paying US$700,000 and returning the blood samples.

Sara Hull, a bioethicist at the US National Human Genome Research Institute in Bethesda, Maryland, says the case helped to change how researchers engage with the people they study, by raising awareness of the complexities of dealing with vulnerable minority populations. For Native Americans, such thorny issues can include privacy. Science-funding agencies and journals often require researchers to put the genetic data they collect into public repositories, but the relatively small size of many Native American tribes can make it easy to identify individual members in a genetic data base. In recognition of this, the US National Institutes of Health sometimes works with researchers it funds to develop methods for sharing data on a minority group without compromising its privacy.

Garrison, who is helping the Navajo Nation develop its new policy, says that the plan is likely to include rules on what types of research will be allowed, who will have access to tribe members' genetic material and information, and who will provide oversight. It is also likely to require that the tribe maintain ownership of its members' DNA samples and data.

The policy that the Navajo Nation ultimately produces could serve as a template for other Native American groups considering how — or whether — to engage with genetic research, says Ellen Clayton, a bioethicist at Vanderbilt University in Nashville, Tennessee. She expects other tribes to watch the development of the Navajo Nation's new policy. "If they reach an agreement, I think it will be influential."

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22780

Comments

Comments

There are currently no comments.

The scientist who spots fake videos

Hany Farid discusses how to detect image manipulations — and the increasing sophistication of forgers.

06 October 2017

Eli Burakian/Dartmouth College

Hany Farid.

Hany Farid, a computer scientist at Dartmouth College in Hanover, New Hampshire, specialises in detecting manipulated images and videos. Farid, who provides his services to clients as varied as universities, media organizations, and law courts, says that image manipulation is becoming both more frequent and more sophisticated. He spoke to *Nature* about the arms race to stay ahead of the forgers.

Where do you start when trying to spot a fake image?

One simple but powerful technique is reverse image search. You give the image to a site such as Google Image Search or TinEye, and they show you all other instances of it. A project at Columbia University, in New York City, is taking this to the next level, and starting to find parts of images that have been repurposed from other images**.**

Generally, we think about which patterns, geometries, colours or structures are going to be disrupted when someone manipulates a photo. For example, when people add an object into a scene, we know that where they put the shadow is usually wrong. A viral video called Golden Eagle Snatches Kid from 2012 is one of my favourite examples. It took us only 15 minutes of analysis to show shadow inconsistencies: the eagle and baby were computer-generated.

What about if fake images make only slight tweaks?

There are a number of analyses we can do. In a colour picture, every pixel needs three values — corresponding to the amounts of red, green and blue at that point. But in most cameras, every pixel records just one colour, and the camera fills in the gaps by taking the average values of the pixels around it. This means that, for any given colour in an image, each missing pixel has a particular correlation with its neighbours, which will be destroyed if we add or airbrush something, and we can detect that**.**

Another technique is JPEG compression. Almost every image is stored in a JPEG file, which throws away some information to save on storage. There is a huge amount of variation in how each camera does that. If a JPEG is unpacked — opened in Photoshop — and then put back together, it is always repackaged slightly differently, and we can detect that. I wish you could just upload any image and we could tell you if it’s real or not, but it’s still a very

difficult process and requires expertise to understand different components.

Who uses your digital forensic services?

I do analysis for organisations such as the Associated Press, Reuters, and *The New York Times*. There are only a handful of academics worldwide who are specialists in this, so it doesn't scale — and that means you can only do the analysis of really high-stakes images. But there are efforts under way to scale this up. Last year, the US Defense Advanced Research Projects Agency (DARPA) got into this game with a large project of which I'm part. Over the next five years they're trying to create a system that will allow you to analyse hundreds of thousands of images a day. It's a very ambitious programme.

I also do a lot of work in the courts. For example, here in the United States, child pornography is illegal, but computer-generated child pornography counts as 'protected speech' under the First Amendment. If someone's arrested they might say that the offending image isn't real, and I might have to prove that it is. I also get lots of e-mails from people about photo hoaxes — almost daily.

Do you apply your techniques to scientific papers?

I have worked on many cases of scientific misconduct, hired by universities conducting internal investigations. When I visited the US Office of Research Integrity recently, they asked me "how do we get our hands on automated tools?" The reality is we're still not there. But creating something that uses some of the tools, such as clone detection, which looks to see whether parts of an image have been copied and pasted from elsewhere, would be possible as a semi-automated process looking at dozens, not millions, of images a day. It's something my colleagues and I are thinking about, and it's a small but not insignificant part of the DARPA programme.

How about fake videos?

Researchers are now able to splice together footage to create videos of famous people seeming to say things they never said — for instance, this video of President Obama. And they can create fake images or short videos using machine learning techniques: in particular, generative adversarial networks (GANs), which learn to generate fake content. These pit a network that generates fake content against a 'classifer' network that attempts to discriminate between real and fake content, so that the faking network rapidly improves.

I've seen the technology get good enough that I'm now very concerned. In 5 or 10 years, this is going to get really good. At some point we will reach a stage where we can generate realistic video, with audio, of a world leader, and that's going to be very disconcerting. I would say that the field of digital forensics is now behind in video.

How can you detect fake video?

JPEG compression has an analogous construct in video, which is a bit harder to detect because video uses a more sophisticated version. Another approach is to use machine learning for detection. But we're taking an approach similar to what we do with images — which is based on the observation that computer-generated content lacks the imperfections that are present in a recorded video. It's created in almost too perfect a world. So one of the things we look at is, are we not seeing the statistical and geometric patterns we'd expect to see in the physical world?

Another technique is based on some beautiful work by William Freeman and colleagues at the Massachusetts Institute of Technology in Cambridge, who showed how if you magnify really small changes in a video of a person, you can see subtle changes in the colours in their face that correspond to their pulse rate. We showed that you can use this to distinguish real people from computer-generated people.

Couldn’t machine learning algorithms learn to include these features?

Perhaps in principle. But in practice, these algorithms have limited time and training data, and there is little control over which features a neural network will pick up on to discriminate between real and fake videos. A GAN is only trying to fool the classifier it’s trained on. That’s no guarantee that it will learn all aspects of what makes an image or video real or fake, or that it will fool another classifier.

My adversary will have to implement all the forensic techniques that I use, so that the neural network can learn to circumvent these analyses: for example, by adding a pulse in. In that way, I’ve made their job a little harder.

It’s an arms race. As we are developing faster, folks are creating more sophisticated technology to augment audio, images and video. The way this is going to end is that you take the ability to create a perfect fake out of the hands of the amateur. You make it harder, so it takes more time and skill, and there’s a greater risk of getting caught.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22784

Comments

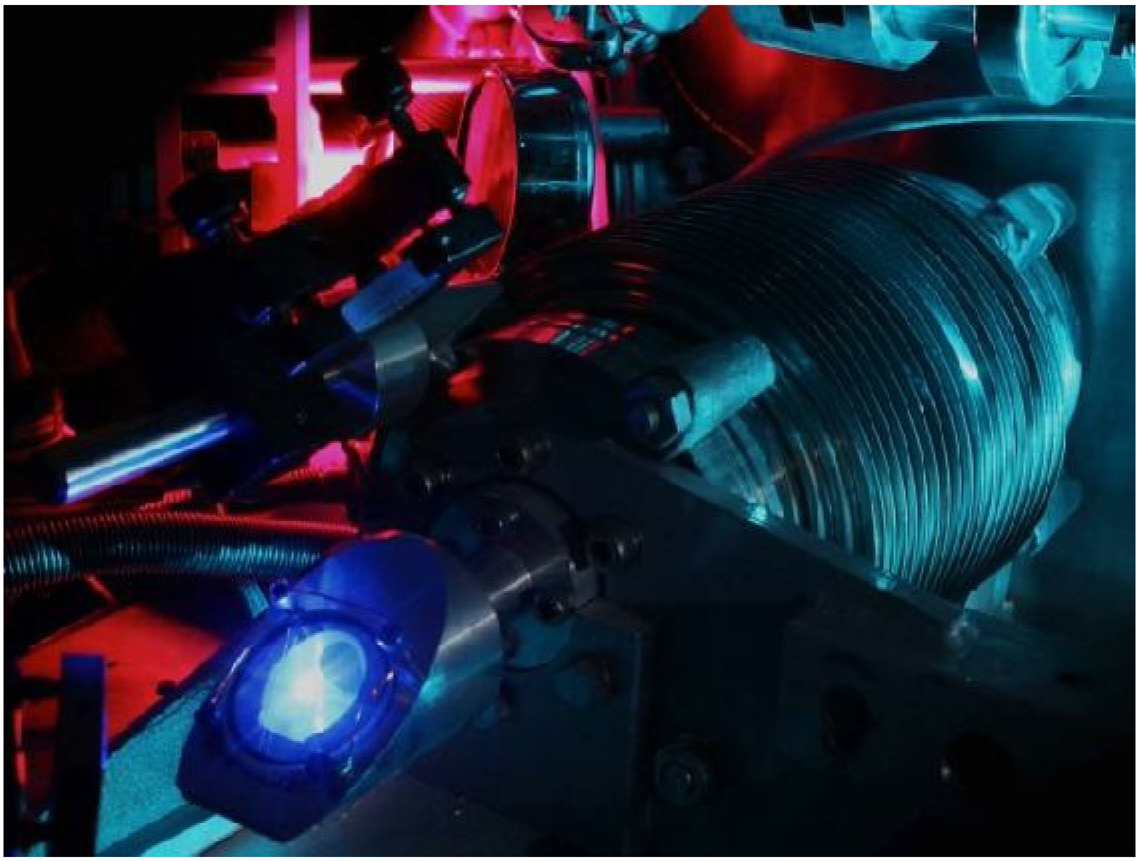
Comments

There are currently no comments.

Proton-size puzzle deepens

Measurement in ordinary hydrogen agrees with a surprising 2010 result on the element's exotic cousin — but gives a smaller value than virtually every other experiment.

05 October 2017



Axel Beyer

Researchers shone lasers at hydrogen atoms in a vacuum chamber to pinpoint the size of the protons inside.

The proton might truly be smaller than was thought. Experiments on an exotic form of hydrogen first found[1] a puzzling discrepancy with the

accepted size in 2010. Now, evidence from a German and Russian team points to a smaller value for the size of the proton with ordinary hydrogen, too.

The results, which appeared on 5 October in *Science*[2], could be the first step towards resolving a puzzle that has made physicists doubt their most precise measurements, and even their most cherished theories.

Still, “before any resolution, this new value has to be confirmed”, says Jan Bernauer, a physicist at the Massachusetts Institute of Technology in Cambridge. If other labs confirm it, he adds, “then we can find why the old experiments were wrong, hopefully”.

Method mix-up

For decades, physicists have estimated the size of the proton using one of two main techniques. Atomic physicists use spectroscopy to measure the energy levels of electrons orbiting an atomic nucleus — consisting of either the single proton in a hydrogen atom, or a bigger nucleus. The size of the nucleus affects those energies because electrons spend some time moving through the nucleus as they orbit it.

Meanwhile, nuclear physicists have used a similar technique to the one that enabled Ernest Rutherford to discover atomic nuclei in the first place. They hit the atoms with beams of fast-moving electrons and measure how the electrons bounce off.

As their precision improved, both methods roughly came to agree on a radius of about 0.8768 femtometres (millionths of a millionth of a millimetre).

But in 2010, a novel kind of experiment completed at the Paul Scherrer Institute in Villigen, Switzerland, disrupted the consensus. After a decade of unsuccessful attempts, a multinational collaboration led by Randolf Pohl, then at the Max Planck Institute of Quantum Optics (MPQ) in Garching, Germany, measured energy transitions not in ordinary hydrogen, but in lab-made ‘muonic’ hydrogen. These are atoms in which the electron has been replaced by a muon — a particle similar to an electron in most of its

properties, but 200 times more massive. The heavier particle spends more time inside the nucleus, which means that the proton's size has a much larger effect on the muon's energies — which, in turn, should lead to a much more precise estimate of the proton's radius.

Pohl's team found the proton to be 4% smaller than the accepted value. Some researchers speculated that perhaps some previously unknown physics could make muons act differently than electrons. This would have required a revision of the standard model of particle physics, which predicts that muons and electrons should be identical in every way except for their masses — and might have pointed to the existence of yet-to-be-discovered elementary particles.

Exciting technique

In the latest paper[2], Pohl, now at the Johannes Gutenberg University in Mainz, Germany, and his collaborators tickled hydrogen atoms — containing ordinary electrons — with two different lasers. The first one sent the atoms' electrons into an excited state, and the second one put them into a higher-energy excitation. The team then detected the photons that the atoms released as their electrons fell back into lower-energy excitation states.

The team combined its data with an earlier, high-precision measurement to calculate the Rydberg constant, which expresses the energy that it takes to rip the electron off the hydrogen atom. Standard theory then enabled the researchers to calculate the radius of the proton from this constant. The value they found was consistent with the muonic-hydrogen measurement, and 5% smaller than the 'official' proton radius.

To ensure that they eliminated any spurious experimental effects, the team spent three years analysing its data, says Lothar Maisenbacher, a co-author of the paper and an atomic physicist at the MPQ.

Bernauer, who works on the electron–proton scattering technique, is impressed. “It's a great experiment,” he says. “I think they really advanced their field with this.”

The care that they took is “very impressive”, and makes their measurement more reliable than many others, says Krzysztof Pachucki, a theoretical physicist at the University of Warsaw who is on the task group of the Committee on Data for Science and Technology (CODATA).

CODATA, the international agency that publishes the best-known values of the fundamental constants, is taking notice of the Mainz experiment. “We will take this result very seriously,” says Pachucki. The committee is due to revise the ‘official’ handbook of universal constants of nature next year. Because of this experiment, CODATA will "most probably” change its values for the proton radius and Rydberg constant, he says.

More evidence needed

But the German–Russian group is not quite ready to claim that the puzzle has been solved, Maisenbacher says. “We have not identified any conclusive reason why the other measurements should not be correct themselves,” he says. “We would like to see more experiments from other people.”

A number of teams around the world are doing just that. Bernauer is interested, for example, in the results of spectroscopy experiments being done at York University in Toronto, Canada. If their measurement is also small, “then I would start to believe that the old data has a problem”, Bernauer says. But that would still leave open the matter of the electron–proton scattering results.

In those experiments, researchers have conventionally used electrons that have a range of different energies. Estimating the size of the proton required extrapolating all the way to an ideal situation, in which electrons had zero energy.

Ashot Gasparian, a particle and nuclear physicist at North Carolina A&T; State University in Greensboro and his team have recently conducted an experiment at the Thomas Jefferson National Accelerator Facility in Newport News, Virginia. They injected cold hydrogen gas directly into their electron accelerator, rather than bombarding liquid hydrogen kept in a plastic box, as

was previously done. This technique enabled them to remove some experimental uncertainties and also to use electrons with lower energies than before. In principle, this could reveal whether and where the previous extrapolations went wrong. They are now analysing their data and hope to have results next year. “The ball is in our court,” says Gasparian.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22760

Comments

Comments

There are currently no comments.

Controversial pesticides found in honey samples from six continents

Neonicotinoids are at the centre of a long-running debate about whether they harm bees.

05 October 2017

Fergus Gill/2020VISION/naturepl.com

Honey is a major source of food for honey bees.

Honey bees on every continent except Antarctica face significant exposure to neonicotinoid pesticides — chemicals that some studies suggest harm bees' health. Researchers who tested honey from nearly 200 sites worldwide found that 75% of their samples contained some level of the pesticides, according to

a report published on 6 October in *Science*[1].

The study is the first attempt to quantify the presence of neonicotinoids in honey on a global scale using standardized methods. Nearly half of the samples tested contained levels of neonicotinoids at least as high as those thought, on the basis of previous research, to impair bees' brain function and slow the growth of their colonies. The study also found that 45% of the samples contained two or more types of neonicotinoid.

"It's not a surprise, in a sense, that we find neonicotinoids in honey. Anybody could have guessed that," says lead author Edward Mitchell, a biologist at the University of Neuchâtel in Switzerland. "What's original is using the same protocol. We now have a worldwide map of the situation."

The research provides additional context for the long-running debate over whether and how neonicotinoids affect bees' health. Some studies have suggested that exposure to neonicotinoids lowers honey bees' nutritional status[2] and impairs their immunity[3]. And in June, a paper published in *Science* reported that neonicotinoids lower honey bees' chances of survival during the winter, and threaten the queen in particular, which can affect reproduction[4].

To assess the scale of honey bees' exposure to neonicotinoids around the world, the authors of the new study collected honey from 198 sites on six continents through a citizen-science project. Then they tested those samples to determine the concentrations of five of the most commonly used neonicotinoids. Honey collected in North America had the highest proportion of samples containing at least one neonicotinoid, at 86%, with Asia (80%) and Europe (79%) close behind.

The extent of the contamination, even in honey from remote places — including islands in the middle of the Pacific Ocean and off the coast of West Africa — is surprising, says Amro Zayed, an insect researcher at York University in Toronto, Canada. The findings suggest that bees the world over are exposed to neonicotinoids constantly over generations, he says, which is worrying because the insects depend so heavily on honey for food. "It's one thing to go out to a restaurant and get a bad meal, but if you have your fridge

at home contaminated with insecticides, that’s an entirely different method of exposure,” Zayed says.

Others say that the widespread presence of neonicotinoids in honey is to be expected, given how commonly the chemicals are used in staple crops such as canola and wheat, as well as in home gardens. “Yes, there is going to be long-term exposure, potentially, to neonics, but that doesn’t say anything about the risk,” says Chris Cutler, an entomologist at Dalhousie University in Halifax, Canada. “Just because it’s there doesn’t necessarily mean there’s a problem.”

Much of the debate about neocotinoids has focused on just this question: how problematic are the pesticides when bees are exposed to them at low levels, but over a long period of time? “One of the issues around assessing the impacts on bees has been the discussion of what a field-relevant level of exposure actually is,” says Nigel Raine, a pollinator-health researcher at the University of Guelph in Canada. “This contributes toward that discussion substantially.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22762

Comments

Comments

There are currently no comments.

Antikythera shipwreck yields statue pieces and mystery bronze disc

Archaeologists think that at least seven life-sized sculptures are hidden nearby.

04 October 2017

Brett Seymour/EUA/ARGO 2017

Archaeologist Brendan Foley discovers a bronze disc, at first thought to be part of the Antikythera mechanism.

Marine archaeologists investigating the ancient shipwreck that yielded the Antikythera mechanism — a complex, bronze, geared device that predicted eclipses and showed the movements of the Sun, Moon and planets in the sky

— have recovered a wealth of treasures, including bronze and marble statue pieces, a sarcophagus lid and a mysterious bronze disc decorated with a bull. The artefacts were trapped under boulders in a previously unexplored part of the site near the island of Antikythera, Greece, and the researchers think that large parts of at least seven statues are still buried nearby.

The discoveries are “extremely exciting”, says Kenneth Lapatin, curator of antiquities at the J. Paul Getty Museum in Los Angeles, California. Only a handful of bronze statues survive from the ancient world, and they have almost invariably been treated and altered by previous conservators, undergoing processes that destroyed much of the information scientists might have gleaned from them. “Technology has improved so much,” says Lapatin. “We can learn from these untreated finds.”

The first-century-BC cargo ship, discovered in 1900 by sponge divers, is famous for yielding a heavily encrusted and corroded geared device that used to predict eclipses and chart the skies. The sponge divers also retrieved many other priceless items, including luxury glassware, jewellery and a two-metre-tall bronze statue, dating from the fourth century BC, nicknamed the ‘Antikythera youth’.

Statue search

Courtesy of ARGO 2017

The bronze arm was one of the most significant recent findings.

The recovery of multiple ‘orphan’ statue pieces — limbs without matching heads or bodies, for example — suggested that several statues still lie buried here. So an international team of archaeologists and divers, co-led by Brendan Foley of the University of Lund in Sweden and Theotokis Theodoulou of the Greek Ephorate of Underwater Antiquities in Athens, is now re-excavating the 50-metre-deep wreck site to look for them.

The team has made a stream of discoveries since work began in 2014, including wine jars, giant anchors, gold jewellery and a human skeleton, which is now being analysed for DNA. But the statues have remained hidden until now.

On 4 October**,** the team announced that during a 16-day dive season the previous month, they found several major statue pieces, including two marble feet attached to a plinth, part of a bronze robe or toga, and a bronze male arm, with two fingers missing but otherwise beautifully preserved. A slim build and “turning hand” gesture suggest that the arm may belong to a philosopher,

says Theodoulou.

In 1900–01, the sponge divers salvaged orphan limbs from a minimum of six bronze statues. The newly discovered arm pushes that total to at least seven, says Theodoulou. The team is particularly excited because the statue pieces were found in an area undisturbed by any previous excavations, buried beneath large boulders dislodged from Antikythera’s steep cliffs over the course of 2,000 years by periodic earthquakes. “We think this means that everything is down there still,” says Foley.

The discovery of seven bronze statues, if they could be recovered, would significantly boost the world’s total from this time period, which stands not much greater than 50, Lapatin estimates. Few of those are complete. And although these ancient figures might look beautiful, they are hard to study because the aggressive treatments by generations of conservators have altered and damaged the bronze.

Technological advances

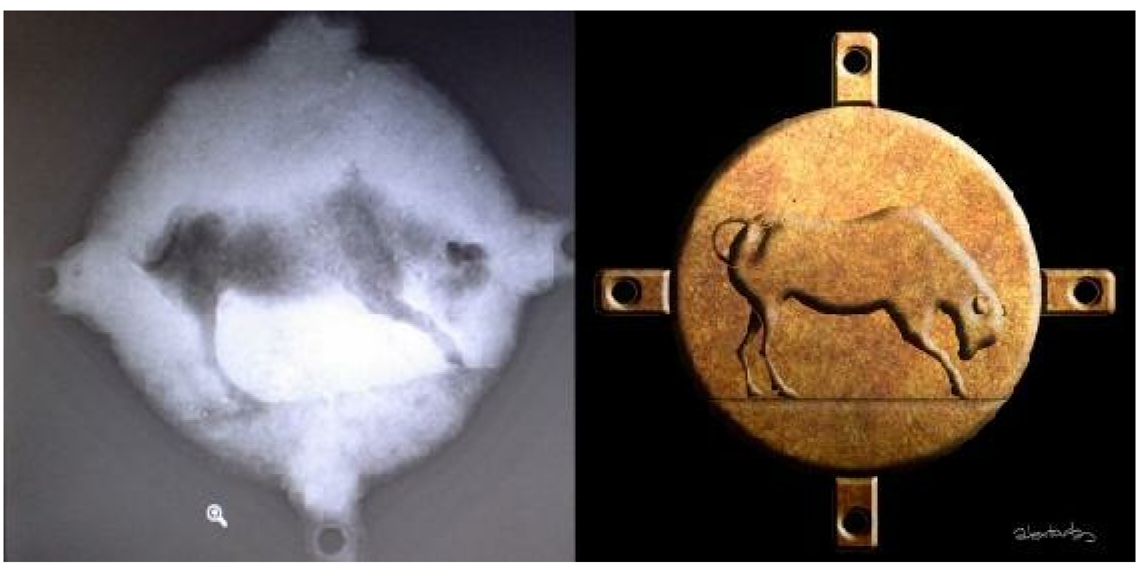
Fresh, untreated finds such as those from Antikythera will give researchers the opportunity to use modern techniques to study a significant aspect of ancient Greek life — for example, by looking at casting methods, which precise alloys were used and whether the statues were made for export or had been previously displayed. Meanwhile, any heads found might enable researchers to identify the people depicted, and to compare their likeness with any existing portraits, for example, marble statues or images etched on coins.

Brett Seymour/EUA/ARGO 2017

The bronze disc, which researchers at first thought might contain some of the lost gears of the Antikythera mechanism.

Foley and Theodoulou’s team also recovered an intriguing bronze disc or wheel, about eight centimetres across, attached to four metal arms with holes for pins. A layer of hardened sediment hides its internal structure, but it superficially resembles the Antikythera mechanism, and researchers had initially hoped that it might be part of that ancient device: perhaps the gearing that calculated the positions of the planets, which is missing from the find.

But preliminary X-ray imaging conducted in an Athens hospital on 25 September revealed a surprise: instead of gear wheels, the image of a bull appeared. The object might have been a decorative element, says Lapatin, perhaps attached to a box or a statue’s shield, or even — because of its sturdy construction — to the doomed ship. More-detailed radiography is planned for the next few weeks.



Left: EUA. Right: Alexander Tourtas.

The X-rays of the bronze disc, and artist's reconstruction of the bull.

Other discoveries this season include a sarcophagus lid made from fine, red marble, more human remains and wooden ship planks and frames that the researchers hope will reveal information about the vessel's size and shape.

The team plans to return to Antikythera in May 2018, to break up the boulders and excavate beneath. "It's going to be a major operation," says Foley. "But we think it will be spectacular."

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22735

Comments

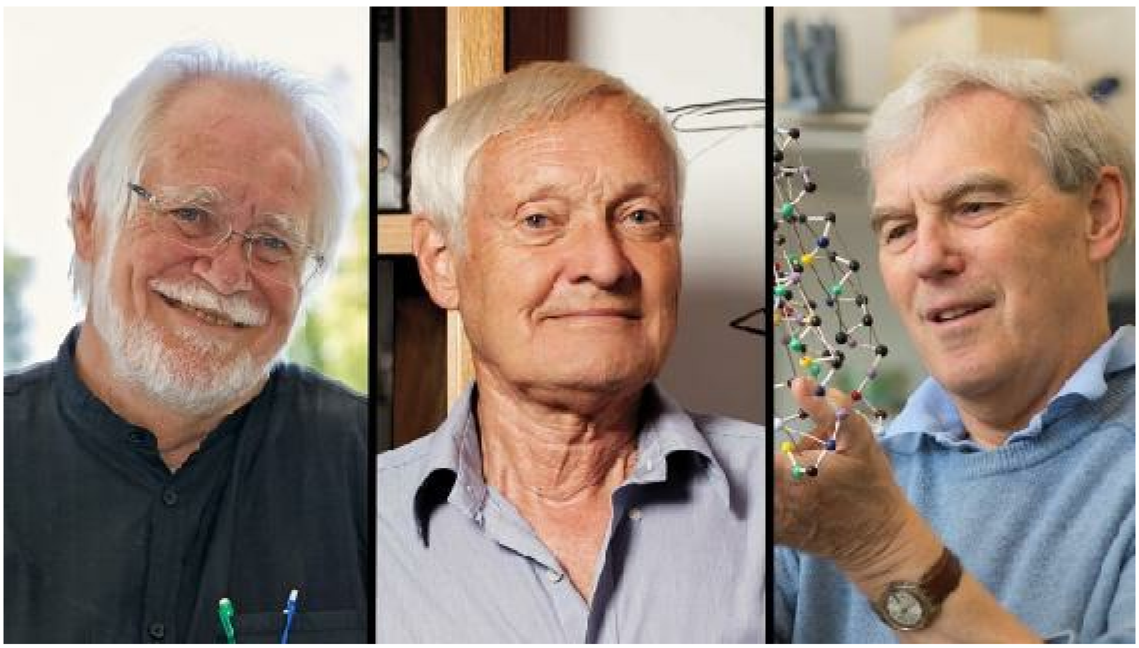
Commenting is currently unavailable.

Cryo-electron microscopy wins chemistry Nobel

Jacques Dubochet, Joachim Frank and Richard Henderson share the prize for developing a technique to image biomolecules.

04 October 2017 Corrected:

1. 05 October 2017



Left: Marietta Schupp/EMBL. Centre: Jorg Meyer. Right: LMB-MRC.

From left: Jacques Dubochet, Joachim Frank and Richard Henderson helped to develop cryo-electron microscopy.

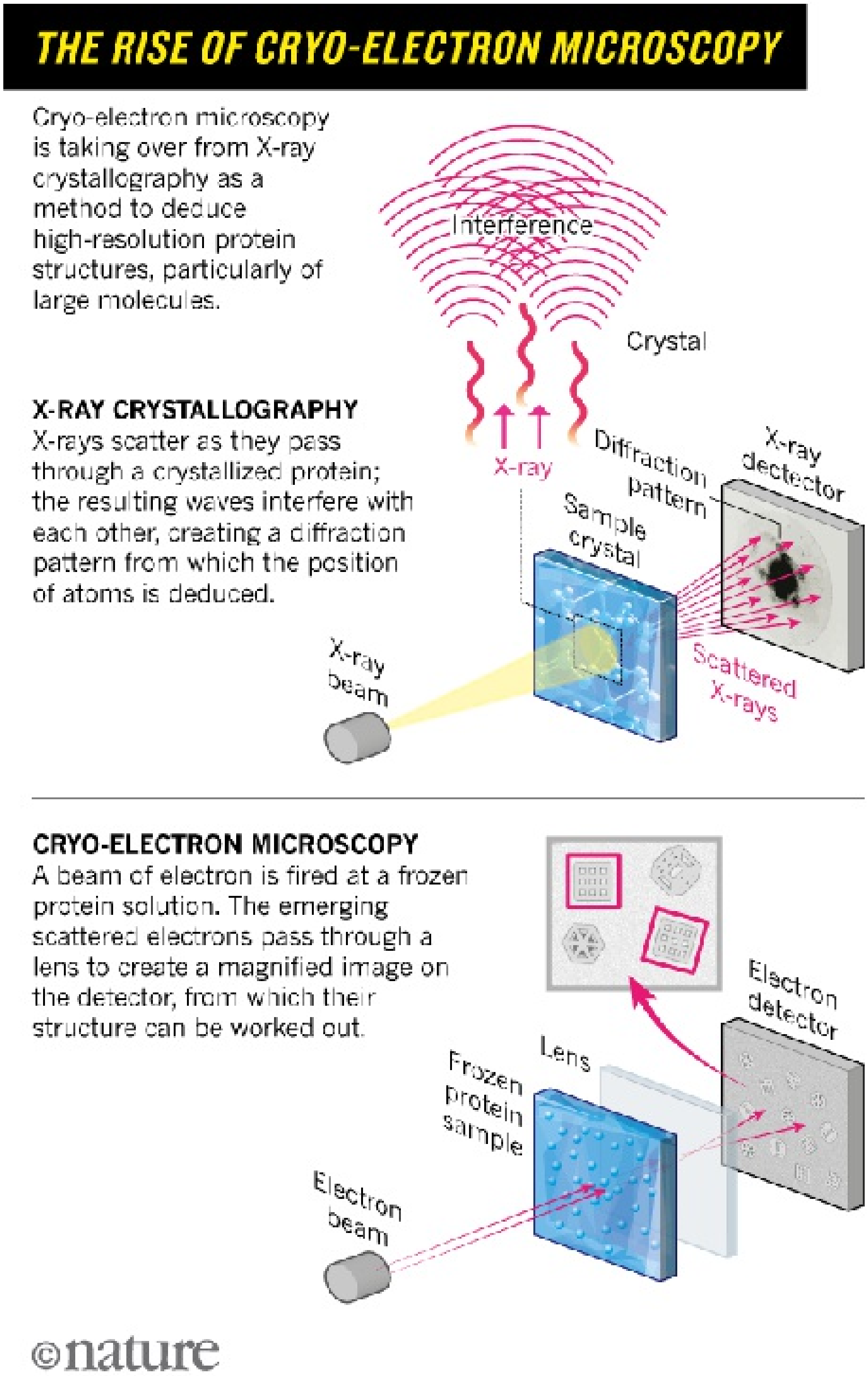
The 2017 Nobel Prize in Chemistry has been awarded for work that helps researchers see what biomolecules look like.

Jacques Dubochet, Joachim Frank and Richard Henderson were awarded the prize on 4 October for their work in developing cryo-electron microscopy (cryo-EM), a technique that fires beams of electrons at proteins that have been frozen in solution, to deduce the biomolecules’ structure.

For decades, biologists have used X-ray crystallography — blasting X-rays at crystallized proteins — to image biomolecular structures. But labs are now racing to adopt the cryo-EM method, because it can take pictures of proteins that can’t easily be formed into large crystals. The tool has “moved biochemistry into a new era”, says the Royal Swedish Academy of Sciences, which awards the prize.

Imaging solutions

In the 1970s, Henderson, a molecular biologist who works at the MRC Laboratory of Molecular Biology in Cambridge, UK, and his colleague Nigel Unwin were trying to determine the shape of a protein called bacteriorhodopsin. The molecule, which uses light energy to move protons across a cell membrane, proved unsuitable for crystallography. So the researchers turned to electron microscopy (see ‘The rise of cryo-electron microscopy’) and, in 1975, produced their first 3D model of the protein[1].



During the same decade, Frank, a biophysicist who is now based at Columbia University in New York City, and his colleagues developed image-processing software to make sense of the fuzzy pictures that are produced when an

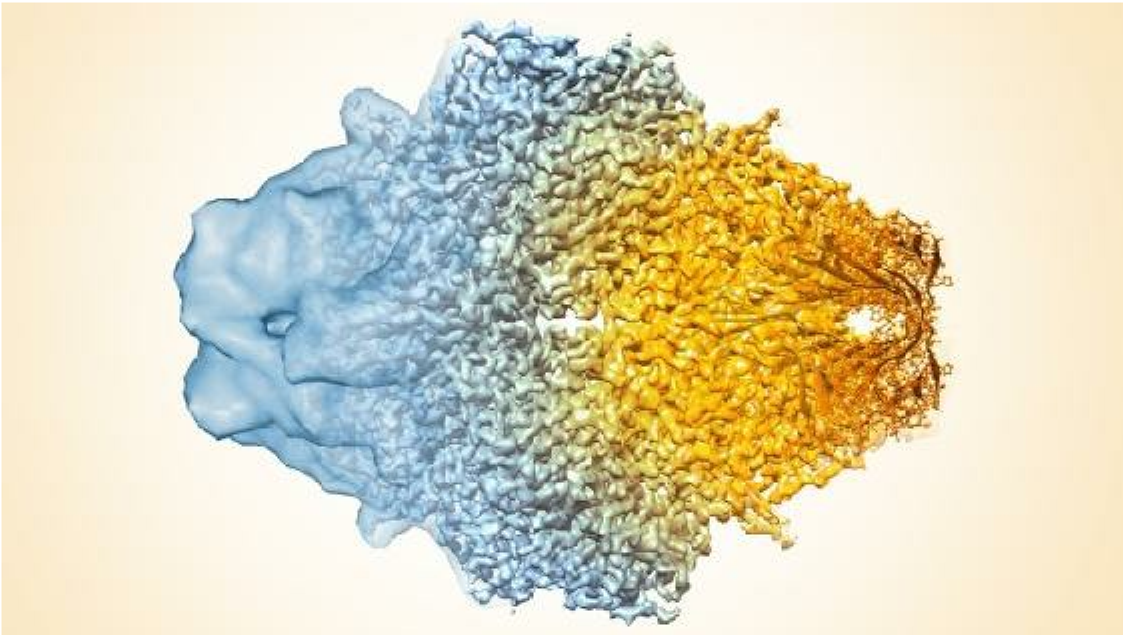
electron microscope is aimed at a protein, and to convert these two-dimensional blurs into 3D molecular structures.

In the early 1980s, a team led by Dubochet, who is now an honorary professor at the University of Lausanne in Switzerland, worked out how to prevent water-soluble biomolecules from drying out in the vacuum of an electron microscope, allowing the molecules to retain their natural shape during imaging. His team found a way to flash-freeze solutions of proteins using liquid ethane, keeping the molecules relatively still when they were pummelled with electrons. This allowed researchers to use electron microscopes to determine the structures of proteins at much higher resolution than before.

These and other improvements enabled Henderson to create the first atomic-resolution images of a protein using cryo-EM in 1990[2].

Resolution revolution

Although the research recognized by the Nobel Committee was conducted in the 1970s and 1980s, it laid the groundwork for what many scientists have dubbed a revolution in recent years. Subsequent improvements in the sensitivity of electron microscopes and in software used to transform their images into 3D structures have caused many labs to favour the technique over X-ray crystallography.



V. Falconieri, S. Subramaniam, NCI-NIH

Cryo-electron microscopy of proteins such as this β-galaxtosidase enzyme has progressed from the low-resolution density map on the left to the atomic coordinates on the right.

Frank told journalists gathered at the Royal Swedish Academy of Sciences in Stockholm that technological innovations can have a larger impact than discoveries. “Cryo-electron microscopy is about to completely transform structural biology,” he said. He added that the ribosome — the machinery that makes proteins inside cells — was the “coolest” molecule he had imaged.

Venki Ramakrishnan, a structural biologist at the Laboratory of Molecular Biology who shared the 2009 Nobel Prize in Chemistry for his work to reveal the structure of the ribosome using X-ray crystallography, is one of many converts to cryo-EM. After learning about the award from a *Nature* journalist, he said: “Oh, fantastic! Those are exactly the people I thought should win the Nobel prize.”

Benoît Zuber, a structural biologist at the University of Bern in Switzerland, who did his PhD with Dubochet, says his mentor was always confident that

cryo-EM would become a vital tool, even as others derided the field as “blobology” for the low-resolution molecular images it captured.“He had a vision and he was convinced about it, even when everybody was telling him that this was just a dream," says Zuber.

“It’s a great recognition for all the developments that have happened in the past. It’s fantastic,” says Sjors Scheres, a cryo-EM specialist who works alongside Henderson. The two were returning from a conference in Leicester, UK, yesterday, when Scheres asked Henderson whether he would keep his phone close in case the Nobel Committee called. “He said, ‘I think they should give it to Jacques Dubochet.’ He would never say that he should get one,” Scheres says. “It’s a well-deserved trio.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22738

Corrections

Corrected:

This story originally indicated that bacteriorhodopsin moves proteins across the cell membrane. In fact, it moves protons.

Comments

Commenting is currently unavailable.

Crash in sea-turtle births stumps ecologists

Leading suspect — climate change — doesn’t fully explain what is happening to leatherback turtles in the US Virgin Islands.

04 October 2017

Jurgen Freund/NPL/Getty

While buried in the sand, sea-turtle eggs are very sensitive to several environmental conditions that affect whether they hatch or not.

The mystery behind a dramatic fall in the number of leatherback sea-turtle (*Dermochelys coriacea*) hatchlings in the US Virgin Islands remains unsolved, despite the latest efforts of researchers. Rising temperatures and

changes in rainfall patterns — the top two suspects — don't seem to be connected to the decline, according to a study published on 4 October[1]. The finding contradicts previous work, leaving researchers scratching their heads over what could be happening.

The latest study focused on a nesting beach in the Sandy Point National Wildlife Refuge on St Croix island in the Caribbean Sea. The researchers found that about 74% of the leatherback sea-turtle eggs laid there in 1990 hatched, but that rate had plummeted to 55% by 2010.

The study analysed detailed temperature and precipitation data at these nests over the 20 years, and found no corresponding trend in either climate-change factor that could fully account for the decline. The researchers reported their results in *Royal Society Open Science*.

Increases in temperature and more-erratic precipitation patterns do affect the nests, but they aren't the sole reason for the hatching declines, says Anthony Rafferty, a marine biologist at Monash University in Melbourne, Australia, and a study co-author.

This trend is especially confusing in light of the increase in the adult sea-turtle population. "The number of nesting females and the population size has been trending upwards at this site," Rafferty says. "But there's been a decrease in hatching success that we are worried about." That could have negative effects on leatherback populations within one or two decades, he says, when those hatchlings come of age.

Conundrum continues

"It's hard to say how much of that is happening because of climate change," says Vincent Saba, a climate scientist at the US National Oceanic and Atmospheric Administration in Princeton, New Jersey. He co-authored a 2015 study[2] that did find a relationship between air temperature, precipitation patterns and declines in leatherback hatching success. That study examined data from 1982 to 2010 and looked at seasonal rainfall, unlike the latest paper, which analysed rainfall only during the nesting season. The study predicted that, by 2100, Sandy Point would have the most unfavourable climate conditions out of all leatherback nesting sites around the world.

“I like the study. They looked at the effect of climate in finer detail,” says Pilar Santidrián Tomillo, a marine biologist and science director of the Leatherback Trust, based in Playa Grande, Costa Rica. She was a co-author on the 2015 study, and appreciates the fuller picture of what could be happening at Sandy Point that the most recent study has provided.

Sea-turtle eggs are exquisitely sensitive to climate because heat, carbon dioxide, oxygen and water all pass freely through their permeable shells. The surrounding temperatures determine the sex of the hatchlings: warmer conditions produce more females, whereas cooler conditions yield males. And rainfall can influence hatchling development and their ability to escape the nest, says Rafferty. Too little rain might mean that the sand is too dry for the young turtles to climb out of it; too much rain during the early stages of egg development might lead to a reduction in oxygen supplies to the growing embryo.

“I think changes in precipitation levels or patterns could explain the decline in hatching success partially, but there could be other reasons, too, like decline in fertility or increase in pollutants, for example,” Santidrián Tomillo says.

Rafferty, who specializes in embryo research, now plans to look at how the age and health of a female sea turtle might affect her fertility, or where she lays her eggs.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22748

Comments

Comments

There are currently no comments.

Scientists plead with Brazilian government to restore funding

If officials don't act soon, research institutions could start shutting down next year.

04 October 2017

Leonardo Benassatto/Reuters

Protests against Brazilian president Michel Temer's policies have consumed the country amid severe budget cuts this year.

Anxiety is growing in Brazil over the country’s collapsing research budgets. President Michel Temer had slashed funding for science by 44% in March and has proposed additional decreases for 2018 — even as some science

institutes run out of money for basic needs, such as paying electricity bills. The 2017 science budget, at 3.2 billion reais (US$1 billion), is the lowest the country has seen in at least 12 years.

On 3 October, the government announced that it will release 440 million reais to science agencies to help keep them afloat until the end of this year. But the money is only about 20% of what's needed, said the Brazilian Society for the Advancement of Science in a statement.

Researchers continue to voice their alarm, with a march scheduled for 8 October in São Paulo — the third such demonstration this year protesting the funding shortfalls. And on 10 October, a public awareness campaign called *Conhecimento Sem Cortes* (Knowledge without cuts) will deliver a petition to Congress with more than 80,000 signatures protesting both the cuts and a 2016 constitutional amendment that put a 20-year cap on federal spending.

Last week, 23 Nobel laureates and nine of the country's scientific societies warned Temer that continued budget reductions will seriously jeopardize Brazil's future. They say that the ongoing uncertainty over science funding risks dismantling research groups and prompting a brain drain.

They all hope to influence a revision of the 2018 budget proposal — first submitted to Congress by the executive branch in August — which included a 16% cut to the Ministry of Science, Technology, Innovations and Communications (MCTIC). The Temer administration has promised to release a revised budget in the coming weeks.

On life support

If the 16% cut remains, it would leave a total of about 2.7 billion reais for 22 federal laboratories and research institutes, 73 National Science and Technology Institutes and Brazil's major science funding agencies, the National Council for Scientific and Technological Development (CNPq) and the Funding Authority for Studies and Projects. "This means institutions will shut down by August next year", says physicist Luiz Davidovich, president of the Brazilian Academy of Sciences.

Davidovich's estimate is based on what has happened this year. MCTIC started 2017 at 5 billion reais, its smallest budget in a decade when adjusted for inflation. In March, after the 44% cut, the ministry was left with 2.8 billion reais, not including money for special projects such as the Sirius synchrotron. The budget rises to 3.2 billion reais with those projects. As a result, institutions began running out of cash in September.

“We don’t have money for electricity bills or for buying radiopharmaceuticals”, says José Augusto Perrotta at the federal Institute of Nuclear and Energy Research. Perrotta is the coordinator of the multi-purpose reactor, a 1.6-billion-reais project that is facing delays because of a lack of funding. This year, the reactor was supposed to receive 106 million reais but got nothing.

The Brazilian Center for Physics Research isn’t doing much better. “We‘ll be able to see it through December without layoffs, but next year I’ll have to cancel all equipment maintenance contracts”, says Ronald Shellard, the centre’s director. The institution’s proposed 2018 budget is 7.8 million reais — well below the 12.7 million reais Shellard says it needs to survive.

Brazil’s 1.6-billion-reais Sirius synchrotron is also in jeopardy. The 2018 budget proposal doesn’t provide funding for the facility’s construction, which is slated for completion in mid-2018.

The build is still on schedule after science minister Gilberto Kassab unfroze 85 million reais this month, says Antonio José Roque da Silva, director of the Brazilian Synchrotron Light Laboratory and head of the project. However, the synchrotron will need an additional 331 million reais to complete construction. “I pay contractors with cash, not with promises,” says Roque.

A skeleton crew

Also at risk is Brazil’s collaboration with CERN, Europe’s particle-physics laboratory near Geneva in Switzerland. The 2017 budget cuts eliminated Brazil’s financial support for CERN, and the proposed 2018 budget doesn’t resume those payments.

The biggest threat, however, is to CNPq, Brazil’s main source of federal research grants. The agency hasn’t paid out the grants it green-lit last year, didn’t launch its annual call for project proposals this year and is 400 million reais short of what it needs to honour its commitments in 2017. If the situation isn’t sorted, Marcelo Morales, a CNPq executive director, fears a repeat of 2016, when scholarships for undergraduates and scientists abroad were suspended.

The continuing funding crisis is already driving away students and young scientists. Sergio Ferreira, a neuroscientist at the Federal University of Rio de Janeiro, runs a lab whose budget has gone downhill since 2014. It's now an average of 85,000 reais — one-tenth of what it used to be. This year, five of Ferreira’s graduate students had to spend six months abroad working with his collaborators because he couldn’t afford the materials the students needed for their research.

“In my group I have several people who have left or are about to leave for good, with no plans to come back”, Ferreira says. “I can’t keep a skeleton colony of students.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22757

Comments

Comments

There are currently no comments.

Supercomputer redesign of aeroplane wing mirrors bird anatomy

Bird-bone structures emerge from an evolution-like algorithm.

04 October 2017

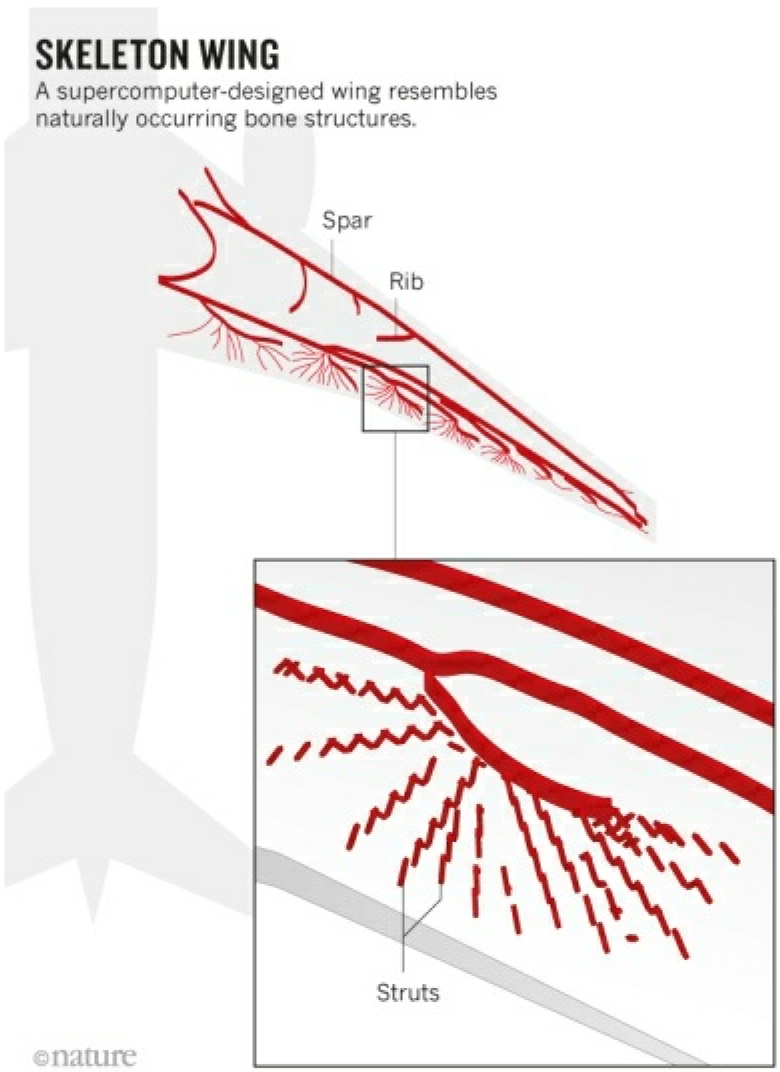
Samuel Taylor/Alamy

Conventional aeroplane wings are supported by straight bars and struts, but a supercomputer has suggested a more organic design.

Engineers have used a supercomputing technique that mimics natural selection to design the internal structure of an aircraft wing from scratch. The

resulting blueprint is not only lighter than existing wings, it also resembles natural formations, such as bird wing bones, that are not present in current aeroplanes. The organic-looking product is as stiff as a conventional aircraft wing but lighter, which could save up to 200 tonnes of fuel per year per plane.

“This is a really nice illustration of how to employ computing-based optimization methods at immensely high resolution,” says Matthew Santer, an aerospace engineer at Imperial College London. The method could feed into the design process, although there are a number of hurdles to using it in aerospace applications in its present form, he adds.



Engineers have been using these kinds of optimization techniques for around

20 years, but only for smaller-scale problems, such as individual wing components, or much simpler structures, says Niels Aage, an engineer at the Technical University of Denmark, near Copenhagen, who led the work[1]. Aage and his colleagues used the Curie supercomputer in Bruyères-le-Châtel near Paris to increase the resolution, enabling them to model the entire 27-metre-long wing of a Boeing 777.

The team started with a wing outline already optimized for maximum lift and minimum drag, known as an aerofoil, and split it into 1.1 billion 3D pixels or ‘voxels’. Each is about the size of the smallest Lego brick — a resolution roughly 200 times greater than previous efforts. The algorithm began by simulating the force exerted on every block and distributing material in response to where the wing experienced a load. Without any human guidance, the program then repeated the analysis several hundred times, adding or removing material depending on the strain felt by each brick, until it reached a final optimum design. “The structure evolves through each design cycle," says Aage. "The process has many similarities to nature’s own evolution."

Organic flight

Unlike conventional wings, the resulting structure did not contain the usual straight beams running the length of the wings, interspersed by crossing supports. Instead, the design looks organic, says Aage. Curved supports fan out at the trailing edge of the wing, resembling the bones in birds’ wings, and intricate support structures in the leading edge look like the internal structure of a beak.

Without compromising stiffness (resistance to deformation), the design weighs 2–5% less than conventional wing structures. That translates into 200–500 kilograms per wing, potentially saving each plane between 40 and 200 tonnes of fuel per year, say the authors. The technique could also be applied to other industries, says Aage, for example, to design high-rise buildings in earthquake-prone zones that maintain their stiffness yet can withstand the dynamics of a quake. It could be used to optimize acoustics, ventilation systems and antennas, as well, he adds.

The technique’s high resolution, which allows the computer to design structures that include features that range in size from millimetres up to tens of metres, could lead to more-innovative designs in these other disciplines, says Liang Xia, a computational engineer at the Huazhong University of Science and Technology in Wuhan, China. But he stresses that running the algorithm requires a heavy computing burden — the equivalent of running a single standard computer for 100 years. This computing cost could be reduced, however, if the team were to employ more-advanced simulation methods, used in artificial intelligence, which in effect model only parts of the wing in such high resolution.

The design is also too intricate to be made by existing manufacturing methods, and would require a giant 3D printer to build. But for now, key aspects of it could be fed into structures produced using conventional methods, says Aage. “We’re speeding up evolution rapidly, meaning we can see how designs should be, and then extract the key features — or those we can afford.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22759

Comments

Commenting is currently unavailable.

Elite Hungarian university may be saved

Hungary-New York agreement could allow Central European University to sidestep law change.

04 October 2017

Bernadett Szabo/REUTERS

Seventy thousand people protested in Budapest last April against a law apparently targeting the Central European University.

The prestigious Central European University (CEU) in Budapest, Hungary, seems to have found a way around a threat to close it down. The university had been affected by a law change that is widely thought to be politically

motivated.

The threat arose in April, when the government rushed through an amendment to its higher-education law, requiring that all international universities operating in Hungary had also to operate as higher-education institutes in their countries of origin.

The law change seriously affected only the CEU, which is legally registered in New York state. The university was founded in 1991 by Hungarian-born philanthropist George Soros, whom Hungarian Prime Minister Viktor Orbán has described as an enemy, because of Soros’s statements in support of refugees, which run counter to Orbán's policies. The revised law, which includes other, smaller amendments, comes into effect on 11 October.

New York connection

A CEU spokesperson said on 3 October that the university has now signed a Memorandum of Understanding with Bard College in Annandale-on-Hudson, New York, to provide educational activities. She added that negotiations between the State of New York and the government of Hungary, which opened at the end of June, have now concluded, although the agreement still has to be signed off by Hungary’s government and Parliament.

The law change sparked immediate protest last April, when 70,000 protestors took to the streets in Budapest, and the Hungarian Academy of Sciences expressed concern. The European Commission is pursuing an infringement procedure against what it sees as an illegal restriction of academic freedom, and an investigation by legal experts of the Council of Europe, a powerful human-rights organization with 47 member states, published a preliminary opinion in August indicating that the law was inappropriate.

“It’s no secret that it has been a hell of a way to treat a university,” says CEU rector Michael Ignatieff.

The university has nearly 1,500 mostly postgraduate students from more than a hundred countries, including a large number from Hungary. It operates mainly in the humanities, but recently expanded to include the cognitive and

network sciences.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22761

Comments

Comments

There are currently no comments.

| 章节菜单 | 主菜单 |

Science without walls is good for all

International mobility and collaboration are linked to stronger research.

04 October 2017

David Williams/Bloomberg/Getty

New studies highlight how closing borders would be bad for science.

Some US biotechnology labs have responded to President Donald Trump's attempts to restrict immigration by releasing contrasting group photographs showing what less-open international borders would do to their workforces. A first image typically shows everyone who works in the lab. A second image includes only those who are permanent US residents, then just US citizens, and then only those who were born in the United States and whose parents also were (see, for example, go.nature.com/2ft02xj). The shrinkage

from the first to the last image is striking — in some cases, about two-thirds of staff are lost. This reflects a widespread reality in research. A 2012 analysis showed that more than 60% of postdocs in the United States grew up overseas (see *Nature* **490,** 326–329; 2012).

When it comes to co-authorship, researchers in Europe are the most international. In 1981, only about one in six papers by a European scientist included co-authors from a different country. By 2011, that had risen to one in two. Papers with authors from more than one country also tend to be more highly cited (J. Adams *Nature* **497,** 557–560; 2013) .

This week, *Nature*'s Comment section publishes two bibliometric analyses that suggest international mobility has similar science-boosting effects.

The first finds that researchers build strong links between nations as they travel around the world. The authors track 16 million individuals who published papers in 2008–15. Only about 4% of these people changed countries, but those who did had 40% higher average citation rates than those publishing solely in one region, a trend that held true across 13 regions. Importantly, mobile scientists retained ties in the countries they left.

The second argues that countries with mobile scientific workforces produce papers that are more highly cited. (These are the same countries that have the greatest fraction of internationally authored papers.) The analysis shows that a nation's willingness to let scientists cross borders was a better predictor of highly cited papers than was the proportion of its gross domestic product that it spent on research.

These are complex issues. Citation rates are not necessarily a sign of quality, influence or long-term importance. And many confounding factors hamper attempts to link policies to impact. Still, such studies are necessary to provide evidence for policies on how to best support the scientific system.

The benefits of international movement are not entirely clear-cut. Leading scientists who change institutional affiliation (but not country) seem to boost both output and impact (G. Halevi *et al. Publ. Res. Q.* **32,** 22–37; 2016). Further work could reveal whether international papers — or more-open countries — prompt more innovative or worthy science. Details of the

relative benefits of collaboration, or how the effects of an international move are mediated by discipline or career stage, must be teased out. So must the effects of particular policies, such as the ease with which potential trainees and working scientists acquire visas or other travel support.

There is a bigger question: does the flow of leading scientists into a country bring tangible benefits for the citizens whose taxes fund their work? What about when one country's funds flow to a scientist's international collaborators? Evidence from patents and technological advances suggests that such investment is rewarded. But attention must be paid to ensure that a nation's connection to elite international scientists also supports work on local interests and needs.

Meanwhile, the scientific powerhouses of the United States and the United Kingdom seem determined to close their doors. US travel restrictions put in place last week tell working scientists from eight countries to stay away. And Britain's departure from the European Union puts scientific collaboration and access to European funds at serious risk.

Many nations with more-welcoming attitudes are poised to benefit. One long-term trend is clear: existing scientific powerhouses are not destined to stand forever. The picture can change — and quickly.

Journal name:
Nature
Volume:
550,
Pages:
7–8
Date published:
(05 October 2017)
DOI:
doi:10.1038/550007b

Comments

Comments

There are currently no comments.

Nobel prizes, giant telescope and buried treasure

The week in science: 29 September–5 October 2017.

04 October 2017

Events | Research | Funding | Facilities | People | Trend watch

EVENTS

Antikythera wreck yields more treasures Marine archaeologists investigating an ancient shipwreck near the island of Antikythera, Greece, announced on 4 October that they have recovered bronze and marble statue pieces, a sarcophagus lid and a mysterious bronze disc decorated with a bull. The cargo ship, which dates to the first century bc and was rediscovered in 1900, is famous for yielding the Antikythera mechanism, a complex bronze geared device that showed the movements of the Sun, Moon and planets in the sky. A team led by archaeologists Brendan Foley of Lund University, Sweden, and Theotokis Theodoulou of the Greek Ephorate of Underwater Antiquities in Athens found the latest artefacts under boulders in a previously unexplored part of the site. They think that at least seven complete statues are still buried nearby.

Brett Seymour/EUA/ARGO 2017

The bronze disc found near the shipwreck.

Volcano threats More than 100,000 residents on the Indonesian island of Bali have reportedly been evacuated to shelters following increased seismic activity from Mount Agung. The government's Center for Volcanology and Geological Hazard Mitigation said on 29 September that, on the basis of the latest information, an eruption was still a probability. Meanwhile, in Vanuatu, the government ordered the evacuation of all residents of Ambae island — about 11,000 people — on 28 September, after Manaro Voui started ejecting lava, poisonous gas and ash. On 1 October, the Vanuatu Meteorology and Geo-hazards Department said the volcano's activity was settling, and a large eruption was less likely. However, as *Nature* went to press, evacuations continued.

Time capsule On an Arctic island, scientists have buried a stainless-steel tube stuffed with artefacts that they say sum up science and technology in 2017. The time capsule, placed in an out-of-use borehole near the Polish

Polar Station in Hornsund, Svalbard, contains samples that include DNA, silicon-based electronics, an ancient meteorite fragment and other items to inform a future discoverer of our present understanding of technology, geology and biology. A team with the Polish Academy of Sciences described the capsule — created to celebrate the sixtieth anniversary of Poland's polar station — in a report in *Gondwana Research* on 28 September.

RESEARCH

Space-time ripples Physicists have announced the first discovery of gravitational waves made together by observatories in Europe and the United States, and the fourth-such discovery overall. At a 27 September press conference, researchers said that on 14 August, both the Virgo observatory near Pisa, Italy, and the twin laboratories of the US Advanced Laser Interferometer Gravitational-Wave Observatory (LIGO) in Livingston, Louisiana, and Hanford, Washington, had picked up gravitational vibrations emanating from a pair of merging black holes 540 million parsecs (1.8 billion light years) away. Observing the event with three detectors, rather than LIGO's two, enabled scientists to pinpoint the location of and distance to the black holes with much greater accuracy. Virgo rejoined the hunt for the waves only on 1 August, after a five-year upgrade.

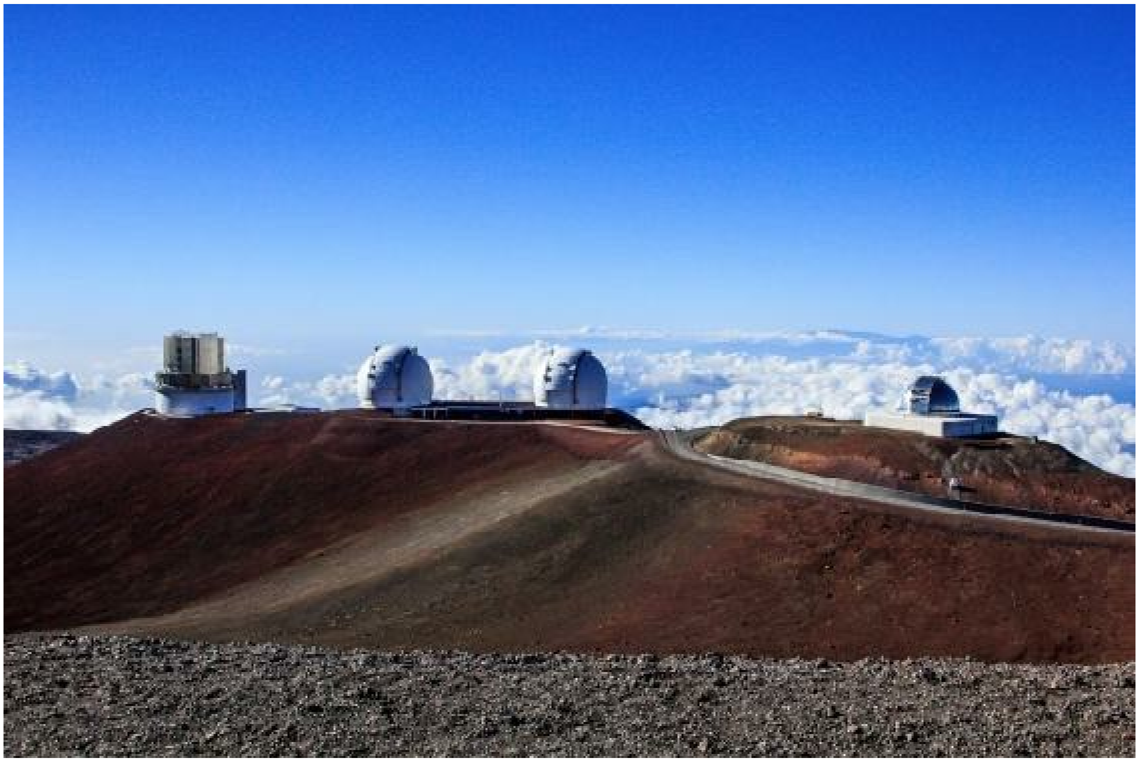
Monkey research The US Food and Drug Administration (FDA) has suspended a study on the effects of nicotine on monkeys after activists, including primatologist Jane Goodall, decried the experiments as cruel. On 25 September, FDA commissioner Scott Gottlieb responded to a 7 September letter from Goodall that called the experiments unnecessary, given that the effects of smoking are well known. The study, which began in 2014 at the FDA's lab in Jefferson, Arkansas, allows monkeys to self-administer nicotine. Gottlieb told Goodall that it would be halted while a team of experts assesses the monkeys' health and determines whether more precautions are needed. The team will also decide whether the study should resume.

FUNDING

French budget French research funding is set for a heartening increase in the country's first budget under President Emmanuel Macron, if draft 2018 plans released on 27 September are voted into law. The research portfolio of France's ministry of higher education, research and innovation would rise by more than 6%, to €8.4 billion (US$9.9 billion) in 2018. And a giant economic-recovery plan unveiled on 25 September by Prime Minister Edouard Philippe should divert an extra €2.4 billion to research over the next five years. Separately, in a 26 September speech, Macron backed the idea of a European Union funding agency to accelerate the commercial applications of basic science, an idea also suggested by EU research commissioner Carlos Moedas.

FACILITIES

Hawaii telescope Hawaii's board of land and natural resources granted a new construction permit to the Thirty Meter Telescope (TMT) on 28 September, reviving the chances that it could be built on the Hawaiian mountain of Mauna Kea. Some Native Hawaiians oppose the TMT, saying that its construction would further violate the sacred mountain, which already hosts multiple telescopes. Hawaii's supreme court invalidated the TMT's first construction permit in December 2015, ruling that the board had not followed appropriate procedures. The new permit gives the project the right to proceed on Mauna Kea, but telescope opponents have filed motions that would put the permit on hold until the state supreme court can hear an appeal.



Julie Thurston/Getty

PEOPLE

Nobel prizes Three biologists were awarded this year's Nobel Prize in Physiology or Medicine for their work on circadian clocks. Jeffrey Hall and Michael Rosbash, both at Brandeis University in Waltham, Massachusetts, split the award with Michael Young at Rockefeller University in New York City. The physics prize was awarded to Rainer Weiss, at the Massachusetts Institute of Technology in Cambridge, and Barry Barish and Kip Thorne, both at the California Institute of Technology in Pasadena, for their work on detecting gravitational waves. *Nature* went to press before the chemistry prize was awarded, but full details will be available at go.nature.com/chem2017.

Science adviser On 26 September, Canadian prime minister Justin Trudeau appointed biochemist Mona Nemer as his country's chief government science adviser, fulfilling his campaign promise to establish the position. Nemer was

most recently vice-president of research at the University of Ottawa and director of the Molecular Genetics and Cardiac Regeneration Laboratory there. Her scientific work has focused on the genetics of cardiovascular disease and birth defects. In her new role, Nemer will have a budget of Can$2 million (US$1.6 million) and report to Trudeau and science minister Kirsty Duncan. The country has been without a science adviser for nearly a decade; the last time such a post existed was from 2004 to 2008.

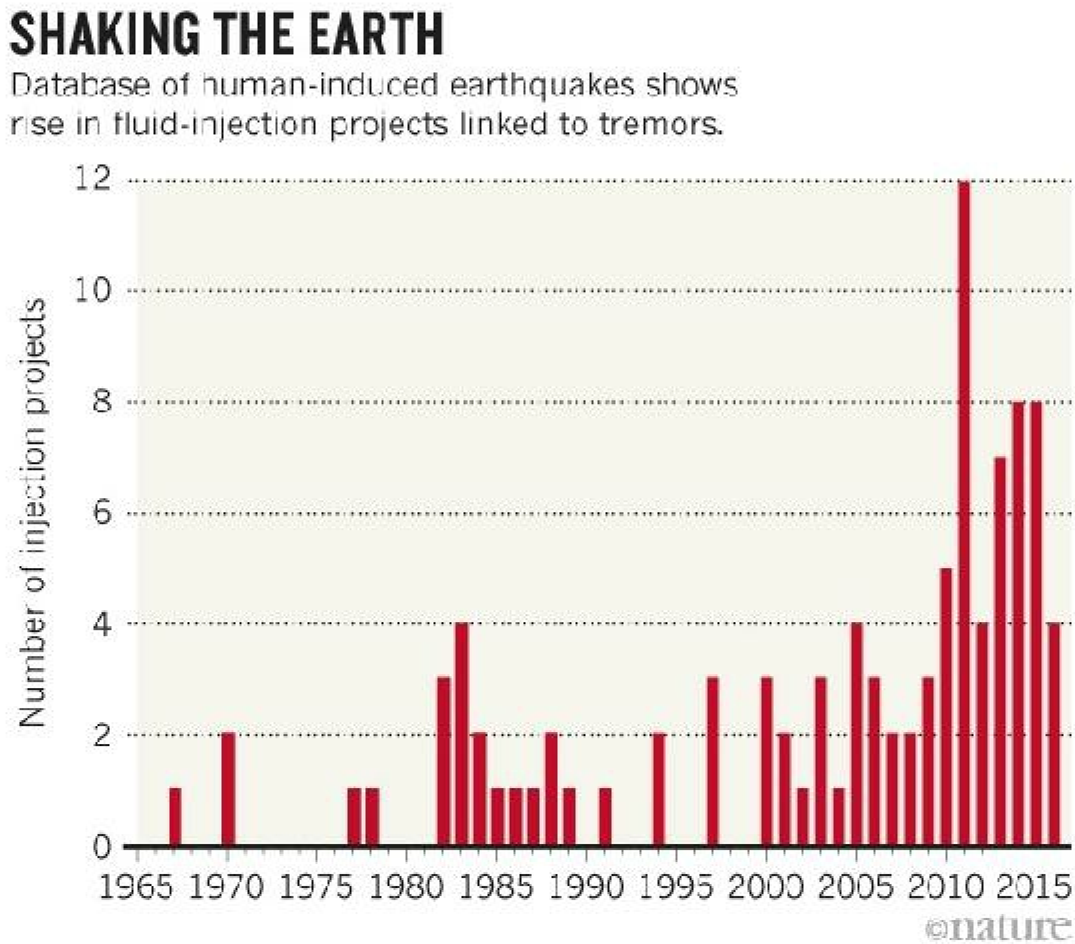
Russian academy After almost six months without a head, the Russian Academy of Sciences (RAS) has a new president: Alexander Sergeyev, a laser physicist and director of the RAS Institute of Applied Physics in Nizhny Novgorod. The academy, which operates a network of hundreds of institutes, is undergoing controversial reforms. In March, its planned presidential elections were unexpectedly cancelled at the last minute, allegedly following a row over voting procedures (see *Nature* **543,** 601; 2017). In the latest elections announced on 26 September, Sergeyev won a majority of votes from the academy's general assembly. A new state law requires that Russia's president Vladimir Putin must also approve the post, which he did the following day.

Defraud alert The FBI has charged bioengineer Yiheng Percival Zhang with defrauding the US government and his employer, the university Virginia Tech in Blacksburg. Zhang was arrested on 20 September and will remain in custody pending a trial, according to court documents. In an affidavit in support of a criminal complaint filed on 18 September, the FBI alleged that Zhang and two of his colleagues at the Tianjin Institute of Industrial Biotechnology in China — Zhiguang Zhu and Chun You — conspired to win US National Science Foundation (NSF) grants for studies that had already been completed in China. The affidavit also claims that Zhang withheld a portion of funds owed to his university from NSF and Department of Energy grants.

TREND WATCH

A database of human-induced earthquakes reveals a rise in tremors linked to wastewater injected into the ground by oil and gas operations. Such projects

spiked in the early 2010s, particularly in the central United States. The HiQuake database is described in *Seismological Research Letters*. Of 728 entries, 37% are linked to mining, 23% to water piling up behind a dam and 15% to conventional oil and gas development. Just 4% are linked to hydraulic fracturing, or fracking, for oil and gas.



Source: M. P. Wilson et al. Seismol. Res. Lett. http://dx.doi.org/10.1785/0220170112 (2017)

Journal name:
Nature
Volume:
550,
Pages:

12–13
Date published:
(05 October 2017)
DOI:
doi:10.1038/550012a

Comments

Comments

There are currently no comments.

Why fake islands might be a real boon for science

The seasteading movement is getting close to building its first prototype, an artificial archipelago where people will live, play and do research.

04 October 2017

Blue Frontiers

Early designs for a floating island in Tahiti aim to mimic a natural landscape.

The view is unbeatable. To the right, steep volcanic mountains, draped in green, rise up from a beachside coconut grove. To the left, the Pacific Ocean glitters turquoise under the midday sun. It is here in this Tahitian lagoon that a group of entrepreneurs plans to build an artificial island — three-quarters of a hectare of floating housing and research space, made up of linked platforms. If the team is successful, the vision could become reality by 2020. But it would be just the first step, says self-described “seavangelist” Joe Quirk. The ultimate goal is to build whole sovereign nations on the open seas, composed of modular floating units.

“French Polynesia has all the stepping stones: lagoons, atolls, shallow waters

right next to deeper waters," Quirk says.

Quirk, one of five managing directors for the company behind the project, and his colleagues propose that artificial islands could serve as laboratories for testing out new technologies and exploring different social structures, or act as life rafts for coastal peoples displaced by sea-level rise.

The non-profit Seasteading Institute was founded by former Google engineer Patri Friedman in 2008, and it has garnered support from influential people in the linked worlds of Silicon Valley, libertarian politics and the anything-goes desert festival, Burning Man. Most media reports have been sceptical, however. The project has been characterized as the dream of "two guys with a blog and a love of Ayn Rand"[1] and "a hacker's approach to government with a *Waterworld*-esque conception of Manifest Destiny"[2].

But the Seasteading Institute and the new for-profit spin-off, Blue Frontiers, have racked up some real-world achievements in the past year. They signed a memorandum of understanding with the government of French Polynesia in January that lays the groundwork for the construction of their prototype. And they gained momentum from a conference of interested parties in Tahiti in May, which hundreds of people attended. The project's focus has shifted from building a libertarian oasis to hosting experiments in governance styles and showcasing a smorgasbord of sustainable technologies for, among other things, desalination, renewable energy and floating food-production. The shift has brought some gravitas to the undertaking, and some ecologists have taken interest in the possibilities of full-time floating laboratories.

LISTEN

Reporter Geoff Marsh investigates ambitious plans to build artificial floating cities.

You may need a more recent browser or to install the latest version of the Adobe Flash Plugin.
Go to full podcast

But the project still faces some formidable challenges. The team must convince the people of French Polynesia that the synthetic islands will benefit them; it must raise enough money to actually build the prototype, which it estimates will cost up to US$60 million; and once it is built, the group must convince the world that artificial floating islands are more than just a gimmick. Producing solid science and broadly useful technology would go a long way towards making that case.

“What we are dreaming is that this structure will be a scientific laboratory,” says Winiki Sage, head of the Economic, Social, and Cultural Council of French Polynesia in Tahiti, who has been concerned about brain drain from his country.

Aesthetic appeal

Designs are surfacing for the prototype island, and its look is a key part of Blue Frontiers's public-relations strategy. The company's current plans don't entirely align with the concept art on the Seasteading Institute's website, which swings from tiki bar to Tomorrowland in various iterations. Bart Roeffen, a 'water pioneer' at the Dutch design firm Blue21 in Delft, has been drawing up new plans that fit with the landscape and culture.

“We are working together with Tahitian designers to make something that is not like an alien invasion,” Roeffen says. In particular, he plans to take cues from Polynesian shipbuilding. The elegant outrigger canoes, or *va'a*, used by islanders are stable and light; oceangoing versions are the type of boat rowed by the Tahitian voyagers who discovered Hawaii and New Zealand around AD 1100. Linked platforms would be arranged to ensure that no coral below is completely shaded and killed. The goal is to actually expand the habitat for reef species (see 'Seasteaders in paradise').

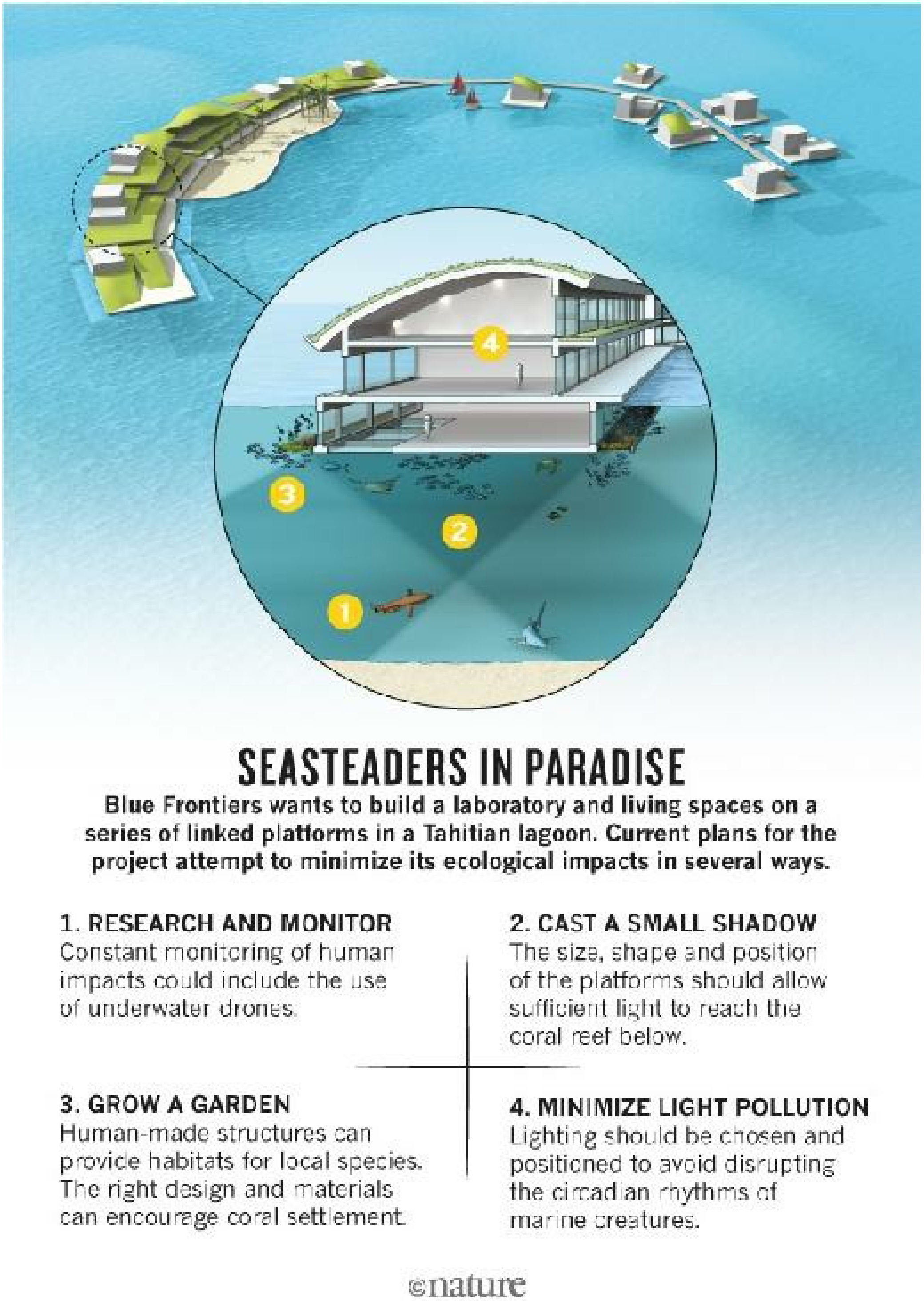


Illustration by Emily Cooper

The team would not provide direct information about funding. Paypal

founder and one-time Donald Trump enthusiast Peter Thiel provided a reported $1.7 million to the Seasteading Institute, but he last contributed to the project in 2014, and any recent investors are keeping a low profile. Quirk says that they have “a nice amount” of seed money and are preparing for what is called an initial coin offering — an investment mechanism that uses digital cryptocurrency. Looking ahead, the company hopes to generate revenue by renting out space on the island and acting as consultants for other would-be island builders. Along with hiring Quirk and the other four managing directors, Blue Frontiers has recruited ten staff members and commissioned environmental, legal and economic studies on the impacts of the project for investors and the government.

The “why?” — everyone's first question about seasteading — is answered differently by everyone involved. Some are captivated by the project because it is an excuse to push sustainable design to the next level. For people on low-lying islands, it looks like a life raft. Félix Tokoragi, mayor of Makemo, an atoll in the Tuamotu archipelago in French Polynesia, told Blue Frontiers that he's interested. The Tuamotus have experienced widespread flooding, and Tokoragi is worried that his people will become climate-change refugees. “We are attached to our atoll; we are attached to our culture,” he says. “We are not against this idea, since the technology can respond to the problems that we face.”

For others, the pull of the project comes down to autonomy and self-reliance, particularly with respect to governance: anyone who decides their island's political style is not for them can detach and depart for another system that they like better.

For at least one scientist advising the project, Neil Davies, executive director of a field station of the University of California, Berkeley, on the neighbouring island of Moorea, the island's appeal is as a base for research that would “fill the gap between oceanographic-research vessels and coastal marine labs”. Ships are on the water, but they are “phenomenally expensive”, he says, and they don't stay put. Coastal labs can gather long time-series of data in one place, but don't provide access to deeper water. Davies dreams about floating “sea stations” that would allow low-cost, long-term access to the ocean for research, especially for students in tropical countries “where

natural systems are among the most sensitive to human activities”, he says. Experiments could include modifying pH or temperature on small sections of a reef to simulate future environmental conditions, and 'planting' different corals to investigate which will thrive best in the future. Data could be gathered using semi-permanent sensors and cameras, along with regular biological-sample collection.

Some scientists not involved in the project see value in the concept, as well. “If you have a floating island and you want long-term study, that is a perfect way to do it,” says Ross Barnes, marine-operations superintendent at the University of Hawaii Marine Center in Honolulu, who oversees two large research vessels and on-shore labs. The university has been conducting research at a spot in the ocean that it calls Station ALOHA, which scientists have visited nearly 300 times by boat since 1988. A floating platform, he says, would mean that scientists could leave behind some instruments — and that some of them could stay as well — allowing for continuous measurement. “It's a good idea,” Barnes says.

Currently, Davies is advising the seasteaders on site selection and environmentally positive design choices. He also plans to help them to document the installation's performance using sensors that measure things such as energy expenditure and waste generation on the platforms, as well as water temperature and quality. And he sees it as a great teaching opportunity for the many students who visit his station. “Seasteading raises many social, legal, ethical, environmental issues, even if it never gets anywhere,” he says.

Whether the seasteaders make progress depends on whether the project is embraced by French Polynesia, a largely autonomous 'overseas collectivity' of France with a population of 287,000 on 67 islands spread out across an area nearly the size of Europe. At one level, a grand floating project could appeal to a nation of voyagers and boat builders. But French Polynesia has been burnt by big-science and technology projects before. From 1966 to 1996, France conducted 193 nuclear tests in its Polynesian possessions, many in the atmosphere. In February 2016, then-president of France François Hollande admitted that the testing had harmed the environment and human health. And the place is littered with defunct projects and closed hotels.

“We have a history of being taken for fools,” says Pauline Sillinger, a

sustainable-development specialist at Te Ora Naho, a federation of environmental groups in French Polynesia, who took a job with Blue Frontiers this year, and also teaches Tahitian dance. “Nuclear testing, big hotels, nice, smiling, white, intelligent people telling us it'll be good for us.”

But their wariness vies against their desperation for new revenue streams, Sage says. After winding down nuclear testing, France began paying French Polynesia more than US$100 million per year in compensation for lost income from military activity. But in 2016, that amount was reduced. Meanwhile, tourism revenues have never recovered from the 2008 recession. Thanks to increased political stability and other factors, things have improved since 2014, when the collectivity was so broke that it risked not being able to pay its civil servants, according to Sage. But it is still dangerously reliant on a small number of income sources — tourism, pearls, coconut oil. Unemployment stands at nearly 18%. “We are looking for new ideas,” Sage says. “We are really open to any ideas, any investors.”

If Sage is sceptical but willing to give it a shot, there are others who have had enough of grandiose project ideas. Among them is a religious leader in Tahiti, Frère Maxime Chan, who heads Association 193, which advocates on behalf of those harmed by nuclear testing. Chan is also vice-president of Te Ora Naho. (Sage, incidentally, is the organization's president.) Chan says that his old friend Sage and the rest of the government are “dazzled” by the flash and money of the Seasteaders. He talks about recent projects — including a tourist resort, an aquaculture scheme and an eco-resort — that were all announced with fanfare and optimistic job projections, only to be cancelled, scaled back or put on indefinite hold. Chan wishes the government would admit that the standard of living for the average Tahitian has been artificially inflated by nuclear-test payments and must come down. This can be done without suffering, Chan contends, by gracefully returning to a version of the pre-1960s subsistence economy. “Small is beautiful,” he says.

Convincing French Polynesia to support the project will fall mainly to Marc Collins, another managing director of Blue Frontiers. Collins is Tahitian and lives there now, but in the early 1990s he lived in Silicon Valley, and fell in love with its fast-paced culture of big ideas and endless possibility. Ever since, he's kept his toe in those waters in part by maintaining a subscription to

Wired magazine. In May 2015, the digital lifestyle glossy ran a story[3] about how the seasteading movement planned to scale back its grand, high-seas concept, reorienting towards safer, shallower waters and looking for “cost-reducing solutions within the territorial waters of a host nation”.

Collins, a serial entrepreneur who has dabbled in every major French Polynesian industry, from hotels to black pearls and telecommunications, saw an opportunity to, as he puts it, “bring some of the DNA of Silicon Valley to Tahiti”. Tahiti joined the world of high-speed Internet in 2010, with the completion of an undersea fibre-optic cable linking it to Hawaii. It has calm lagoons aplenty and daily flights from Los Angeles, California, and, as a minor bonus, is widely regarded as paradise on Earth. Collins fired off a LinkedIn request to the Seasteading Institute's executive director, Randolph Hencken.

The Seasteaders were interested in Collins's pitch, but they wanted a more official gesture of support. So Collins, who served as French Polynesia's minister of tourism in 2007 and 2008, began working his government contacts. By August, the president of French Polynesia, Édouard Fritch, signed a letter formally inviting the Seasteaders to present their ideas. A delegation of nine took him up on the offer the next month, and by January, a memorandum of understanding with pledges of cooperation was signed.

The next step in making the island a reality will be the passage of a law defining the 'special economic zone' that will cover the synthetic island. Blue Frontiers isn't asking French Polynesia for any subsidies to build the island, but it is asking for a 0% tax rate, among other regulatory exceptions. It has hired French firm GB2A, based in Paris, to prepare legal research and a set of requests, which Blue Frontiers presented to the government at the end of September. The team hopes to see a bill emerge before the end of the year.

In the meantime, the Seasteading Institute is building excitement and courting potential investors with a series of gatherings. In May, it held talks, networking events and tours in Tahiti. Speakers included Fritch; Tony Hsieh, chief executive of online retailer Zappos in Las Vegas, Nevada; Tua Pittman, a master canoe navigator from the Cook Islands; and engineers, nanotechnologists and a 'blockchain strategist', a specialist in the distributed information systems behind cryptocurrencies. The seasteaders hope to use

such systems to handle their financials, as well as any scientific data that they generate. But the event wasn't all work. An announcement for a party on outrigger canoes cheerfully suggested: “Do not wear heels. Bring a swimsuit for an optional moonlight swim.”

On 22–29 October, Blue Frontiers will hold an Insiders Access Week for supporters and potential investors, a mix of tours, discussion and morning yoga with Hencken. Always ambitious, the team hopes to have draft legislation from the Polynesian government by then, and some detailed architectural plans. The goal is to break ground — or rather, sea — in 2018.

While all this work goes on behind the scenes, the lagoon remains fairly quiet. On a day in July, locals compete in a stand-up paddle-board race while families play on the shore and young women drink beer with their feet in the waves. By the roadside, freshly caught tuna are for sale. On one level, it is hard to imagine this place being improved upon.

Time will tell whether the Seasteaders' island becomes a refuge for Polynesians facing rising seas and an incubator for Polynesian science and business, or merely a playground for wealthy foreigners who want to dodge bothersome regulations. That is, if it materializes at all.

Journal name:
Nature
Volume:
550,
Pages:
22–24
Date published:
(05 October 2017)
DOI:
doi:10.1038/550022a

Comments

Comments

There are currently no comments.

Scientists have most impact when they're free to move

04 October 2017

An analysis of researchers' global mobility reveals that limiting the circulation of scholars will damage the scientific system, say Cassidy R. Sugimoto and colleagues.

Spencer Platt/Getty Images

Measuring the global movements of researchers will help to assess the effects of political actions on science.

Recent political upheavals portend an era of increased isolationism in

science, with a chilling effect on collaboration and mobility. Last month, US President Donald Trump issued his third travel ban in a year, suspending entry of individuals from several countries into the United States, and placing restrictions on many more for visa renewals. These orders have stranded scholars abroad and prevented those who were in the country from engaging in international work. In March, UK Prime Minister Theresa May began the process of formally severing ties with the European Union. As a result, British institutions face a potential exodus of non-resident EU researchers and will have to overcome barriers to participating in and receiving funding for European collaborative projects. The list of countries engaging in these isolationist actions, and the list of actions themselves, grows longer.

To assess the impacts of such political actions, we need better ways to measure researcher mobility. Although the size and composition of the scientific workforce is fairly well established through national surveys and registries[1], less is known about how often researchers move, where they go, what networks they form, and how important their movement is to the scientific impact of their work[2].

We present here a new analysis based on the records of 14 million papers from nearly 16 million unique individuals who published between 2008 and 2015. In our study, some 96% of researchers had only one country of affiliation; we classed these as non-mobile. About 4% (more than 595,000 researchers) were mobile — meaning that they had more than one affiliation during that period. Our analysis revealed surprising trends.

Chain reaction

Over the study period, Europe and Asia saw a dramatic net loss of researchers, whereas North America saw large gains. Many commentators have anguished about 'brain drain' or 'brain gain', assuming that receiving countries get the lion's share of scientific capital at the expense of the nations from which researchers originate. The reality is more complicated (see 'Brain circulation').

We found that the majority of scientists didn't cut ties with their country of

origin but instead built a chain of affiliations that linked nations together. Many researchers returned to their home country. Brain circulation may be a more apt term for the movement of contemporary scholars[3].

Different nations have different roles in the circulation of elite scholars (for which our proxy is highly cited researchers). But wherever they are, wherever they stop off and wherever they come from, mobile scholars have about 40% higher citation rates, on average, than non-mobile ones (see Supplementary Information; Table S7). Closing borders takes these elite scholars out of circulation.

Origin stories

Our study looks at the country stated in a researcher's affiliation when they published their first paper, and uses this as their country of scientific origin (this should not be confused with where they were born). We then track whether they moved or gained new affiliations in other countries over the eight years of this study.

The conventional idea of mobility focuses on migrant researchers — those who begin publishing in one country and then move to another, at some point discontinuing their attachment to the previous country. This group made up less than one-third of the mobile researchers in our study (27.3%, or 162,519 researchers). By far the largest proportion were those we call travellers: scholars who retain a footing in their country (or countries) of scientific origin throughout their career, while gathering up more international affiliations to add to their name (72.7%, or 433,375 researchers). Nearly half of the travellers are 'non-directional': they have more than one affiliation in their first year of publication, and they retain all these affiliations in each publication year.

Circulation networks that map the number and flow of researchers reveal the importance of the United States, United Kingdom, France, Canada and Germany as prominent nodes in the global scientific network (see Supplementary Figure S2). Isolation of these countries would have dramatic consequences. Although the United Kingdom is not particularly central to researcher migration in the European Union, it serves a crucial function in providing a bridge for European scientists to other areas of the world (see Supplementary Figure S2). Isolationist policies in the United Kingdom could deconstruct this network, redirecting scholars through other countries.

More patterns emerge if we look only at migrants and directional travellers who moved between and within continents, who first published in 2008, and who published at least eight papers during the study period. Admittedly, our short time window means that we focus on junior scholars. But it avoids conflating them with senior scholars whose movement and networking are likely to differ.

This group comprised 12,046 researchers. Europe provides the largest share (35%) followed by about one-quarter each from Asia and North America (see 'Making tracks'). The relationship between these latter continents is strong:

the majority of mobile scholars associated with an Asian address in their first publication in 2008 have a North American address by 2015, and more than one-third of mobile North American scientists end up in Asia. Both of these trends can probably be explained by the same underlying phenomenon — the influx of Asian students into the United States (some of whom publish before their arrival, and others of whom do so afterwards), and their subsequent moves back to Asia.

We see a 22% net loss of researchers from Europe, a 20% loss from Asia, and a nearly 50% gain for North America (see Supplementary Table S4). European scholars make up the largest population of mobile scholars in nearly every country, with the exception of Asian countries, where most scholars are drawn from North America (see 'Scientist shuffle').

It is also of interest to know the degree to which certain countries are responsible for the production and cultivation of high-impact scholars. We assess this by looking at citation scores for mobile researchers before and after their moves (see 'Trip adviser').

Countries in North America and Northern Europe act as strong producers: they put into circulation scholars who are well-cited before they move. The same countries are also strong cultivators, identifying talent early and providing fertile ground for scholars to achieve high impact once they arrive. Asian regions are strong recruiters, gaining affiliations with established scholars who were well-cited before their arrival. Oceania is a notable incubator, affiliated with scholars who realize high potential once they move on.

Some migratory routes tend to be associated with highly cited scholars. Those from North America with the highest impact tend to land in Northern and Western Europe and, to a lesser extent, in Southeastern Asia. Mobile, high-impact Northern Europeans are recruited to Southern Europe; mobile, high-impact Western Europeans are recruited to Oceania and Eastern Asia.

Mobile scholars from Oceania produce particularly high-impact work when they arrive in North America and Southern Europe. Central and Western Asian scholars (including those from countries implicated in the US immigration ban) realized their highest citation rates for work done in North

America and Europe. Barring scholars from these countries is likely to displace high-impact ones to other nations.

Regardless of region, mobility pays in terms of citations. Across all regions, mobile scholars are more highly cited than their non-mobile counterparts. The advantage varies by region. Mobile North Americans see only a 10.8% boost in citations over their non-mobile colleagues. For Eastern European scholars, the gulf is 172.8%.

Mobility measures

Of course, our method has limitations. We cannot tell if our 'country of academic origin' represents country of birth, of academic training or of academic employment — it reveals solely where an individual began publishing. If researchers from some countries tend not to publish first in a journal indexed in the Web of Science, then our measures would underestimate mobility from these places. Those we have counted as 'non-mobile' might really be 'pre-mobile' — meaning that they have not yet moved. Furthermore, examining less than a decade of papers, focusing on journal articles and adding restrictions for number of publications may privilege certain disciplines in the analysis. And our study does not look at mobility rates within each country: for large nations such as the United States, these might be significant and interesting.

Internationally comparable mobility indicators for the scientific workforce are particularly necessary in an era in which mobility is growing, complicated and increasingly threatened. We need indicators that provide more nuanced and dynamic assessments of the exchange of human capital and the effect of this exchange on the knowledge economy, particularly given that the 'travellers' in our analysis account for the majority of mobile scholars. This study provides a start.

It might be argued that collaboration can continue, even when mobility is restricted. However, despite advances in computing, collaboration tends to be initiated and sustained through interactions that happen in person[4]. Limiting mobility is likely to have adverse effects on the scientific system, which is

increasingly dependent on international collaboration[5].

Disruption of the existing network would have serious effects on many nations, including large science producers and cultivators such as the United States. The country benefits significantly both from its centrality in the global knowledge network, and from the educational investments of other countries. Its exceptional contributions are disproportionately made by researchers who are both foreign-born and foreign-educated[6]. Disconnection would also seriously affect those nations that benefit from the United States' role as a cultivator — it invests in researchers who come from Asia and elsewhere and later return home.

Some countries may see benefits, however: isolationism among central countries can lead to advantages for other competitive nations. For example, the number of graduate-student applicants to Canada has risen since the change in the US administration (see go.nature.com/2fjc4i). However, if adequate scientific capacity does not exist in these other countries, global talent will not be cultivated to the extent it is today. With good bibliometric standards to measure the impact of mobility, we can test the effects of these political changes in the decades to come.

One thing is already clear. Internationally mobile scholars are in the minority, yet show the highest impact across the globe. Limiting the circulation of scholars will damage the entire scientific system.

Journal name:
Nature
Volume:
550,
Pages:
29–31
Date published:
(05 October 2017)
DOI:
doi:10.1038/550029a

Supplementary information

PDF files

1. Supplementary information (1.6M)

Comments

Comments

There are currently no comments.

Open countries have strong science

04 October 2017

Caroline S. Wagner and Koen Jonkers find a clear correlation between a nation's scientific influence and the links it fosters with foreign researchers.

Spencer Platt/Getty

Nations that welcome international researchers and encourage cross-border collaboration tend to produce papers with high scientific impact.

International projects account for at least 20% of national government spending on scientific research. Some countries spend as much as 50% of these funds on international collaborations[1, 2]. The number of internationally co-authored papers is growing rapidly[2]. For countries at the forefront of

research, the fraction of papers that are entirely 'home grown' is falling[3].

Is there a connection? We analysed publication and citation data for 36 nations, along with government expenditures on science. We found that although government spending on research and development (R&D;) does correlate with the number of publications produced, it does not correlate with scientific impact — at least as assessed by citations, one of the few practical metrics available. What does correlate with impact is a country's openness, which we approximated by combining metrics of international co-authorship and the mobility of each nation's research workforce.

In 2016, we partnered with Jeroen Baas, head data scientist at Elsevier, the publication house that also runs the citation database Scopus, to examine nearly 2.5 million publications that were published in 2013 across all scholarly fields and that had three years' worth of citation data available. Publications and a field-weighted citation index were apportioned to countries according to authors' locations. (So if two-thirds of the authors on a publication were in the United Kingdom and one-third in Singapore, those fractions were applied to determine the publication count and citations assigned to those countries for that paper.)

In terms of papers published, the United States and China dominate. For 'international papers' (those with authors from more than one country), the United States still leads, followed by the United Kingdom, China, Germany, France and Canada. When international papers are considered as a percentage of all of a country's papers, Switzerland (42%) appears as the most connected country, followed by Belgium (38%), Singapore (37%), Austria (36%) and Denmark, the Netherlands and Sweden (all 34%). In terms of impact for international papers, Singapore tops our list, followed by the United States, and then Sweden, Belgium, Switzerland and the Netherlands.

We looked for factors that could explain this. In addition to international collaboration, scientific mobility was expected to contribute to impact[4]. So we also considered new researchers coming in, returnees and emigrating researchers, all of which are tracked by the Organisation for Economic Co-operation and Development (OECD). These variables, together with collaboration, proved to be highly correlated as measures of international

engagement; so we used them to create an index of openness and were able to assign values to 33 of the countries that we looked at (data available at go.nature.com/2fzrnt3).

To assess whether government R&D; spending (as tracked by the OECD and Eurostat, the statistical office of the European Union) and our openness measure explained the relatively higher impact for smaller countries, we used a Pearson correlation analysis, which allows comparisons to be made across a large quantitative range, such as the publication output of the United States versus that of Singapore.

Public R&D; funding is tied to publication output: the more money spent, the more articles produced (counting sole-authored, co-authored and internationally co-authored). But we found only a weak correlation between spending and impact. In other words, more government funds spent does not necessarily result in more citations.

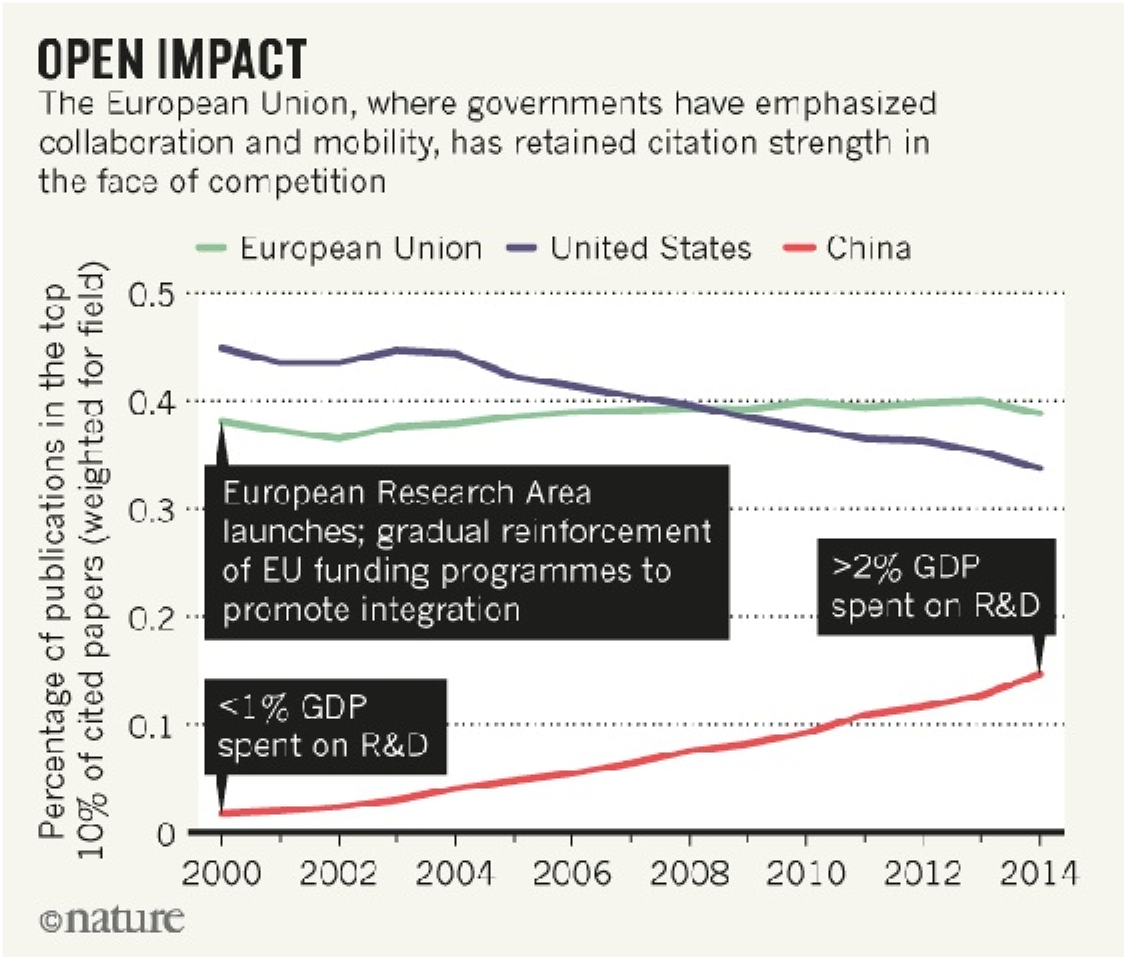
Countries that are highly 'open' and that produce high-impact research seem to benefit from participating in international collaboration. This is seen in the higher impact of smaller nations, which cluster in the top-right quadrant of the graphic (see 'Open countries have impact'). Singapore, the United Kingdom, the Netherlands, Switzerland, Sweden and Denmark all scored highly on this measure as well as on citations. The correlation between openness and citation impact was tight ($r^2 = 0.7$ according to a regression analysis) regardless of R&D; spending or numbers of articles published.

Countries with low openness and low impact include Russia, Turkey and Poland, China, Japan, Latvia, Lithuania, the Czech Republic and, against expectations, South Korea (which spends a higher percentage of its GDP on R&D; than almost every country, including the United States) These countries are shown in the lower-left quadrant.

The United States scores highly on impact, but less so on openness — perhaps because of the magnitude of its scientific enterprise and its geographic distance from possible collaborators. Of our 33 countries, only 4 (the United States, Italy, Spain and Finland) have low openness and high impact, and only 2 (Hungary and Mexico) have high openness and low impact.

Our analysis suggests that openness is related to impact, although we recognize that correlation is not causation. Nevertheless, we note that many of the countries whose scholarship has high impact, and whose policies encourage international engagement, are from Europe. The EU has established the European Research Area (ERA). Its governments have been implementing measures to strengthen domestic research systems while also promoting both international collaboration and mobility. The EU's Framework programmes have similar aims — one of the current stated objectives of EU research policy is to be more “open to the world”.

Analysis of citation strength for countries in Europe shows that they have greatly enhanced their impact compared with the United States (see 'Open impact'). As a bloc, the EU now outperforms the United States. Both far exceed China in impact, although China's share of high-impact papers is growing rapidly[5]. Other countries that promote openness also perform well in terms of impact: examples include Singapore and Australia.



EU Joint Research Centre Tools for Innovation Monitoring, based on Scopus data release August 2016

Some will argue that citation is not synonymous with quality or importance, but it does signal engagement and recognition. Studies dating as far back as 1992 show that international papers are, on average, more highly cited[6]. The countries that are engaging internationally are seeing a dividend in terms of attention to their research.

It may be that the exchange of ideas encourages greater creativity, or that a virtuous cycle of quality work attracts others to work with those in higher-impact countries. In fact, we had very similar results when we considered each component in our openness metric separately, although most of the effect of the mobility variables is mediated by international collaboration.

Analytically, it makes sense to combine these into a single variable. However, other factors — such as the ease of obtaining visas or support to study in a country — are not explicitly incorporated.

In Japan, especially, output and citation impacts have remained flat since 2000. Japan is also among the least internationalized of leading nations, and this could be dragging on its performance. Lack of professional mobility, as well as language barriers, may be hindering engagement.

Our analysis suggests that national funding programmes should, whenever possible, move away from policies that fund only national researchers. In the longer term, countries could benefit more by funding the best science, wherever it is, and ensuring that domestically based scientists are linked with it. Restricting the movement of researchers — by limiting exchange opportunities or imposing visa restrictions, for example — could be counterproductive.

Just as industries make 'build or buy' decisions, so governments must make 'link or sink' decisions about research investment. Our data add to a growing body of work about the changing science system, indicating that science policymakers who seek to enhance impact should prioritize international exchange.

Journal name:
Nature
Volume:
550,
Pages:
32–33
Date published:
(05 October 2017)
DOI:
doi:10.1038/550032a

| 章节菜单 | 主菜单 |

Collaborative software development made easy

Save time and protect critical code with 'continuous integration' services.

04 October 2017

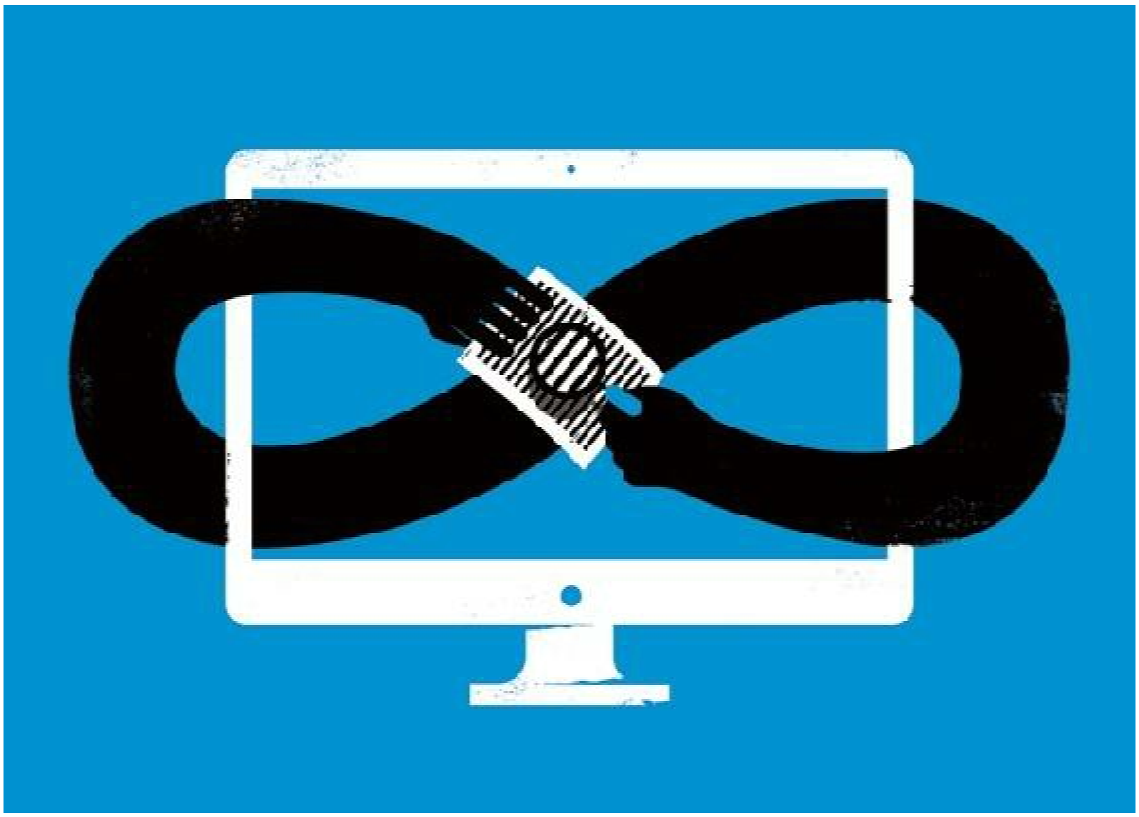


Illustration by the Project Twins

Sebastian Neubert, a particle physicist at Heidelberg University in Germany, leads a group studying subatomic particles called pentaquarks. The six team members all have access to the software code used to run their multi-step analyses, and the programmers update it daily with new features and bug fixes. With each code change, however, they run the risk of introducing

inadvertent errors that foul the underlying algorithms.

To prevent that, the team checks and rechecks the analyses, and uses error-checking algorithms, functions they can call whenever a change is proposed, to ensure that their software works as intended. One test, for example, verifies that a noise-cancelling algorithm gives the correct output when it is run on practice data.

In 2015, in an effort to save time and resources, the team took inspiration from the technology industry, automating their testing using a process called 'continuous integration'.

In continuous integration, changes to software code automatically trigger repetitive tasks, such as error-checking. Fundamentally, the process simplifies a task that diligent coders already perform. Programmers usually write lists of tests that they will run periodically to ensure that their code still works, just as Neubert's team do. But a busy team might forget or lack the time to run them, allowing errors to creep in. Continuous integration automates that process so those checks run whenever a change is proposed, saving team members the time they would spend hunting down an error. A team running genomic analyses could spend more time at the bench, while a group developing climate-prediction software could better refine its models. That said, the resulting peace of mind is only as good as the tests themselves: a poorly designed test can still allow mistakes to pass undetected.

The process is common in the commercial and open-source sectors. A study presented at the 2016 IEEE/ACM International Conference on Automated Software Engineering in Singapore found that about 40% of the 34,544 most-popular open-source projects hosted on the coding collaboration site GitHub used continuous integration in some form.

Only a few of those open-source projects might be considered scientific software, but an increasing number of scientists are looking to continuous integration to automate all sorts of time-consuming tasks, from testing code to updating documents with the latest data.

Researchers at institutions such as CERN, Europe's particle-accelerator laboratory near Geneva, Switzerland; the Pacific Northwest National

Laboratory in Richland, Washington; and the Ontario Institute for Cancer Research in Toronto, Canada, have embraced the practice, but adoption in the scientific sector remains relatively sparse.

For Neubert, continuous integration ensures that the pipeline's behaviour remains correct and consistent as his team refines its code, providing an “incredibly valuable” safeguard. “There is a real danger of just missing something or making a slight mistake,” he says.

Exceptions

A variety of continuous integration services exist. These include the open-source Drone, and commercial options such as CircleCI, Codeship, GitLab, Shippable and Travis CI, all of which offer pricing tiers based on the desired testing behaviour, number of users and whether the project is public or private. Travis CI, for instance, is free for open-source projects; private projects cost from US$69 per month. Shippable offers a free basic service for public projects, but charges $25–150 per month for support for private projects and greater computing power, among other features.

Researchers should consider what is a suitable and worthwhile investment, however. Not every project needs continuous integration and setting up and configuring a service can be challenging. Further difficulties can arise if the services need to interact with software or data with legal restrictions on its use, says Daniel Himmelstein, a data-science postdoc at the University of Pennsylvania in Philadelphia.

Also, code is often used only once, making the cost even less worthwhile. “For day-to-day research coding, the amount of code is not large enough to make continuous integration valuable,” says Andrea Zonca, a specialist in high-performance computing at the University of California, San Diego. He uses Travis CI when publishing code, but most that he writes is for his own one-time use and is not executed again.

Computing costs can also mount if code is being constantly updated and requires repeated testing, which is why Neubert's lab only tests its most

critical data analyses after code changes.

Despite these challenges, continuous integration services tend to improve code quality, says Björn Grüning, a bioinformatician at the University of Freiburg in Germany, especially on large projects such as Galaxy, a bioinformatics toolkit that Grüning, along with about 160 others, contributes to.

According to Grüning, continuous integration has shortened the turnaround time for approving contributions to the Galaxy project and given programmers more confidence when submitting new features and fixes. Before these services were available, it was often impractical for researchers in such projects to test every new feature collaborators proposed because they didn't have the time, he says.

Some researchers use continuous integration to automate non-programming tasks. In April, as part of a project studying how ecosystems change over time, Ethan White, an ecologist at the University of Florida in Gainesville, helped to configure Travis CI to update tables and plots automatically with new field or weather-station data, saving the research team up to 5 hours a month.

Continuous integration helps Himmelstein automate revisions to scientific papers, citations and web pages following text or code updates. Without continuous integration, he says, human maintainers would probably “get lazy and update the manuscript less frequently than every change”.

Initializing

Whether hosted externally by a third party or on a user's own machine, the continuous integration service is controlled with a custom set of instructions. This configuration file defines the tasks to be run and sets up the server with the correct environment — the operating system and software libraries — required to run them. The service then executes those instructions at set times or on receipt of a code or data update.

University of Pennsylvania bioinformatician Casey Greene, who uses

continuous integration to rerun his data analyses, has tested many of today's most popular services. “The good news about all of these services is that they're quite similar,” he says.

Subtle differences do exist, for instance in the number of concurrent jobs users can run, or the amount of computing power available to run them. “I'd encourage people to dig into the limits of each service to make sure they are compatible with their workflows,” advises Greene.

Although continuous integration adoption in science right now is small, it is growing, and more researchers should get on board, Greene says. Getting up to speed takes time, he acknowledges, but often, the effort is worth the reward. “Scientists analysing data should have it in their toolbox.”

Journal name:
Nature
Volume:
550,
Pages:
143–144
Date published:
(05 October 2017)
DOI:
doi:10.1038/550143a

Comments

Comments

There are currently no comments.

A taste of Toolbox

Nature's technology editor, Jeffrey Perkel, started blogging about workplace technology in science in 2016. Here are some highlights.

04 October 2017

From stadiums to genomes

Most bioinformaticians are either biologists skilled in programming or programmers with an interest in biology. Mike Goodstadt, the programmer behind the 3D genome-visualization tool TADkit, took a different approach. In the early-to-mid 1990s, Goodstadt was a student at the University of Bath, UK. His course of study? Architecture, with an emphasis on 3D modelling. After graduation, he helped to design and build a 61,500-seat stadium. But a faltering economy and newly acquired programming skills helped to steer him towards biology.

Lorena Barba, reproducibility champion

Lorena Barba, a mechanical and aerospace engineer at George Washington University in Washington DC, has long championed research reproducibility. “I've always believed that the open-source model is ideal for science, as it exposes the complete sequence of steps that produces a given result,” she says. In January, she travelled to Chile to run a week-long course on reproducible research computing. The month before, she had been awarded a 2016 Leamer-Rosenthal Prize, which celebrates those “working to forward the values of openness and transparency in research”. In this Q&A;, she talks flying snakes, 'repro-packs' and copyright.

The sound of DNA

With an alphabet comprising just four letters, a DNA sequence isn't much to look at. So when sequence-analysis tools want to highlight key elements, they typically do so using colour or font, or by overlaying other types of information. In the not-too-distant future, there may be another option. Molecular biologist and part-time drummer Mark Temple at Western Sydney University, Australia, describes DNA sonification, “an auditory display tool” for DNA: sequence in, audio out. “I'm not saying audio by itself is the bees' knees for interpreting DNA sequence,” Temple says, “but surely audio can contribute to your visual interpretation.”

Journal name:
Nature
Volume:
550,
Pages:
144
Date published:
(05 October 2017)
DOI:
doi:10.1038/550144a

Comments

Comments

There are currently no comments.

South Korea cracks down on dirty air

Despite huge clean-up effort, scientists say country’s pollution problem could get worse over next five years.

03 October 2017

Ed Jones/AFP/Getty

South Korea's capital, Seoul, ranks among the world's most polluted cities.

In a major attempt to clean its increasingly dirty air, South Korea’s government last week unveiled a five-year, 7.2 trillion won ($6.3 billion) plan to close down old coal plants, get diesel vehicles off the road and curb polluting emissions from industrial plants, construction sites and ships.

Although much of the spending had already been pledged, researchers say that the new strategy, announced on 26 September, is the country's most ambitious attempt yet to scrub its air. But because it omits controls on a class of chemicals called volatile organic compounds (VOCs), the initiative might make air quality worse before it improves.

The plan fulfils a key campaign pledge by President Moon Jae-in, who was elected in May by a Korean public increasingly concerned about their country's worsening air quality. At times this year, Seoul ranked among the world's top three most polluted cities. And the Organisation for Economic Co-operation and Development (OECD), based in Paris, reports that in 2015 South Korea's average exposure to fine-dust particles under 2.5 micrometres in size was the highest of all OECD member nations. This particulate matter, known as PM2.5, is small enough to enter the lungs and can cause respiratory illnesses.

The government hopes to cut domestic emissions of PM2.5 by 30% before 2022. Moon's administration has already focused on shutting down coal plants, temporarily closing eight of them in June and beginning the permanent shutdown of three in July. And the previous administration of Park Gyun-Hye had pledged 5 trillion won by 2020 to speed the adoption of electric cars to replace diesels.

NOx-ious crackdown

But the new strategy also aims to crack down on emissions of nitrogen oxides (NOx), which can react with other atmospheric compounds, including VOCs, sulfides and ammonia, to form ozone and fine-dust particles. Large industrial facilities such as steel plants and petroleum refineries will be fitted with monitoring equipment and held to a cap on their NOx emissions starting in 2019, the environment ministry's deputy director JaeHyun Kim says.

That approach has been informed in part by data released in July from a joint US–South Korean study called KORUS-AQ[1], says Kim. The most comprehensive examination of air quality in the region, it involved more than 580 researchers from the United States and South Korea, as well as several

research aircraft, including a NASA DC-8 jet that flew across the Korean peninsula and the Yellow Sea. Researchers found that South Korea was emitting more NOx and VOCs than its own ministry estimated, and recommended reductions in these chemicals. This highlighted the importance of addressing South Korea’s domestic pollution, says Kim, at a time when many in the country were more concerned about pollution blowing over from China.

The focus on NOx means the new plan is “a lot better than before”, says Kyung-Eun Min, an atmospheric chemist at the Gwangju Institute of Science and Technology. But she and other scientists point out that it says little about curbing VOCs. These are typically aromatic molecules produced for activities such as painting, printing and dry cleaning. A compound called toluene, used to manufacture solvents, is particularly instrumental in producing fine dust and ozone, the KORUS-AQ study found. The VOCs often leak during production, or while being stored or used by small businesses.

Ozone up?

Paradoxically, Min says, reducing NOx without reducing VOCs is likely to increase ozone across much of South Korea. That is because, according to the KORUS-AQ results and Min’s own work, relative levels of NOx are so high in Korea — especially in car-filled Seoul — that they restrict the efficiency of ozone production, much as an over-rich fuel mixture makes an engine sputter. The quickest way to cut ozone is to starve it of both NOx and VOCs, “but the VOC part is not really there,” Min says. However, regions downwind of Seoul may benefit more quickly from NOx reductions, says Rokjin Park, an air chemist at Seoul National University.

Tracking VOC emissions is particularly difficult, because there is no clear way to monitor or regulate small businesses such as painters and dry cleaners. A first step would be to collect data to nail down where South Korea’s VOCs are coming from, Min says. In the longer term, she suggests developing technology that can capture dirty air from such emissions sites so that it can be purified at treatment facilities — in a process analogous to sewage treatment.

Yong Pyo Kim, an environmental scientist at Ewha Womans University in Seoul and an author of the KORUS-AQ report, says he thinks that both ozone and fine dust could get worse for the next five years. “In my opinion, the environment ministry did not learn from the KORUS-AQ results seriously,” he says. The South Korean environment ministry has not responded to requests for comment from *Nature* about the criticisms.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22448

Comments

Comments

There are currently no comments.

Xenon view, butterfly wings and a strange squid

September’s sharpest science shots, selected by *Nature*’s photo team.

03 October 2017

CRISPR catches

Richard Wallbank/Smithsonian Institution and University of Cambridge

The beauty of butterfly wings owes much to just two genes, researchers revealed this month. They used the CRISPR gene-editing system to turn off the genes, called *WntA* and *optix*, to show how their absence dulls the colours

of these fleeting flyers. Left are the wings of an unmodified Sara longwing (*Heliconius sara sara*) from the study; right is a gene-edited version.

Inside Xenon

Image Slideshow

1. 

   Winner of a gold award in the 2017 International Images for Science competition, this picture by Enrico Sacchetti shows the interior of the Xenon1T experiment at Italy's Gran Sasso Laboratory, which hunts for dark matter.

   Enrico Sacchetti/Royal Photographic Society

2. 

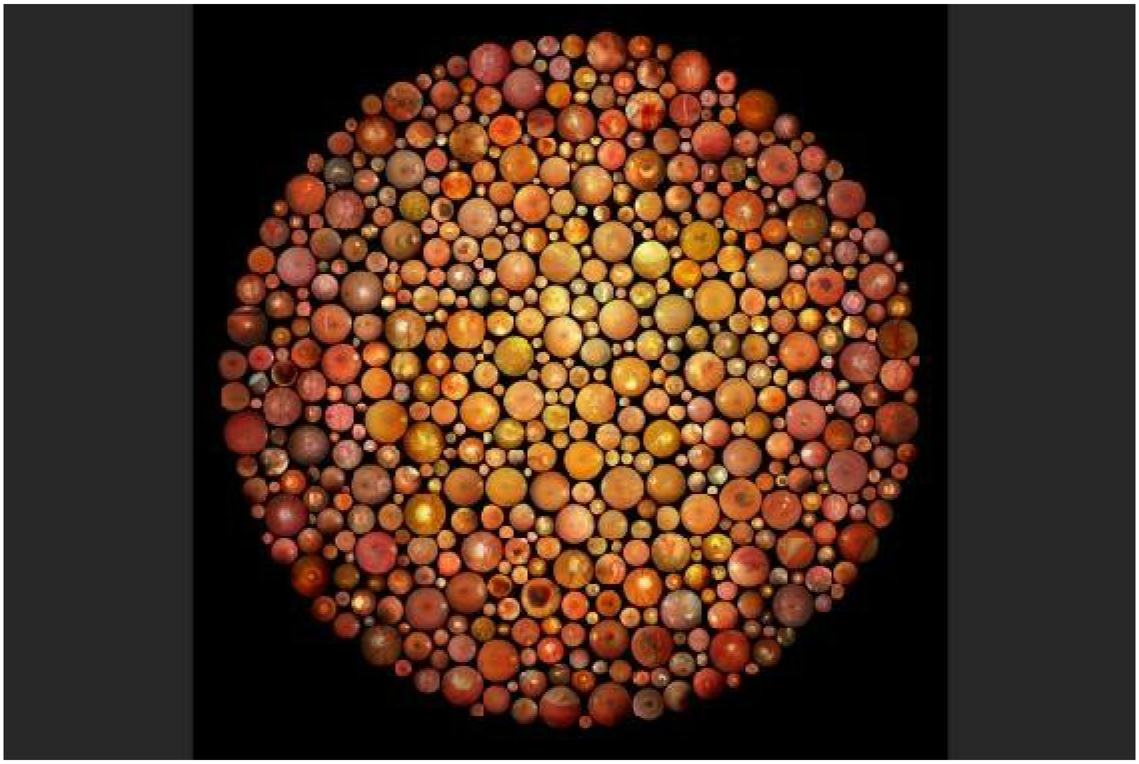
Another gold-award winner, this one taken by Teresa Zgoda. What looks like a frightening visage is actually a close-up of a pork tapeworm (*Taenia solium*), showing in detail the suckers that allow it to stick to the inside of humans and grow — and grow, and grow.

Teresa Zgoda /Royal Photographic Society

3. 

These legs belong to impalas (*Aepyceros melampus*); the black patches are glands used for scent marking. This image from Morgan Trimble won a bronze award in this year’s competition.

Morgan Trimble/Royal Photographic Society

4. 

This shot is a combination of hundreds of images of retinas shot by Jonathan Brett, and assembled to mimic a colour-vision test chart. The eyes took a silver award.

Jonathan Brett/Royal Photographic Society

Coming down…

Bill Ingalls/NASA

At the start of the month, this Soyuz capsule brought back three astronauts to Earth, landing near Zhezkazgan in Kazakhstan. Among them was Peggy Whitson, who spent 288 days in space aboard the International Space Station.

… and going up

Bill Ingalls/NASA

Ten days after Whitson and her colleagues returned to this planet, another three people left it when this Soyuz left for the space station from Baikonur Cosmodrome.

A complex cloud

Artem Mironov

This nebula — called the Rho Ophiuchi cloud complex — is 140 parsecs (460 light years) from Earth. Photographer Artem Mironov took three nights to capture this image of it, which went on to win this year’s Insight Astronomy Photographer of the Year award.

Seamount squid

NOAA Office of Ocean Exploration and Research

On 17 September, the crew of the US National Oceanic and Atmospheric Administration's ship *Okeanos Explorer* were exploring the Musicians Seamounts, a formation of undersea mountains in the Pacific Ocean, with remotely operated submersibles when they spotted this cranchiid squid. You can see more pictures of weird and wonderful deep-sea denizens on their diary site.

Bee bounty

Image Slideshow

1. 

The USGS Bee Inventory and Monitoring Lab in Laurel, Maryland has long been among our favourite purveyors of online insect images. Among the latest additions to its catalogue is this *Hoplitis fulgida*.

Anders Croft/USGS Bee Inventory and Monitoring Lab

2. 

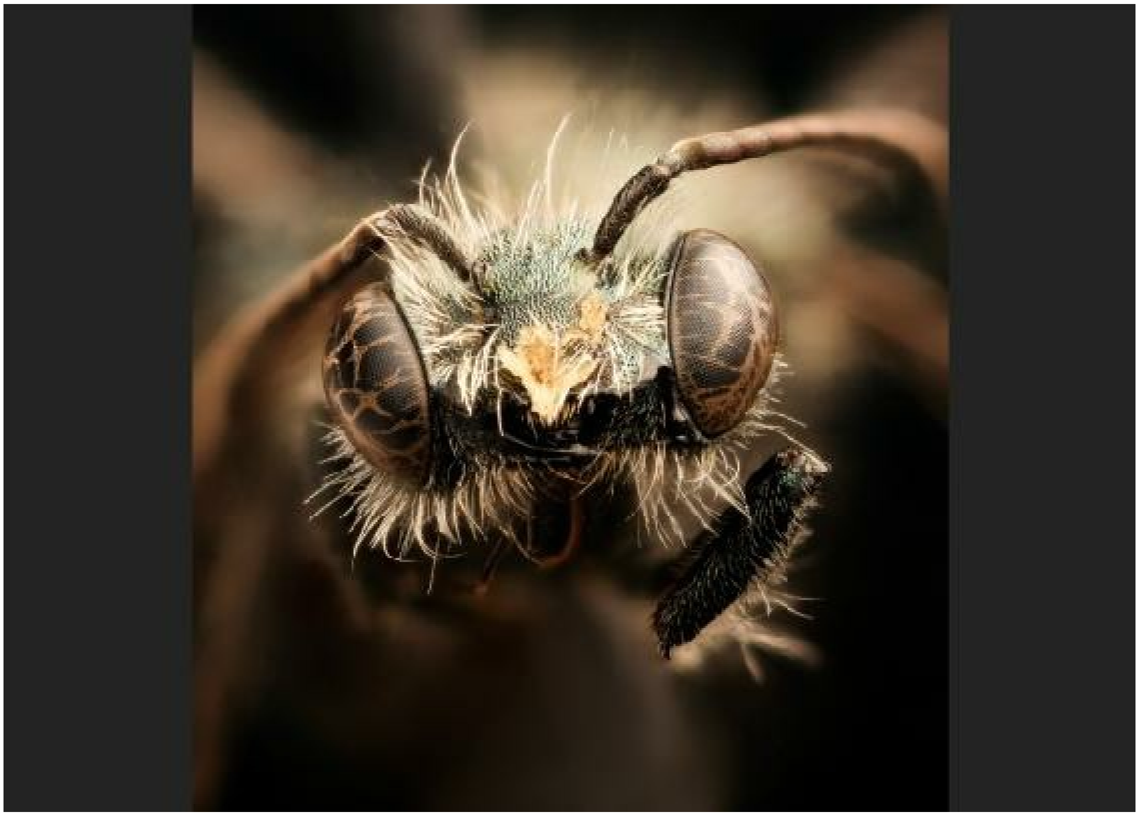
Another shot of *H. fulgida*, collected in Yosemite National Park, California.

USGS Bee Inventory and Monitoring Lab

3. 

Dianthidium singulare glues rocks together to make little houses for its eggs. The lab calls it a “boss looking bee”, and it’s hard to disagree.

USGS Bee Inventory and Monitoring Lab

4. 

The lab says this mason bee *Osmia subarctica* is a terrible specimen, but it has photographed beautifully.

USGS Bee Inventory and Monitoring Lab

Cassini comedown

NASA/Joel Kowsky

It is finally over. The Cassini mission this month dived into Saturn’s atmosphere, destroying itself. In this photo, Cassini programme manager Earl Maize packs up his workspace at mission control in the Jet Propulsion Laboratory in Pasadena, California. on 15 September.

They grow up so fast

Online Tracking of Arabidopsis Root

Arabidopsis thaliana, or thale cress, is widely used as a model organism in labs. Daniel von Wangenheim of the Institute of Science and Technology Austria in Klosterneuburg won first place in the Nikon Small World in Motion Photomicrography Competition for this remarkable time-lapse video of the root tip of one *A. thaliana* plant growing.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22741

Comments

Comments

There are currently no comments.

Europe’s Joint Research Centre, although improving, must think bigger

External report criticizes lack of exploratory research.

03 October 2017

Sean Gallup/Getty

Europe’s Joint Research Centre first raised awkward questions about diesel car emissions.

The European Union’s Joint Research Centre (JRC) uses the label EU Science Hub now. Whether the rebranding will increase its profile is one

question. What science gets done inside this hub is another. In response to that query, there is some positive news. It is doing what it should be, and doing it well: collecting scientific and technical evidence in support of EU policies. That's according to the report of an external evaluation released this week. Furthermore, EU research commissioner Carlos Moedas praised the JRC at its annual public meeting on 26 September for contributing to the interminable struggle to counter false information and communicate science effectively to a sceptical public.

The JRC employs more than 2,000 scientists, who generate or collate a constant feed of information for authorities and politicians. In theory, this helps to support evidence-based policies — from the old chestnuts of genetically modified (GM) crops and nuclear safety to the ongoing refugee crisis, for which it holds a repository of relevant information and reliable statistics. Yet most of this work fails to reach public attention. For example, staff in the JRC transport section had worked out and published evidence that car makers were manipulating diesel-emission data years before the public scandal over Volkswagen finally broke in 2015.

The JRC celebrates its 60th anniversary this year. It has become a complex beast, operating at six sites in five EU countries, with a budget this year of €372 million (US$437 million). It was originally set up as a nuclear research organization, but widened its remit over the decades, adding institutes. Twenty years ago, it morphed into a centre with an explicit mission to provide support for a wide range of EU policies. But by that time it had lost its way, and tough reforms were introduced. A 2009 evaluation led by former UK government science adviser David King concluded that it was carrying out its new remit well, but criticized it for doing too little independent research of the type required to attract and keep the best scientists.

The new report, headed by the former Irish government science adviser Patrick Cunningham, echoes this call. It acknowledges how rapidly the centre has broken out of its much-criticized institute-based silos to restructure thematically into cross-site departments, such as energy and health, which more directly mirror policy areas. It also notes that the JRC has significantly increased its presence in the world's top-cited literature. But it says that the centre still does too little exploratory research — such research engages only

3.5% of JRC staff, well below the target of 10% that it set itself in 2015.

Why has it struggled? Although it has established partnerships with European universities and research institutes, and aided the exchange of scientists, many JRC researchers have different motivations from those of colleagues in universities. There is much satisfaction in contributing to policies that influence the lives of people in the EU. But officials and staff must look again at their priorities. As well as keeping the JRC relevant, a wider focus on the cutting edge would allow it to flag up hot topics to policymakers earlier.

But what policymakers do with the information they receive from their science service is another matter entirely. EU policy on GM crops is notoriously weak — scientific evidence for their safety has failed to convince some countries, whose citizens viscerally reject the technology. And sometimes the EU's intrinsic political weakness can block the implementation of its science-based policies. After all, the European Commission and EU member states ignored the findings on diesel emissions, and acted only after regulators in the United States cracked down.

Journal name:
Nature
Volume:
550,
Pages:
8
Date published:
(05 October 2017)
DOI:
doi:10.1038/550008a

Comments

Comments

There are currently no comments.

Bill &
Melinda
Gates
Foundation

Make plans to eliminate cholera outbreaks

Governments must stop denying the occurrence of cholera and unite in long-term prevention strategies, says Anita Zaidi[1].

03 October 2017

As a medical student in Karachi in the 1980s, I saw cholera all the time. We had a dedicated diarrhoea ward in the hospital, and if there was an increase in diarrhoea cases in children aged over 3, we knew we had a cholera outbreak. Over the past decades, the world has become much better equipped to fight cholera, yet the disease continues to spread across sub-Saharan Africa, Asia and the Caribbean.

In Yemen, cholera has killed more than 2,000 people and infected nearly 700,000 in the past 5 months alone, eclipsing the post-earthquake outbreak in Haiti. Haiti still battles with the disease 7 years after its reintroduction. Meanwhile, Somalia is experiencing its worst outbreak in five years. South Sudan continues to fight its worst outbreak since it gained independence in

2011. If nothing changes, cholera will continue to claim some 100,000 lives a year and afflict around 3 million people, many of them children.

This week, the World Health Organization (WHO) launches a campaign to eliminate cholera outbreaks by 2030. The plan could move countries beyond ad hoc reactions, to sustainable prevention.

The disease is caused by the bacterium *Vibrio cholerae* and spreads mainly through contaminated water. Infection usually causes no or mild symptoms, but in approximately one-tenth of cases it swiftly leads to watery diarrhoea, vomiting and cramps. Rapid loss of fluid can result in dehydration and death within hours. An oral rehydration solution that costs cents can reduce fatality from a high of 50% to under 1%. Every year, it still fails to reach tens of thousands of victims in time.

Clean water, improved sanitation and better access to treatment have been game-changing for much of the world, but cholera is still thought to be endemic in 69 countries, including most of sub-Saharan Africa.

In the twenty-first century, no one should die from this disease. We have treatments and prevention strategies that work, including sufficient cholera-vaccine stocks. We know where outbreaks are most likely to start. To spread, cholera needs estuaries, rivers or coastal waters that are contaminated with faeces, and susceptible people living nearby; it has clear patterns of recurrence. What we need to do is get there first.

What’s stopping us? One barrier is stigma. Many national and regional governments don’t want to admit that their territory harbours cholera. Rather than controlling it, they hide it. The stigma goes back hundreds of years, to when ships with sick passengers were not allowed to dock and people feared being put in quarantine. Now the fears are public anger and loss of economic opportunities. Many countries with known endemic cholera in Asia and Africa report to the WHO that they have no cases, and in the face of an outbreak do not request cholera vaccines. In 2010, during the massive floods in Pakistan, my colleagues and I saw hundreds of cases of acute watery diarrhoea in Sindh that we confirmed to be cholera in our laboratory, but national health officials told us to keep it quiet.

Too many countries act only after a crisis has emerged: then they request vaccine campaigns, set up makeshift cholera clinics and urgently mobilize supplies.

These tactics can quell an outbreak and dampen transmission in the short term, but they don't stop outbreaks from happening again. For that, governments must intervene preemptively to control cholera in places where it recurs frequently. Since the WHO cholera-vaccine stockpile was established in 2013, almost 13 million doses have been delivered. Millions more doses should have been requested.

To truly stop cholera outbreaks, countries must do two things: deploy vaccines where cholera is endemic and strengthen the infrastructure that provides clean water and good sanitation.

Events in Malawi give reason for optimism. In April this year, the country adopted a national plan to control and prevent cholera that directs vaccines to affected communities identified by geo-spatial mapping. More than 2 million citizens have been vaccinated ad hoc since 2015. The new plan, made possible by strong political commitment at the Ministry of Health, collates two decades' worth of information to better estimate cholera burden, identify hotspots and support early intervention. At the same time, Malawi is planning to strengthen water and sanitation infrastructure. Experts are hopeful that this will reduce the country's cholera burden to its lowest level in years.

Similarly, the WHO Global Task Force on Cholera Control is launching a renewed strategy to eliminate cholera outbreaks worldwide. Unlike past efforts, this plan goes beyond responding to cholera flare-ups: it encourages countries to invest in protecting people from cholera over the short and long term.

The success of the WHO's plan ultimately depends on the commitment of governments worldwide. All governments, whether or not they are directly affected by cholera, must unite and increase their political and financial investment in cholera prevention and control.

The first cholera pandemic, in 1817, swept across South Asia, East Africa, the Middle East and Europe, claiming hundreds of thousands of lives. Back

then, we had no vaccine and a limited understanding of transmission. It is unacceptable that, now, in that pandemic's 200th anniversary year, a disease we know how to fight remains out of control.

Journal name:
Nature
Volume:
550,
Pages:
9
Date published:
(05 October 2017)
DOI:
doi:10.1038/550009a

Comments

Comments

There are currently no comments.

Ethics of Internet research trigger scrutiny

Concern over the use of public data spurs guideline update.

03 October 2017

Matt Cardy/Getty

A Banksy artwork in Cheltenham, UK. Scientists tried to find the artist’s true identity using public data.

British graffiti artist Banksy is renowned for his anonymity. But that status was dented last year when researchers published a paper that cross-referenced the locations of Banksy’s street art with public information about people’s

addresses and likely movements ([M. V. Hauge *et al. J. Spatial Sci.* **61,** 185–190; 2016]). The team, led by academics at Queen Mary University of London, concluded that someone previously suspected to be Banksy probably was the secretive artist.

Because the study used public data, a university ethics committee said that the work was exempt from formal review — and informally advised academics that it would do no harm because a UK national newspaper had already identified the person in question as Banksy. But for some ethicists, the paper highlights growing concerns about the potential hazards of research that uses public data. “I think this study should never have been done,” says Jake Metcalf, a technology ethicist at the think tank Data & Society in New York City.

Metcalf is one of several academics calling for new guidelines to steer scientists through ethical quandaries in Internet research. The unprecedented availability of online data — together with tools to draw patterns from it, such as machine learning — is opening up research possibilities that outpace existing ethics frameworks around privacy, consent and harm, says Charles Ess, a research ethicist at the University of Oslo and a member of the Association of Internet Researchers. The association will discuss how to update its guidelines at its annual meeting on 19 October in Tartu, Estonia.

A flurry of similar initiatives is under way. Earlier this year, the SATORI project, funded by the European Commission, published recommendations on Internet research as part of an effort to standardize and update research-ethics guidelines. In September, the US National Science Foundation funded a US$3-million, 4-year study called PERVADE — of which Metcalf is a part — that aims to chart attitudes to data-research ethics, produce best-practice guidelines and create tools to assess the potential harms of such work. And some British universities are preparing their first guidelines on the ethics of Internet research, after the UK Research Integrity Office, a national advisory body, published non-binding recommendations about it last December.

Common themes among these efforts include rethinking what counts as ‘public’ data, the ethical use of social media and the need to consider a study’s potential harm to wider society, as well as to individuals. Many

countries have long-standing ethical checks for research that intervenes in human lives. But those principles, set up for medical and psychological studies, apply to research on human subjects, the definition of which often excludes Internet research, says Metcalf.

In the United States, for instance, studies using public data (which includes that purchased from a third party) generally do not count as human-subjects research because they don't access private, identifiable information about people. They don't need to be checked by an institutional review board (IRB) or require informed consent. Guidelines issued in 2013 add that researchers should sometimes consider seeking review — if a person incorrectly assumed that access to his or her public information was restricted, for example. But IRBs have no obligation to adopt these proposals, and different committees may come to different verdicts, says Metcalf.

Peter Hedges, head of the research-operations office at the University of Cambridge, UK, argues that even researchers who use information that is undeniably public, such as Twitter data, should review the ethics of their work. The SATORI guidelines advise that regulators and researchers should carefully consider whether publicly available information is actually private, and not fall back on simple classifications.

If someone's data are considered private and identifiable, that would usually mean obtaining their informed consent. But, in practice, such consent is often impossible to acquire for large-scale data studies, says Ess. And anonymizing data is difficult, because search engines can easily identify individuals from even small snippets of anonymized text or by cross-referencing them in multiple data sources. The SATORI guidelines recommend that researchers take precautions to ensure the anonymity of study participants, and Ess suggests that scientists can still, without too much effort, seek consent from anyone they explicitly quote in research papers.

When ethics committees do assess data studies, their viewpoint might be too narrow, says Ansgar Koene, an engineer and ethicist at the University of Nottingham, UK. They tend to consider the direct damage to an individual involved in research, rather than a project's potential to do widespread harm to society. That debate flared up in September when artificial-intelligence researchers at Stanford University in California posted a preprint of research

that predicted whether someone is gay from their photo; it used pictures sourced from an online dating site (see https://osf.io/zn79k). The study was approved by Stanford's IRB, but provoked condemnation from some advocacy groups for lesbian, gay, bisexual, transgender and queer (LGBTQ) people, which branded it dangerous. The study's lead author, Michal Kosinski, said the work aimed to protect people by exposing an existing threat from widely used technology. Kosinski and his colleague, Yilun Wang, discussed their results afterwards with representatives of the LGBTQ community, but Koene says that the discussion should have happened beforehand and the paper should have addressed their comments.

Computer science is a flashpoint for Internet-research ethics. Researchers in this field are not used to working with human study participants and often don't consider the ethical impact of their work, says Koene, who has surveyed approaches to ethics in different disciplines. A major concern, academics agree, is how companies use online data for research — much of which they have proprietary access to. In 2014, for example, Facebook altered users' newsfeeds without telling them, to study how this affected their emotions. A public backlash prompted Facebook to publish some details of its internal review process (M. Jackman and L. Kanerva *Wash. Lee Law Rev. Online* **72,** 442; 2016) — but there is little transparency overall about how this works, says Koene.

Researchers may not want to see their science slowed by formal ethical review, which can be time-consuming and opaque. Better ethics training is one solution, says Koene. But a failure to align data science with public perceptions of what is acceptable could generate a severe reaction, he warns. "The public will see us as no different from corporate or other special-interest groups pursuing a hidden agenda," he says.

Journal name:
Nature
Volume:
550,
Pages:
16–17
Date published:

(05 October 2017)
DOI:
doi:10.1038/550016a

Comments

Commenting is currently unavailable.

Gravitational wave detection wins physics Nobel

Rainer Weiss, Barry Barish and Kip Thorne share the 2017 prize for their work at LIGO to detect ripples in space-time.

03 October 2017

Left: Bryce Vickmark/MIT. Centre: Caltech. Right: Caltech Alumni Assoc.

Rainer Weiss (left), Barry Barish (centre), and Kip Thorne (right), who led work to detect gravitational waves.

Three physicists who had leading roles in the first direct detection of gravitational waves have won the 2017 Nobel Prize in Physics.

Rainer Weiss, at the Massachusetts Institute of Technology (MIT) in Cambridge and Barry Barish and Kip Thorne, both at the California Institute

of Technology in Pasadena, share the 9 million Swedish krona (US$1.1-million) award for their work at the US-based Laser Interferometer Gravitational-Wave Observatory (LIGO). In September 2015, LIGO picked up the deformations in space-time caused by the collision of two distant black holes.

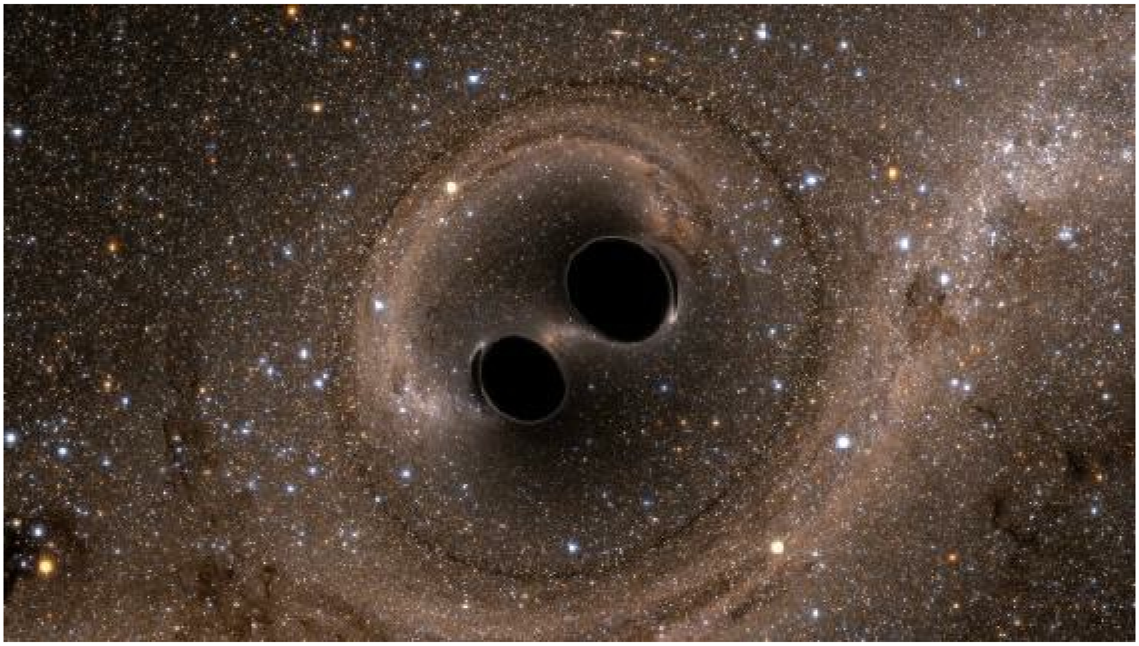
That discovery, which was announced in February 2016, opened up a new field of astronomy, in which scientists listen to the space-time vibrations emitted by some of the Universe’s most cataclysmic events. And it confirmed the existence of gravitational waves, which Albert Einstein had predicted a century before.

Weiss and Thorne are two of three physicists known as the Troika — the founders of LIGO’s giant twin detectors in Livingston, Louisiana, and in Hanford, Washington. The third troika member, Ronald Drever, died on 7 March this year. And Barish, who was LIGO director from 1997 to 2005, is widely credited with having transformed the collaboration from a chaotic endeavour to a well-oiled machine.

"I view this more as a thing that recognizes the work of about 1,000 people, a really dedicated effort that’s been going on for — I hate to tell you — as long as 40 years," said Weiss in an interview with the Nobel Committee just after winning the prize.

"We were all very happy for them to be recognized. They worked on this for decades," says Gabriela Gonzalez, a physicist at Louisiana State University in Baton Rouge, and a LIGO team member and former spokesperson for the collaboration. The Nobel prize can be awarded only to a maximum of three people, but the Nobel Committee noted the huge numbers of people who worked on LIGO in its press release.

Researchers had been widely expecting the committee to reward the team since last year's detection announcement. "I'm very happy that they got the right people," says Charles Misner, a general relativity theorist at the University of Maryland in College Park. Half of the Nobel prize has been awarded to Weiss, with the other half split between Barish and Thorne.



The SXS Project

A computer simulation of two black holes colliding, which generates gravitational waves.

Unimpeded motion

Few physicists doubted the existence of gravitational waves before the LIGO discovery. The distortions in space-time are an inevitable consequence of Einstein’s general theory of relativity, and propagate across the Universe almost unimpeded. In 1974, they were confirmed indirectly when researchers examined the radio flashes emitted by a pair of merging neutron stars; the shifts in the flashes' timing matched predictions of how gravitational waves would carry energy away from the event. That discovery was rewarded with the 1993 Nobel Prize in Physics.

But sensing the waves themselves was a monumental task. Even the most powerful deformations — those produced by collapsing stars or colliding black holes — would typically be tiny by the time they reached Earth. The waves detected in 2015 stretched and squeezed LIGO’s perpendicular 4-kilometre vacuum pipes by a fraction of a proton’s width, but that was

enough to noticeably shift out of sync the laser beams bouncing inside the pipes.

Physicists in the United States and the then-Soviet Union first proposed using laser interferometers to detect gravitational waves in the 1960s. Weiss made the first detailed calculations for how an interferometer would work in 1972. The idea seemed so far-fetched that even he was not sure it would work. “It might come to a junction in a year or so when we will decide it ain’t worth it,” he told science sociologist Harry Collins at the time[1].

Weiss, who was born in Germany in 1932, emigrated with his family to the United States in 1938 to escape from Nazism. He built his first prototype interferometer in the mid-1970s, soon followed by researchers in Europe — among them, Drever and his collaborators at the University of Glasgow, UK, and another group in Munich, Germany.

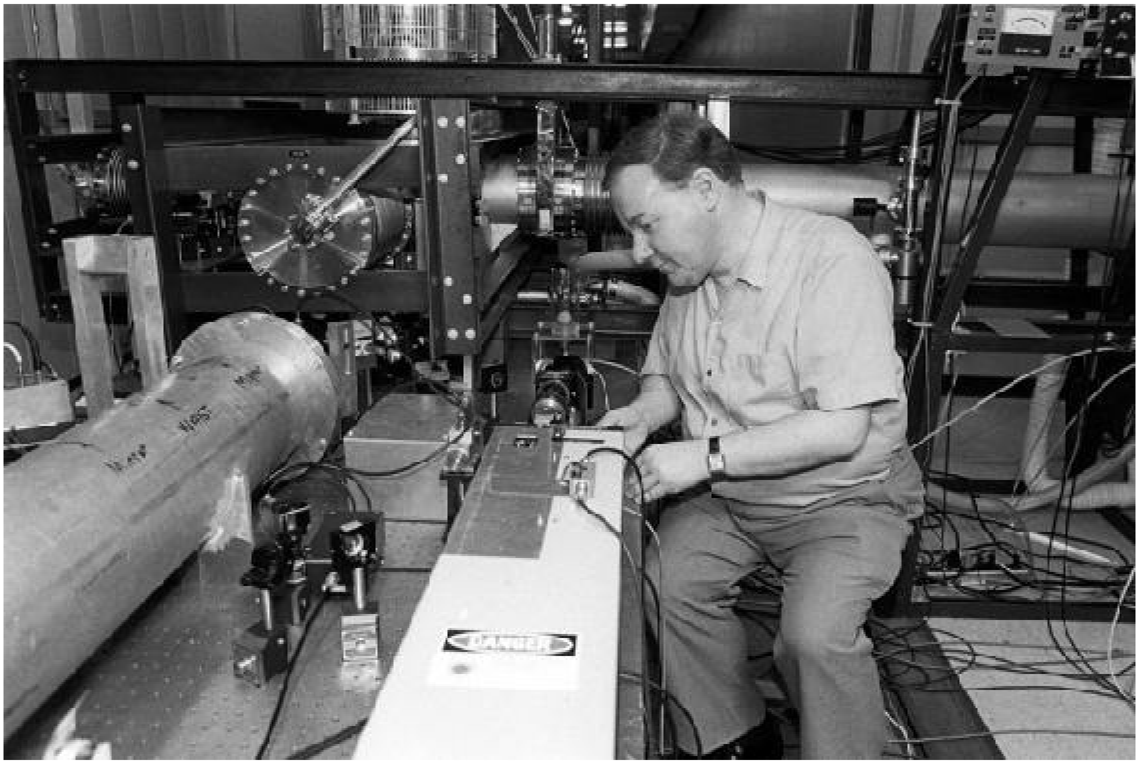
Thorne, born in Utah in 1940 to Mormon parents, specialized in general relativity and had also been developing ideas on the waves. At a conference in Washington DC in 1975, Thorne and Weiss shared a room in an over-booked hotel. During their conversations, Weiss convinced Thorne that interferometers were the right approach. Thorne, Weiss and Drever joined forces in the early 1980s, when it became clear that the US National Science Foundation would not fund two separate efforts, and the LIGO collaboration was born.

Dramatic turn-around

The troika did not always work smoothly and, at their own admission, did not possess the right skills for managing what was quickly becoming a vast operation. Things improved dramatically after Barish, who had been LIGO’s principal investigator since 1994, became director in 1997. Collins, who has closely studied the collaboration for decades, says that Barish turned LIGO into a ‘big science’ organization. “Without Barish turning things around, it would have collapsed,” he says.

LIGO initially struggled to get funded, but ended up being the largest and

most expensive experiment in the history of the US National Science Foundation. Its two nearly identical detectors first opened in 2002, with an admittedly scant chance of detecting anything during their first phase of data collection. The observatory shut down in 2010 for a major overhaul, and restarted in September 2015, three times more sensitive than before.



Bob Paz/Caltech Archives

Ronald Drever was one of the original co-founders of the LIGO project; he died in March 2017.

Researchers were cautiously optimistic of a discovery within a few years. But the Universe was kind to LIGO, providing a dramatic event for it to record on 14 September, while the interferometers were still being calibrated, days before their official science run was due to start. Since then, LIGO has detected at least three other gravitational-wave events — the most recent [also spotted by Virgo, a similar interferometer near Pisa, Italy](#).

The LIGO team benefited from significant research efforts in other countries.

Germany and the United Kingdom have contributed funding and research, and GEO600, a smaller interferometer near Hannover, Germany, is the main test-bed for technologies that are implemented on its larger cousins in the United States.

The three winners have other strings to their bows: as well as working on LIGO, Weiss was a leading scientist in the Cosmic Background Explorer (COBE), a NASA probe that in the 1990s produced the first map of the cosmic microwave background, the ‘afterglow’ of the Big Bang. (Two other COBE researchers shared the physics Nobel in 2006.)

Thorne, who has spearheaded theoretical studies of gravitational waves, also helped to conceive the original idea for the plot of the 2014 film *Interstellar*, on which he was an executive producer. And before joining LIGO, Barish worked on neutrino experiments at the Fermi National Laboratory in Batavia, Illinois and elsewhere. He has also led the design of a proposed International Linear Collider.

Thorne and Weiss were generally considered shoo-ins for the Nobel. Before Drever’s passing last March, the troika raked up almost every prize there was for them to win, including the $3-million Special Breakthrough Prize in Fundamental Physics; the $500,000 Gruber Foundation Cosmology Prize; the $1.2-million Shaw Prize in Astronomy; and the $1-million Kavli Prize in Astrophysics.

Journal name:
Nature
Volume:
550,
Pages:
19
Date published:
(05 October 2017)
DOI:
doi:10.1038/nature.2017.22737

Comments

Commenting is currently unavailable.

Risk of human-triggered earthquakes laid out in biggest-ever database

Geologists track hundreds of quakes caused by people and the projects that set them off.

02 October 2017

Chris McGrath/Getty

A 7.8-magnitude earthquake that hit Nepal on April 30, 2015, has been linked by some to groundwater pumping.

From mining projects to oil and gas operations, human activity has set off

earthquakes around the world and in many geological settings. Research now highlights how big these quakes can get — and how little scientists agree on which ones are caused by people.

The Human-Induced Earthquake Database, or HiQuake, contains 728 examples of earthquakes (or sequences of earthquakes) that may have been set off by humans over the past 149 years. Most of them were small, between magnitudes 3 and 4. But the list also includes several large, destructive earthquakes, such as the magnitude-7.8 quake in Nepal in April 2015, which one paper linked to groundwater pumping[1].

Miles Wilson, a hydrogeologist at Durham University, UK, and his colleagues describe the database in a paper set to be published on October 4 in *Seismological Research Letters*[2]. The scientists say that HiQuake is the biggest, most up-to-date public listing of human-caused quakes ever made. By bringing the data together in this way, they hope to highlight how diverse induced quakes can be — and help society to understand and manage the future risk.

Earth-shaking activity

HiQuake began in 2016, when the Dutch Petroleum Society (NAM), an oil and gas company based in Assen, funded a team of researchers at Durham and at Newcastle University, UK, to collect examples of induced earthquakes. NAM drills in the Groningen gas field in the Netherlands, where it has set off many small earthquakes.

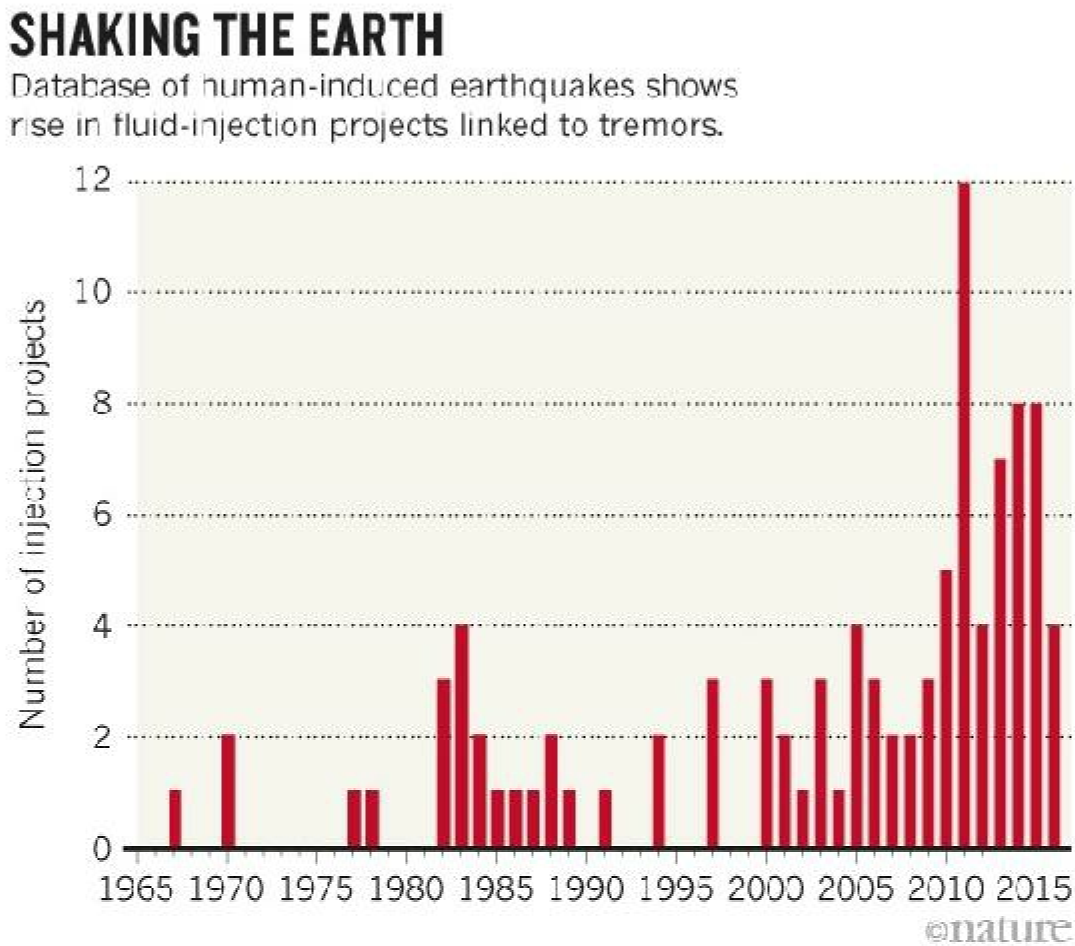
Wilson's team trawled through sources including scientific papers and media accounts to come up with its 728 events. When a single project, such as a wastewater-injection well, set off more than one quake, the researchers counted those as a single event. Further details appear in *Earth-Science Reviews*[3].

The result is a database in which the earliest entry dates to 1868, with a quake triggered by an Australian coal-mining operation. Of the 728 events, 271 (37%) are linked to mining — often from tunnel collapses. About 23% are

linked to water piling up behind a dam and 15% to conventional oil and gas development. Just 4% are linked to hydraulic fracturing, or fracking, for oil and gas. Some of the more unusual cases involve quakes triggered by the building of heavy skyscrapers or by an underground nuclear-bomb test.

Mass movement

In HiQuake, the fastest-growing quake-inducing activity in the database is the injection of wastewater back into the ground by oil and gas operations (see 'Shaking the earth'). The process that can increase stress on buried geological faults and cause them to generate small earthquakes. The number of these projects spiked in the early 2010s, at the height of wastewater-injection in Oklahoma and other parts of the central United States.



The largest event in the database is the magnitude-7.9 earthquake that struck in Sichuan, China, in 2008, which some have linked with the filling of a nearby reservoir[4]. Wilson says his team was initially startled to see quakes that large proposed as human-induced. But in retrospect, he says, “we probably shouldn’t be surprised by any anthropogenic cause”. All the projects linked to earthquakes — whether blasting a mining tunnel, injecting wastewater or pumping groundwater — involve moving mass around on Earth’s surface in ways that can nudge already-stressed faults.

The scientists found a relationship between the volume of material moved — such as the size of the reservoir filled before the Chinese quake — and the magnitude of the largest linked earthquake that followed. No such relationship was seen with factors such as dam height or reservoir area. The researchers suggest that limiting the amount of material moved in a construction project could help to minimize any quakes triggered.

Judgement calls

All possible instances of induced quakes were included “without regard to plausibility”, writes the team, because of the difficulty involved in deciding what constitutes absolute proof that an earthquake was caused by human activity. But that could mislead people about the real hazard from induced quakes, says Raphaël Grandin, a geophysicist at the Institute of Earth Physics in Paris. “When you put a dot in the database, and a scientific reference behind it, then you may lead the non-expert to think that the earthquake was caused by humans,” he says. Such a listing might hide scientific uncertainty, as with the Chinese quake: despite the paper linking it to reservoir filling, many seismologists do not believe it was triggered by human activity[5].

Susan Hough, a seismologist at the US Geological Survey in Pasadena, California, says she understands why the HiQuake team included all possible instances of induced quakes. “I suspect the authors were unwilling to pass judgement on published studies, which I consider a reasonable decision,” she says. “If you start down the road, where do you stop?”

Wilson agrees. “Any judgement calls we leave to users,” he says.

Over time, HiQuake should become more useful as researchers add examples and references to its entries, says Gail Atkinson, a seismologist at the University of Western Ontario in London, Canada, who leads a Canadian collaboration to study induced seismicity.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22693

Comments

Comments

There are currently no comments.

Discoveries have awkward first dates

Fuzzy timings over a plate-tectonics anniversary highlight the rolling nature of scientific discovery.

02 October 2017

Archive of Alfred Wegener Institute

Alfred Wegener first suggested the idea of continental drift which led to the theory of plate tectonics.

This week, the Geological Society in London will mark the 50th anniversary

of plate tectonics — the theory that describes the workings of Earth, how earthquakes strike, and why volcanoes happen. Or will it?

The timing of the anniversary is disputed. After all, this journal published its own 50th anniversary commemoration of plate tectonics 4 years ago (*Nature* **501,** 27–29; 2013). Columbia University's Lamont–Doherty Earth Observatory in New York celebrated last May. Confused? Blame the rolling nature of scientific discovery. Plate tectonics did not spring into existence fully formed, Athena-like, on a particular day in a particular year.

No doubt aware of this, the London conference, although billing itself as "Plate Tectonics at 50", pins next week more cautiously: as a commemoration of the "advent of the paradigm" — the arrival of the model of the theory.

Coming up with the modern theory of Earth involved sparks of insight from many different researchers, working in different laboratories on different continents. Most of the resulting papers were published in the 1960s, many of them in *Nature*.

In September 1963, Frederick Vine and Drummond Matthews described how stripes of changing magnetism on the sea floor represented the spreading of new oceanic crust away from the ridge where it was born (F. J. Vine and D. H. Matthews *Nature* **199,** 947–949; 1963). This was the crucial insight that nailed the concept of sea-floor spreading, which had been hinted at in the 1950s, when oceanic mapping by Marie Tharp and Bruce Heezen revealed a mountainous rift, and so this is the paper that *Nature* editors choose to commemorate in plate-tectonics anniversaries. Fast-forward four years, and Dan McKenzie and Robert Parker publish the first complete description of how crustal plates move around on the surface of the sphere (D. McKenzie and R. L. Parker *Nature* **216,** 1276–1280; 1967), the paper that the Geological Society is now celebrating.

Of course, Vine, Matthews, McKenzie and Parker were far from alone. In the 1960s, plate tectonics was such a fecund, fast-moving field that it involved several instances of simultaneous discovery. In early 1967, as McKenzie was developing his ideas of rigid-plate motions, he looked at a conference abstract by colleague Jason Morgan and decided not to attend the talk. As it

turns out, Morgan veered from the text of his abstract and instead described ideas of plate motions that were eerily like McKenzie's. Later that year, McKenzie sent off his manuscript to *Nature* — and, when he realized that Morgan was about to publish similar ideas, he asked the journal to delay his own paper in order to give Morgan the credit. *Nature*'s editor, John Maddox, sent a telegram back saying that the issue had already been typeset, so there would be no delay. Who has not skipped an event, only to have that affect their careers for years to come?

But back to the question of anniversaries. Popular interpretations of scientific history are biased towards the single great discovery by a single great person — and they are more easily commemorated in an anniversary. But most discoveries are much more nuanced and communal. Charles Darwin would not have published his ideas of evolution by natural selection when he did, had he not been prompted into it by the similar thoughts of Alfred Russel Wallace. Albert Einstein relied on the work of friends and colleagues to develop his general theory of relativity.

Similar broad revolutions are unfolding today. Despite all the bitterness and infighting over who invented the CRISPR–Cas9 gene-editing technique, the fact remains that a large number of very bright scientists made enormous advances quickly by playing off one another. Just as in the heyday of plate tectonics, one gene-editing breakthrough inspired the next, until biologists were brimming with publications. Historians may one day bicker about which CRISPR paper to celebrate on the 50th anniversary of the technique, but science as a whole is much better off than it was before.

And so, we could celebrate a 1963 publication on the magnetism of the sea floor, or a 1967 paper on the geometry of spherical rotations, or even the entirety of the dawning of plate tectonics. But when was that? Was it in 1912, when Alfred Wegener came up with the idea of continental drift? Or was it decades later, when his ideas were finally transformed into the concept we now know as tectonics? Much of that delay might trace to US researchers viciously opposing his ideas, as historian Naomi Oreskes described in *Plate Tectonics* (Westview Press, 2001). But after the slow start, Earth scientists in the 1960s were quick to embrace the data and theories that redrew almost every aspect of their field.

Such is the nature of discovery — incremental at times, fast-paced at others, occasionally derailing into pettiness. But it does nearly always move in the right direction. In these times of political uncertainty and global unrest, that is an accomplishment worth noting.

Journal name:
Nature
Volume:
550,
Pages:
7
Date published:
(05 October 2017)
DOI:
doi:10.1038/550007a

Comments

Commenting is currently unavailable.

Chinese scientists fix genetic disorder in cloned human embryos

A method for precisely editing genes in human embryos hints at a cure for a blood disease.

02 October 2017

Mauro Fermariello/SPL

Fixing the genetic mutation linked to β-thalassaemia would save affected individuals from having to get life-sustaining blood transfusions.

A team in China has taken a new approach to fixing disease genes in human embryos. The researchers created cloned embryos with a genetic mutation for a potentially fatal blood disorder, and then precisely corrected the DNA to

show how the condition might be prevented at the earliest stages of development.

The report, published on 23 September in *Protein & Cell*[1], is the latest in a series of experiments to edit genes in human embryos. And it employs an impressive series of innovations, scientists say. Rather than replacing entire sections of genes, the team, led by Junjiu Huang at Sun Yat-sen University in Guangzhou, China, tweaked individual DNA letters, or bases, using a precision gene-editing technology developed in the United States[2].

Huang's team is also the first to edit out the mutation responsible for a 'recessive' disease: one caused by having two faulty copies of a gene. Because it would be difficult for researchers to find dozens of embryos that all have this rare double mutation, the team worked around this roadblock by developing embryonic clones from their patient's skin cells.

"I thought, 'Why would they do cloning?' Then I read the paper, and thought, 'Wow, that's fascinating,'" says Shoukhrat Mitalipov, a reproductive-biology specialist at the Oregon Health and Science University in Portland who pioneered human cloning and also works on gene editing in embryos. "I would not have thought to do this."

Scientists around the world have now published eight studies reporting gene editing in human embryos, five in the past two months. None have permitted the embryos to grow beyond 14 days, and the research has had different purposes: some to test gene-editing technologies; others to edit various disease-related genes; and some to unravel the mechanisms behind early embryonic development. Huang's team led the first report, published in April 2015, in which they used the CRISPR–Cas9 enzyme complex to snip chromosomes at specific locations, excise DNA and replace it with other genetic material[3].

Precision editing

In the latest study[1], Huang's team used 'base editing', a modification of CRISPR–Cas9. It guides an enzyme to specific gene sequences, but does not

cut the DNA. Instead, the Cas9 enzyme is disabled and tethered to another enzyme that can swap out individual DNA base pairs. So far, this technique can convert guanine (‘G’) to adenine (‘A’), and cytosine (‘C’) to thymine (‘T’). Hundreds of genetic diseases are caused by single-base changes, or ‘point mutations’, and so editing of this sort at the embryonic stage could potentially stave off such conditions.

Huang’s team chose one mutation common in the Chinese population: a switch from an A to a G at a certain spot in the *HBB* gene, which can lead to β-thalassaemia, a recessive blood disorder associated with severe or fatal anaemia. Researchers generally source embryos from *in vitro* fertilization (IVF) clinics, but it’s rare for these facilities to have embryos with two copies of the same rare mutation. So Huang’s team found a person with the blood disorder, extracted their skin cells and used cloning techniques to develop embryos with the same genetic makeup.

The researchers reported that in 8 of 20 cloned embryos, they were able to convert the errant G back into an A in one or both copies of the gene. (Repairing only one copy might be enough to cure a recessive disease.) That rate is too low for the technique to be considered for clinical use, but the efficiency was high relative to that achieved in other gene-editing studies. “The repair rate is pretty good, and certainly promising,” says Gaetan Burgio, a geneticist at the Australian National University in Canberra. “Our study opens new avenues for therapy of β-thalassaemia and other inherited diseases,” says Huang.

But scientists caution that not all cells in the eight embryos were fixed. Such embryos are ‘mosaic’, meaning that they have a patchwork of cells with different genetic make-ups, which is potentially dangerous. “It looks like solid work, but highlights that the problem of mosaicism remains a challenge for any form of gene editing in the human embryo,” says Dieter Egli, a stem-cell biologist at Columbia University in New York City.

Unintended consequences

Some scientists also question whether Huang’s team looked thoroughly

enough for unintended genetic changes, called off-target effects, that might have been caused by the base-editing procedure, although the authors reported that none were found.

Huang says future experiments will be more comprehensive, but that this first study was a successful proof of principle that the base-editing technique can be used to correct a disease mutation in a human embryo. It may be that conventional CRISPR–Cas9 cannot fix embryos when both copies are faulty, although this isn't yet clear. In August, for instance, Mitalipov's team reported using CRISPR–Cas9 to repair a mutation in a gene that can cause a potentially deadly heart disorder, by using the other, healthy copy of the gene as a template[4].

In the future, Huang says, he plans to ask for oocytes and sperm from donors who have one mutated copy of the gene — and so are unaffected by the condition, but are carriers of the disease — and use these to produce embryos. Some of those embryos would have two mutated copies, and some one, but Huang wants to edit both types. That raises the contentious idea that gene editing might be used not only to prevent severe disease, but also to eliminate the chance of people becoming carriers of the disorder. "Base editing can repair the mutant site and block it from being passed on to the next generation," he says.

Journal name:
Nature
Volume:
550,
Pages:
15–16
Date published:
(05 October 2017)
DOI:
doi:10.1038/nature.2017.22694

Comments

Comments

There are currently no comments.

Medicine Nobel awarded for work on circadian clocks

Jeffrey Hall, Michael Rosbash and Michael Young unpicked molecular workings of cells' daily rhythms.

02 October 2017

Nora Tam/SCMP

Michael Rosbash (left), Jeffrey Hall (centre) and Michael Young (right) have been recognized for their work on circadian clocks.

Three scientists who studied the workings of organisms’ inner circadian clocks have won the 2017 Nobel Prize in Physiology or Medicine. Jeffrey Hall and Michael Rosbash, both at Brandeis University in Waltham, Massachusetts, will split the award of 9 million Swedish kronor (US$1.1

million) with Michael Young at Rockefeller University in New York City.

Beginning in the 1980s, the three researchers isolated and characterized a gene in fruit flies, *period*, that encodes a protein that builds up each night, only to be broken down the following day. In subsequent work, the trio, as well as other scientists, unpicked the molecular regulation of the *period* gene (and the protein that it encodes, called PER) and identified additional components of the circadian clock.

All multicellular organisms possess circadian clocks, and human versions of the genes that comprise their clocks have been implicated in sleeping disorders and other medical conditions.

Rosbash, Hall and Young have been collecting awards together for the past five years. In 2013, for example, they shared the Shaw Prize in life science and medicine, then worth US$1 million. That has set the expectation that a Nobel might be around the corner, says Herman Wijnen, who studies circadian clocks at the University of Southampton, UK and was a postdoc in Young's lab. "This has been one that people have been looking out for," he says. "It's been settled in the scientific community that this is the trio."

But Young says he was so stunned by the news that he could barely get his shoes on the morning he found out. "I'd go and I'd pick up the shoes, and then I'd realize I need the socks," he said during a press conference. "And then I realized I needed to put my pants on first." The award took Rosbash by surprise too, says Thomas Perlmann, secretary of the Nobel Assembly, which selects the prizewinners. "I first got hold of Michael Rosbash, and he was silent," says Perlmann. "And then he said, 'you are kidding me'."

The work has its roots in genetic screens performed by physicist and molecular biologist Seymour Benzer and geneticist Ronald Konopka, who together found fruit-fly mutants with abnormal hatching rhythms. (Benzer died in 2007; Konopka in 2015.) At the time, the idea that behaviour could have a genetic basis was controversial, says Wijnen. Years later, two teams — Young leading one, Hall and Rosbash working together to lead another — would clone the genes responsible. "That really changed the situation," says Wijnen. "Since then, it has become clear how conserved this system is and how conceptually it could work."

The competition between the two teams — each with ambitions to be first to identify the gene — was initially intense, says Charalambos Kyriacou, a behavioural geneticist at the University of Leicester, UK, who worked with Hall in the late 1970s. “As they got older they mellowed,” he says. “They’re all good buddies now.”

Subsequent work detailed how abundance of the PER protein peaks at night and then declines during the day. Researchers gradually pieced together a model in which the accumulation of PER serves as a signal that represses expression of the gene that encodes it. This type of negative feedback loop would become a prevailing theme in the study of circadian rhythms, as researchers identified additional loops and clock proteins over the years.

Joseph Takahashi at the University of Texas Southwestern Medical Center in Dallas and others extended the work from fruit flies to mammals, and showed that the system is remarkably conserved across species. Researchers have since tied the circadian clock to many aspects of mental and physical well-being. “We expose ourselves to inappropriate light, we travel across time zones, we do shift work,” says Wijnen. “And all of that is negatively impacting our health.”

The links between the circadian clock and human health are so pervasive that medical schools should increase their focus on chronobiology, says Martha Merrow, chair of medical psychology at Ludwig Maximilian University of Munich in Germany. This could be either as a speciality in its own right, or incorporated into medical training in other specialities such as endocrinology or rheumatology, she adds. A Nobel prize may give Merrow and her colleagues added force to make that case. Merrow learnt of the news before heading into an administrative meeting. “I was so breathless, I could hardly go into my meeting,” she says. “It’s just a fantastic choice. It will be great for our field.”

Journal name:
Nature
Volume:
550,
Pages:
18

Date published:
(05 October 2017)
DOI:
doi:10.1038/nature.2017.22736

Comments

Commenting is currently unavailable.

Parakeet invasion of Mexico driven by Europe’s ban on bird imports

Attempts to stop the spread of bird flu and protect wildlife had unintended consequences.

29 September 2017

Joel Sartore/NGC

The monk parakeet is popular in the pet trade, but is also considered an invasive species when it escapes into the wild.

Small, emerald-coloured birds called monk parakeets (*Myiopsitta monachus*) invaded Mexico in the span of a decade because of trade policies thousands of kilometres away in Europe, according to a study released this month. The research highlights how fears over avian flu, which prompted a ban on bird imports in Europe, had wide ranging effects in other countries.

Monk parakeets, a type of parrot native to South America, popped up in countries such as the United States in the 1960s and have established themselves from Brooklyn to Brussels. There were only a handful of reported sightings of the bird in Mexico City in 2005. But by 2015, feral monk parakeets were documented in 97 cities throughout the country, say researchers in a study[1] published on 19 September in *PLoS ONE*. Monk parakeets are considered agricultural pests, and their enormous communal nests can cause blackouts when built on electrical equipment[2]. But they are popular as pets, and so have been part of the international parrot trade.

“It’s been a really, really fast invasion,” says Elizabeth Hobson, a behavioural ecologist at the Santa Fe Institute in New Mexico and lead author on the study, both in terms of the geographic scope and the shifts in the trade policies that contributed to it. Usually, it’s hard to work out when a non-native species first appeared in an area, says Hobson. But the arrival of monk parakeets in Mexico has a sharply defined start and end point, thanks to shipping documentation and bird sightings recorded by citizen scientists using apps such as iNaturalist and eBird, Hobson says.

Unintended consequences

She and her colleagues contend that two pieces of legislation shifted the global demand for monk parakeets from Europe to Mexico. In 2004, concerns about the spread of avian influenza in Europe led to an import ban on birds from southeast Asia. By 2007, the European Union had banned the importation of all wild-caught birds, regardless of their origin.

As EU demand for monk parakeets crashed, the international market for the birds shifted to Mexico, where regulatory changes in 2008 had made it illegal to purchase native Mexican parrots as pets, in an effort to preserve wild population numbers. The monk parakeet was one of the few options left for people who wanted to lawfully purchase a parrot.

More than half a million monk parakeets were imported into Mexico as part of the pet trade between 2000 and 2015. Hobson and her colleagues used international trade data to determine that 90% of those birds entered Mexico starting in 2008 and ending in 2014, mostly from Uruguay. The increase in wild monk-parakeet sightings throughout Mexico roughly coincided with the changes in regulations and commercial imports.

“This whole invasion seems like it was just a fascinating series of unforeseen consequences of regulation changes,” says Hobson. It’s important to think about how policy changes can both protect human populations and have unexpected negative results — such as the introduction of an invasive species, she says.

Setting a baseline

Mexico stopped its commercial imports of monk parakeets in 2014 over concerns about the possible spread of avian influenza. The country declared the monk parakeet an invasive species in late 2016, and is required by law to devise a species management plan. This doesn’t necessarily mean the invasion is over, Hobson says, because there are a lot of monk parakeets in Mexico that can escape their owners and reproduce in the wild. It’s also still unclear what effect the animals are having on the country’s native wildlife, urban infrastructure and local economy.

The study’s findings punctuate the importance of banning the international trade in parrots, as well as the need for evaluating the unintended consequences of legislative and management action, says Michael Russello, an evolutionary biologist at the University of British Columbia in Kelowna, Canada.

The baseline data provided by the study “will be invaluable for tracking the spread and potential establishment of self-sustaining monk-parakeet populations in Mexico moving forward, and monitoring the performance of any management action”, Russello says.

Journal name:

Nature
DOI:
doi:10.1038/nature.2017.22653

Comments

Commenting is currently unavailable.

Time capsule buried to preserve science for the ages

Message in a bottle sums up state of research in 2017.

29 September 2017

Marek Lewandowski

The science time capsule buried in Svalbard.

On an Arctic island, researchers have buried a stainless-steel tube stuffed with artefacts that they say sum up science and technology in 2017. The capsule, buried on 17 September, could remain in the ground for more than half a million years before it resurfaces as a result of geological uplift, sea-level rise and erosion.

Placed five metres deep in an out-of-use borehole near the Polish Polar Station in Hornsund, Svalbard, the 60-centimetre-long tube holds smaller containers with samples that include a fragment of a 4.5-billion-year-old meteorite, basaltic lava from an Icelandic volcano eruption and Namibian sand hiding particles of kimberlite and diamonds — all geared at informing a future discoverer of our present understanding of Earth's geology.

To summarize biology, it includes dried DNA samples from humans, rats, salmon and potato, a bee in resin, seeds and around 300 tardigrades, the minuscule aquatic 'water bears' that can survive extreme radiation, drought and heat.

And to communicate to future historians the state of today's technology, scientists packed into the tube silicon-based electronic devices, including accelerometers, a radiation detector and a mobile phone. They added a credit card, a wristwatch and a photograph, etched into porcelain for longevity, of Earth taken from space. Researchers also left their fingerprints on the inside of some of the container caps.

Polar anniversary

The message in a bottle was created to celebrate the sixtieth anniversary of Poland's polar station, which was set up during the International Geophysical Year 1957-58, a research project that included a series of global geophysical activities.

"I wanted to create a memorial for the ages," says Marek Lewandowski, a permafrost specialist with the Polish Academy of Sciences Institute of Geophysics in Warsaw, who selected the objects for the time capsule. Lewandowski, who thought up the idea in May, says that he consulted dozens of experts at Polish and foreign research institutes about the capsule's inventory. The capsule is described in a manuscript published in the journal *Gondwana Research*[1] on 28 September.

Image Slideshow

1. 

Seeds, including oats, pumpkin seeds, maize, beans, peas and a sunflower, were buried in the capsule.

Adam Nawrot

2. 

Also in the capsule: DNA from a woman, a man, a rat, a salmon and a potato.

Ewa Gojska-Sledzewska

3. 

A medical injector, coal for a grill, and a model car were among the items buried to represent everyday life.

Marek Lewandowski

4. 

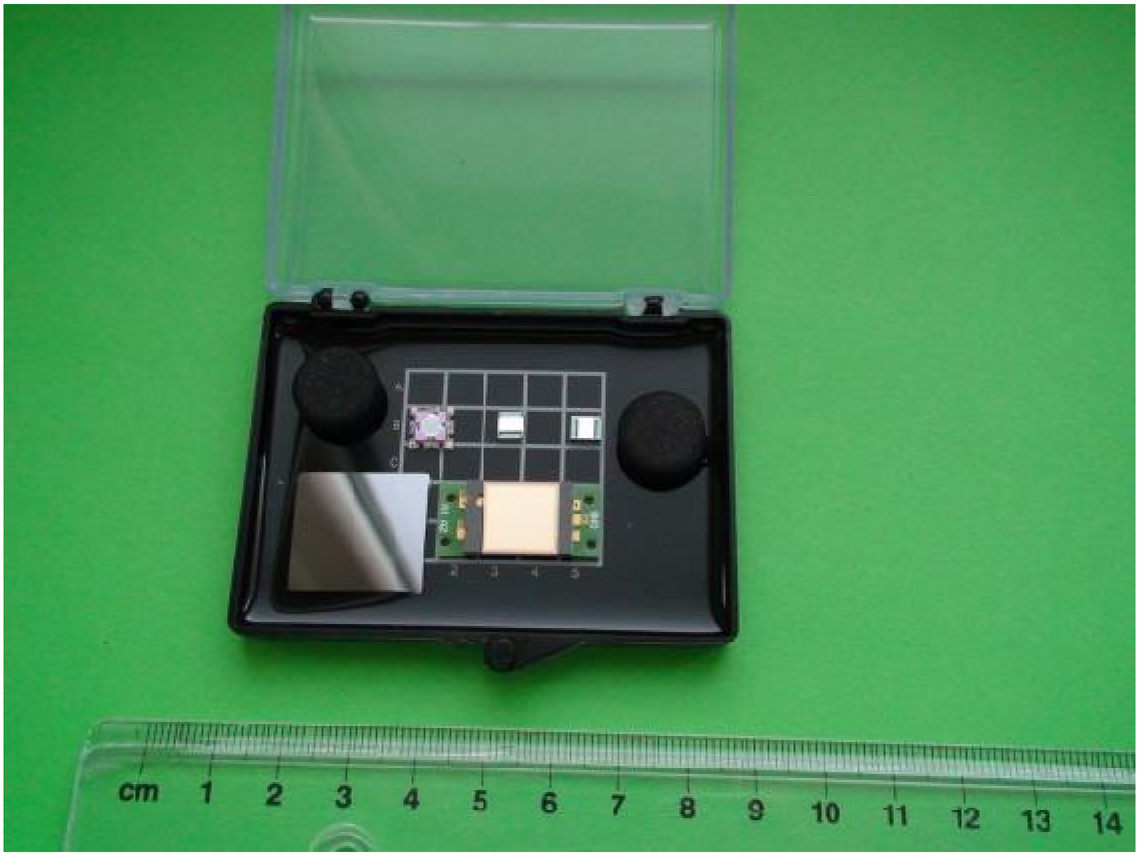
The Moon and Earth printed on porcelain.

Marek Lewandowski

5. 

A mesozoic ammonite, one of a host of fossils and rocks in the capsule.

Marek Lewandowski

6. 

Silica-based electronics were also buried in Svalbard.

Dariusz Szmigiel

It’s a bit of a balancing act between jocular and serious science,” Lewandowski says. “But I do think it’s a good way to capture what we know today about the natural history of our planet and the evolution of life on it.”

The objects are nicely, if quirkily, chosen, says Jan Zalasiewicz, a geologist at the University of Leicester, UK. “They have put together a thoughtful and ingenious message for the far future,” he says, “But the few things in the capsule will be a drop in the ocean among the huge diversity of ‘techno-fossils’ that humans will leave behind as geology.”

Zalasiewicz adds that he thinks the capsule might resurface well before the half-a-million year estimate, because the chosen burial place is just a few metres above sea level, and marine erosion from sea-level changes are difficult to predict.

It’s not the first time that humans have designed a time capsule for distant civilizations to unwrap and decode. The Voyager Golden Record — phonograph records (together with a cartridge and a needle) on board the two Voyager spacecrafts launched in 1977 — contains 115 images, musical selections, natural soundscapes and spoken greetings to any extraterrestrials that might pick up the messages.

But chances are slim that Voyager’s snapshot of twentieth-century human culture, selected by a NASA committee, will ever be delivered and understood, says Lewandowski.

“Our own time capsule is sure to be found one distant day, and its discoverers will be able to grasp the message,” he says. “If they look carefully inside — like we did into the Cheops pyramid and the tombs and artefacts inside it — they will understand who we were.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22657

Comments

Commenting is currently unavailable.

Tsunami wreckage serves as liferafts for invasive species

Hundreds of species can subsist for years on tsunami debris.

29 September 2017

Oregon Parks Department/ Handout/Corbis via Getty

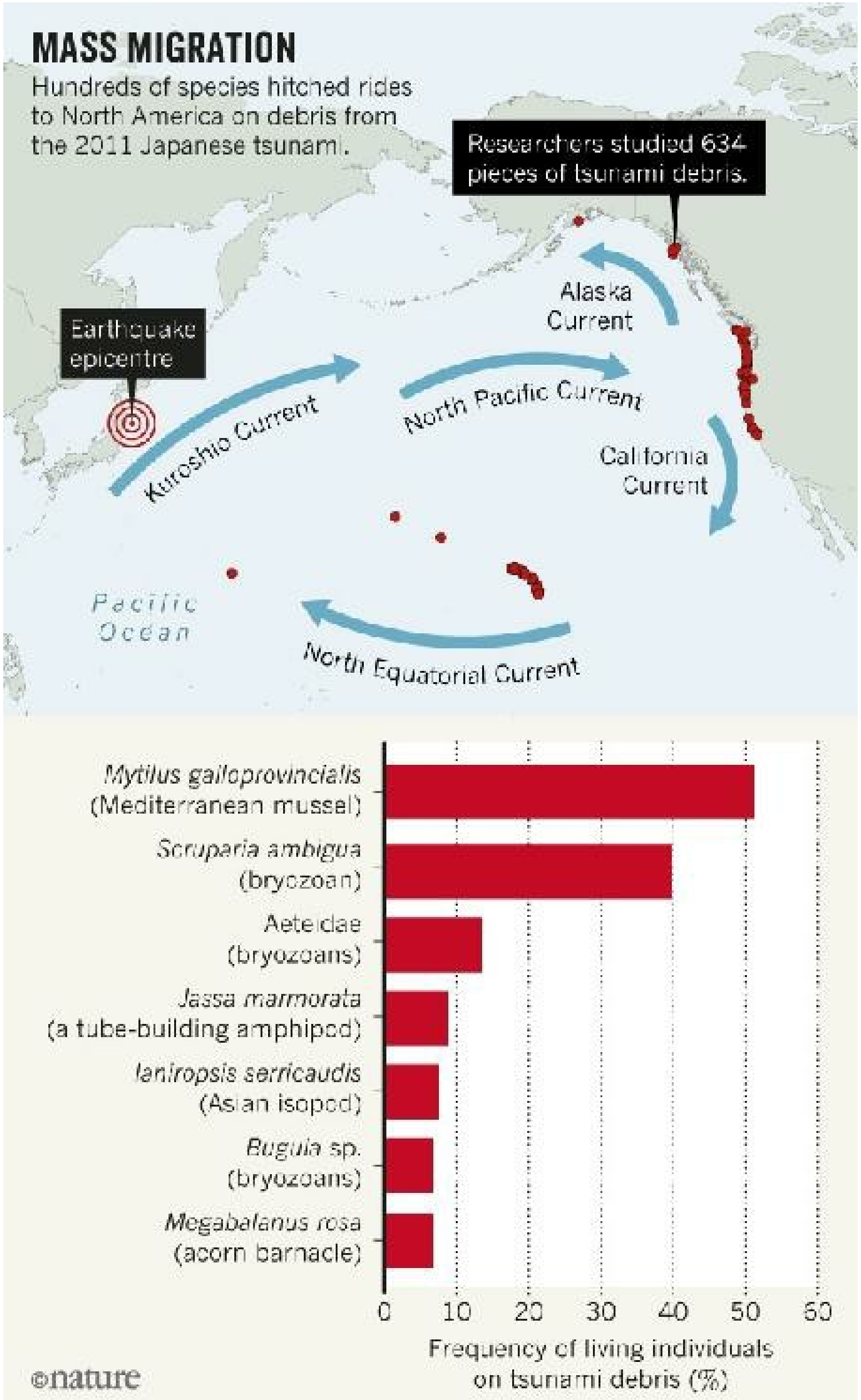
Tsunami debris included this Japanese dock, which washed up on the shores of Oregon.

Two years after a tsunami devastated parts of Japan, a small black-and-white-striped fish washed ashore in Long Beach Peninsula, Washington. The barred knifejaw (*Oplegnathus fasciatus*), which is native to Asian waters, had made the 7,000-kilometre trip in the stern well of a deserted fishing vessel set adrift by the giant wave.

The knifejaw found in 2013 is just one of hundreds of species carried across the Pacific Ocean to North America by debris — estimated to weigh a total of nearly 1.5 million tonnes — that was swept out to sea after the Tohoku earthquake in March 2011. As extreme coastal weather events such as hurricanes, typhoons and tsunamis become more intense and frequent as a result of climate change, researchers warn that such mass-migration events could also become more common.

James Carlton, a marine ecologist at the Maritime Studies Program of Williams College and Mystic Seaport in Mystic, Connecticut, and his colleagues worked with more than 100 volunteers to look for tsunami debris along North American shores, including the west coast of the United States and Canada, as well as Hawaii. Over almost 5 years starting in 2012, they intercepted 634 objects that could be traced back to the tsunami, ranging in size from small fragments of plastic to fishing vessels and mooring docks (see ‘Mass migration’). Between them, they carried from Japan 289 species of living invertebrates and fish, the researchers report in *Science*[1]. Some of the creatures had survived adrift for several years.

That’s just a fraction of the “thousands or tens of thousands” of objects estimated to have landed in North America, says Carlton. And he suspects there are more to come. “Many of these can subsist in the ocean for longer than we could imagine,” he says. “We had no idea this would last into 2017.”



Source: Ref. 1

The team began its search when a 165-tonne dock — made of concrete, steel and polystyrene foam — washed up on the coast of Oregon, 15 months after the disaster. This ‘megaraft’ was coated with almost 100 different species. It was a harbinger, Carlton says, of the need to monitor what else might be coming. More-recent debris has not been so species-rich; only one object hosting more than 20 species has been found since summer 2015.

The team’s finds included gooseneck barnacles (*Lepas* sp.) that blanketed the bottom of a wrecked fishing boat and a Japanese limpet (*Siphonuria sirius*) that had hitched a ride on a buoy. Most of the creatures arriving were invertebrates: molluscs, annelid worms, cnidarians (jellyfish and their relations), crustaceans and moss-like marine invertebrates called bryozoans. It is unusual for vertebrates such as the knifejaw fish to be carried so far, says Gail Ashton, a marine ecologist at the Smithsonian Environmental Research Center in Tiburon, California.

The mass migration raises the concern that some of these trans-Pacific passengers might establish invasive populations on the North American coast. None of the species has been spotted doing so yet. But “the fact that they’ve lasted in the ocean for four or five years shows they’re pretty hardy”, says Ashton. And by the time any species do settle, says Carlton, it could be too late to do anything about it. Once a population is common enough to see, he says, “it becomes harder to manage eradication”.

Such a huge rafting event is unprecedented, say the researchers. Japan has seen only two other earthquakes with magnitudes comparable to Tohoku in the last few centuries; they occurred in 1896 and in 1933. “If you look at photos of the same coasts in those years, there are small villages with wood houses,” says Carlton. “Back then, a tsunami could not generate this sea of plastic we saw in 2011.”

Biodegradable objects such as wood would rarely survive such a long trip. The study underscores the far-reaching consequences of plastic in the environment, says Jenna Jambeck, an environmental engineer at the University of Georgia in Athens. “Once something enters the ocean, it becomes a global problem.”

Journal name:
    Nature

DOI:
doi:10.1038/nature.2017.22691

Comments

Comments

There are currently no comments.

Tropical forests may be carbon sources, not sinks

Combination of satellite images and on-the-ground data enables more complete tracking of forest carbon flows.

29 September 2017

Tim Laman/NGC

Tropical forests may emit more carbon than they absorb.

Every moment, the world’s roughly 3 trillion trees either suck up carbon dioxide from the air or release it into the atmosphere. Accurately quantifying these carbon flows is a long-standing challenge that has hindered scientists’ understanding of how forests help to regulate Earth’s climate. Now, researchers have combined ground and satellite measurements to conclude that tropical forests seem to be a net source of heat-trapping carbon emissions, rather than a carbon sink.

The team’s paper, published on 28 September in *Science*[1], bolsters a growing consensus: that tropical forests are drying out or being cleared, burned and logged so fast that they now spew out a lot more carbon than they squirrel away.

Whereas earlier estimates based on measurements of atmospheric carbon flows suggested that tropical forests might be carbon neutral or even a net sink, more-recent studies — including ones based on data from NASA’s Orbiting Carbon Observatory-2 satellite — agree broadly with this recent paper, says David Schimel, an ecologist at NASA’s Jet Propulsion Laboratory (JPL) in Pasadena, California. He suspects that human activities such as starting fires and natural factors including droughts have dealt a severe blow to forests’ ability to store carbon.

Tracking carbon

The study authors estimate that the world’s tropical forests release approximately 425 million tonnes of carbon annually, equivalent to roughly 5% of the globe’s annual fossil-fuel emissions, and about five times more than an estimate in a highly cited 2011 paper[2] that relied on ground-based forest inventories. Their work captures nuances in how droughts and other natural or human-caused disturbances could affect the amount of carbon that tropical forests exchange with the atmosphere.

The research team first travelled to forests throughout the tropics to measure tree diameters and heights. The scientists then fed those measurements into species-specific equations to estimate how much carbon the trees stored. Next, they used those estimates to ground-truth data collected by NASA’s Ice, Cloud, and Land Elevation Satellite (ICESat), a laser-equipped satellite that from 2003 to 2010 gathered data on forest height and vegetation layers around the globe.

Finally, the researchers used a machine-learning algorithm to translate measurements from the Moderate-Resolution Imaging Spectrometer (MODIS) instruments — part of NASA's Terra and Aqua satellites that image Earth's entire surface every one to two days — into data they could compare to the ICESat numbers. By extrapolating this comparison to MODIS images for the entire tropics, the team tracked how much carbon tropical forests gained and lost between 2003 and 2014.

The scientists quantified losses due to deforestation, degradation — including logging, firewood gathering and other human activities — and natural disturbances such as droughts. Because degradation and natural disturbances often leave forest canopies mostly intact, most previous satellite studies have failed to account for their impact on carbon emissions, says Alessandro Baccini, a remote-sensing scientist at the Woods Hole Research Center in Falmouth, Massachusetts, who led the work. Yet the researchers calculated that these processes accounted for more than two-thirds of forests' carbon emissions. "We were surprised how much of the emissions were a result of degradation," he says.

On the map

The study also tracks carbon captured by growing forests, which had been missing in previous analyses of satellite data, says Nancy Harris, a carbon scientist at the World Resources Institute in Washington DC. "This paper really helps to put carbon gains on the map." In doing so, it moves scientists closer to being able to monitor countries' progress toward forest-protection goals set under the 2015 Paris climate agreement, which requires accurate tracking of both carbon losses and carbon gains due to forest growth, she says.

Carbon estimates from satellite imagery should be viewed with caution, however, says Matthew Hansen, a geographer at the University of Maryland in College Park who produces satellite-based maps of changes in tree cover. MODIS and other optical sensors can be compromised by atmospheric interference, he says. And Hansen is concerned that the Woods Hole team reports large carbon losses in areas where forests have not disappeared, such as northern Brazil. “Geographically, there are some places that look suspect” in the team’s analysis, he says.

Moreover, MODIS cannot easily detect how much older forests are growing, potentially causing Baccini’s team to underestimate the carbon that these areas absorb, says Sassan Saatchi, a remote-sensing scientist at JPL. That could change when NASA’s Global Ecosystem Dynamics Investigation instrument launches to the International Space Station in 2018, Saatchi says. The instrument will measure forest height and vegetation layers using lasers that will capture far more data than those of ICESat, and should provide a more direct way to estimate tropical-forest carbon.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22692

Comments

Commenting is currently unavailable.

French government proposes big science-spending boost

President Emmanuel Macron’s 2018 draft budget would raise research funds by 6%.

29 September 2017

Ludovic Marin/AFP/Getty Images

Frédérique Vidal, France's higher education, research and innovation minister, said the budget would give 'fresh oxygen' to the country's research.

French research funding is set for a heartening increase in the country’s first budget under President Emmanuel Macron, if draft 2018 plans released on 27 September are voted into law.

The research portfolio of France’s ministry of higher education, research and innovation would rise by more than 6%, to €8.4 billion (US$9.9 billion) in 2018. And on top of that, a giant economic-recovery plan unveiled on 25 September by Prime Minister Edouard Philippe should divert an extra €2.4 billion to research over the next five years.

The cash injection will lead to a “small revolution”, said Frédérique Vidal, the country’s minister for higher education, research and innovation at a press conference the day after the budget release. In particular, Vidal said that France’s public laboratories stand to gain money after years of cuts. “We all know we have come to the end of a movement where laboratories’ allocations have been trimmed, year after year. With the 2018 budget, we are reversing the trend and are starting to give fresh oxygen to our research,” she said.

Scientists who have long campaigned for more funding praised the proposals. “It is a signal that President Macron and the government have understood the long-term consequences of the funding crisis that has hit universities and research agencies for years,” says Patrick Lemaire, a biologist at the University of Montpellier and founder of the researcher-led campaign group Sciences en Marche.

For Bernard Meunier, a chemist and a past president of the French Academy of Sciences, the most positive point of the budget was that Vidal seemed to recognize the poor state of French labs’ finances. “There couldn’t be any further cut in their funding, because there is practically nothing left. The minister is aware there is a problem, whereas her predecessors said there wasn’t,” he says.

In the draft proposal, the French National Research Agency (ANR), which funds individual projects on a competitive basis, would see its budget rise by 5%, to €706 million — although its funding levels are still slightly lower than they were in 2012, and it still has no head after former president and chief executive Michael Matlosz resigned in July. Competition for grant funding remains fierce at the ANR, where only around 12% of grant applications are successful, and Lemaire doubts that the extra money will do much to improve that.

The funding boost is welcome, but not sufficient on its own to transform the agency, says Meunier. “We need the ANR to be restructured to permit more blue-skies funding and simpler grant-application procedures,” he says.

There would be a smaller increase for the country’s public-research bodies — including the basic-research agency CNRS and the biomedical agency INSERM — which give out grants and run their own laboratories, many of them jointly with universities. These agencies see their collective spending rise by just over 1%, to €5.94 billion. Some of the money will be used for Macron’s Make Our Planet Great Again campaign, which aims to attract foreign climate scientists to France.

This year’s budget is the first since Vidal, a biochemist who was president of the University of Nice Sophia Antipolis from 2012 to 2017, was appointed to the research ministry. In a sign that France’s government is taking the post more seriously, Vidal's role was also made more senior: she reports directly to the prime minister, whereas her predecessor, Thierry Mandon, reported to a minister for education.

The proposed increases are all the more welcome because the European Commission is pressuring France to rein in its deficit. This July, around €184 million was trimmed from the ministry’s 2017 budget for research, as part of a series of public-spending cuts.

France’s controversial system of tax credits for companies that conduct research will remain in place, economy and finance minister Bruno Le Maire told reporters. The system, which costs the state up to €6 billion a year in tax revenues, has come under fire for alleged abuses: critics say companies use it to reduce their tax bill, rather than to increase their research spending. But Le Maire said he would simplify the system to make it easier for smaller companies to apply for credits, although he did not give details.

Macron, meanwhile, has urged the European Union to pay more attention to research. In a 26 September speech, he argued that the EU should create an agency to accelerate the commercial applications of basic science, with the idea of spurring innovation in fields such as artificial intelligence.

Journal name:

Nature
DOI:
doi:10.1038/nature.2017.22733

Comments

Comments

There are currently no comments.

Toad tadpoles turn homegrown poisons on each other

Young amphibians are the first animals thought to use toxins against rivals of their own species.

29 September 2017

Bert Willaert/NPL

These common-toad tadpoles produce a potent toxin that affects the heart.

Many tadpoles ward off predators with potent poisons — but those toxins also seem to help win battles with their own kind, a new study finds.

Tadpoles of common toads (*Bufo bufo*) are more poisonous when raised in crowded conditions, which may give them a competitive edge, according to the work published on 23 September in *Functional Ecology*[1].

Many noxious plant species are known to modulate their defences to fend off different threats[2], but it is less clear whether animals possess similar toxin-tuning abilities. Although predation pressure is known to induce tadpole chemical defences[3], the new findings are the first unequivocal evidence of toxin synthesis spurred by competition in vertebrate animals.

Being poisonous can make a species essentially inedible to predators, but making potent toxins comes at a metabolic cost — so it’s best to make that investment count. “It would be very profitable for such animals to kill two birds with one stone by using their anti-predatory toxins as chemical weapons against their competitors, too,” says the study’s lead author, Veronika Bókony, an ecologist with the Hungarian Academy of Sciences in Budapest.

Common toads are equipped with bufadienolides, potent toxins that cause harm by accelerating and disrupting the heart’s rhythms[4]. Field studies have found that common toad toxicity varies geographically, with the intensity of competition being the most reliable predictor[5]. But it has been unclear whether such patterns occur because populations are genetically isolated from one another in different ponds, or whether they reflect defences induced by environmental factors.

Bókony and her colleagues took this question to the laboratory, rearing toads in artificial ponds with varying numbers of individuals — a proxy for the strength of competition. The species composition of the ponds also varied; some contained common toads, others contained agile frogs (*Rana dalmatina*) and some contained a mix. Agile frogs hatch earlier and grow to larger sizes than common toads, so they were considered to represent tougher competition. Because the frogs are non-toxic, the researchers wanted to see whether the toads’ toxins are especially aimed at these intense rivals (a phenomenon called allelopathy).

Toxic relationships

The more competitors the toads were raised with — of either species — the smaller and more toxic they were, echoing the field results. But surprisingly, toad tadpoles defended themselves against their own kind more fiercely, by producing more toxins than they did against the frogs. Meanwhile, the frogs didn’t seem to be bothered by their toxic tankmates.

The study is “very well designed”, says Thomas Hossie, an ecologist at Trent University in Peterborough, Canada. The plasticity of other tadpole traits, including morphology and behaviour, is well documented, he notes, but most studies examine the response to predation risk. “This paper is another great example of how amazingly plastic larval amphibian traits really are.”

Gary Bucciarelli, an ecologist at the University of California, Los Angeles, also praises the work: “I think the researchers present a very compelling study that questions the evolution and ecological role of amphibian chemical defences.” His own research has shown that newts become more toxic in response to stressful conditions[6]. Such findings “really begin to scrutinize the idea that predation alone drives variation in animal chemical defences”, he adds.

Toxicity that varies by the density of an organism’s population has also been observed in insects[7], notes Hossie: “This experiment indicates that it may be more widespread than we anticipated.”

Bókony and her colleagues aren’t done with the toads yet, as the unexpected lack of harm to the competitor frogs “begs the question what exactly [the toads] are defending themselves from”. Cannibalism is certainly a possibility, as tadpoles of many species are known to turn on their own when times are tough.

But Bókony wonders whether the toxins might serve a different function altogether. She hypothesizes they may “provide a sort of immune defence against contagious diseases they could catch from [fellow tadpoles], especially when crowded”. She and her colleagues hope to explore this possibility next.

Journal name:
Nature

DOI:
doi:10.1038/nature.2017.22734

Comments

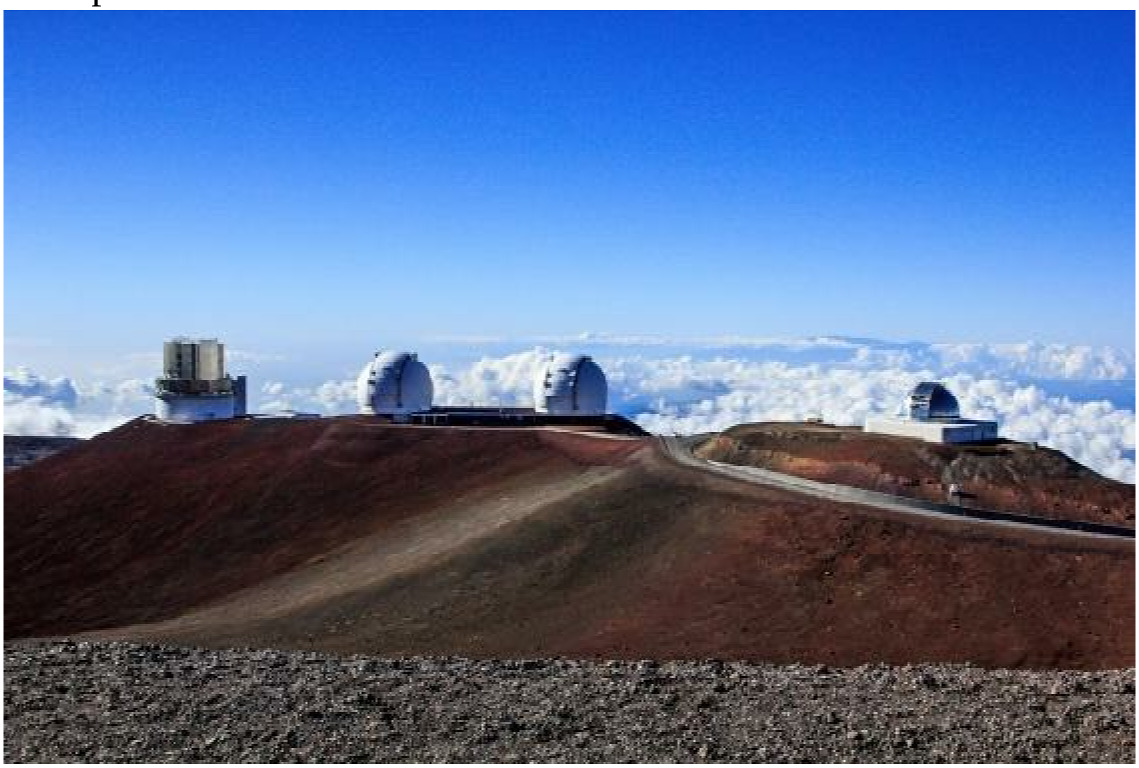
Comments

There are currently no comments.

Controversial Thirty Meter Telescope gets go-ahead to build in Hawaii

State board issues construction permit for project, but legal fight over telescope continues.

29 September 2017



Moment Editorial/Getty

The Thirty Meter Telescope would join other large telescopes atop Mauna Kea in Hawaii.

Hawaii’s board of land and natural resources granted a fresh construction permit to the Thirty Meter Telescope (TMT) on 28 September, reviving the fortunes of the US$1.4-billion observatory — at least temporarily.

The permit moves the international project closer towards restarting construction near the summit of the Hawaiian mountain of Mauna Kea. Some Native Hawaiians oppose the TMT, saying that its construction would further violate a sacred mountain that is already home to multiple telescopes.

The board's decision effectively puts the TMT project back where it was before protestors halted the telescope's construction in April 2015, just days after it had begun, by blocking the road up Mauna Kea. That December, following months of challenges, Hawaii's supreme court invalidated the telescope's first construction permit. The court ruled that the state land board had not followed appropriate procedures because it had approved the first permit, in 2011, before it held a set of public hearings on the case.

The board's latest decision follows a July recommendation to issue the permit from retired judge Riki May Amano, who oversaw more than 40 days of additional hearings earlier this year for the board. Another set of public hearings took place this month, after which the seven-member board voted five to two to issue the permit. "This was one of the most difficult decisions the board has ever made," said chairperson Suzanne Case.

The new permit adds requirements to construction plans for the telescope, including a zero-discharge wastewater system and cultural and natural-resources training for workers.

"We are greatly encouraged," said TMT board chair Henry Yang in a statement. "In moving forward, we will listen respectfully to the community in order to realize the shared vision of Maunakea as a world center for Hawaiian culture, education and science."

Telescope opponents have filed motions that would effectively put the permit on hold until the state supreme court can hear an appeal. "Construction should not begin before all legal processes have run their course," said KAHEA: The Hawaiian–Environmental Alliance, a group in Honolulu that opposes the TMT, in a statement. Mauna Kea "is being stripped and disrespected".

But TMT supporters say the telescope would bring educational and employment opportunities to a state with a long history of astronomy. TMT organizers have been exploring the possibility of building the telescope on the island of La Palma, in Spain’s Canary Islands, if they cannot begin construction on Mauna Kea by a self-imposed deadline of April 2018. Project partners include the University of California system, the California Institute of Technology in Pasadena and the governments of India, China, Japan and Canada.

Journal name:
Nature
Volume:
550,
Pages:
20
Date published:
(05 October 2017)
DOI:
doi:10.1038/nature.2017.22731

Comments

Comments

There are currently no comments.

Nature News

周日, 08 10月 2017

Nature News

[周日, 08 10月 2017]

- **Nature News**

Nature News

Nature is a weekly international journal publishing the finest peer-reviewed research in all fields of science and technology on the basis of its originality, importance, interdisciplinary interest, timeliness, accessibility, elegance and surprising conclusions. Nature also provides rapid, authoritative, insightful and arresting news and interpretation of topical and coming trends affecting science, scientists and the wider public.

- **Navajo Nation reconsiders ban on genetic research** [周五, 06 10月 08:00]
  Tribal leaders are developing a policy for genetic research and data sharing, potentially ending a 15-year moratorium.
- **The scientist who spots fake videos** [周五, 06 10月 08:00]
  Hany Farid discusses how to detect image manipulations — and the increasing sophistication of forgers.
- **Proton-size puzzle deepens** [周四, 05 10月 08:00]
  Measurement in ordinary hydrogen agrees with a surprising 2010 result on the element's exotic cousin — but gives a smaller value than virtually every other experiment.
- **Controversial pesticides found in honey samples from six continents** [周四, 05 10月 08:00]
  Neonicotinoids are at the centre of a long-running debate about whether they harm bees.
- **Antikythera shipwreck yields statue pieces and mystery bronze disc** [周三, 04 10月 08:00]
  Archaeologists think that at least seven life-sized sculptures are hidden nearby.
- **Cryo-electron microscopy wins chemistry Nobel** [周三, 04 10月 08:00]
  Jacques Dubochet, Joachim Frank and Richard Henderson share the prize for developing a technique to image biomolecules.
- **Crash in sea-turtle births stumps ecologists** [周三, 04 10月 08:00]
  Leading suspect — climate change — doesn’t fully explain what is happening to leatherback turtles in the US Virgin Islands.
- **Scientists plead with Brazilian government to restore funding** [周三, 04 10月 08:00]
  If officials don't act soon, research institutions could start shutting down next year.
- **Supercomputer redesign of aeroplane wing mirrors bird anatomy** [周三, 04 10月 08:00]
  Bird-bone structures emerge from an evolution-like algorithm.
- **Elite Hungarian university may be saved** [周三, 04 10月 08:00]

Hungary-New York agreement could allow Central European University to sidestep law change.

- **[Science without walls is good for all]** [周三, 04 10月 08:00]
  International mobility and collaboration are linked to stronger research.
- **[Nobel prizes, giant telescope and buried treasure]** [周三, 04 10月 08:00]
  The week in science: 29 September–5 October 2017.
- **[Why fake islands might be a real boon for science]** [周三, 04 10月 08:00]
  The seasteading movement is getting close to building its first prototype, an artificial archipelago where people will live, play and do research.
- **[How fracking is upending the chemical industry]** [周三, 04 10月 08:00]
  As shale-gas compounds flood the market, chemists are working out the best ways to convert them into the ingredients of modern life.
- **[Scientists have most impact when they're free to move]** [周三, 04 10月 08:00]
  An analysis of researchers' global mobility reveals that limiting the circulation of scholars will damage the scientific system, say Cassidy R. Sugimoto and colleagues.
- **[Open countries have strong science]** [周三, 04 10月 08:00]
  Caroline S. Wagner and Koen Jonkers find a clear correlation between a nation's scientific influence and the links it fosters with foreign researchers.
- **[Neuroscience: The mother lode of invention]** [周三, 04 10月 08:00]
  Dan Jones compares three studies on the origins and fruits of human creativity.
- **[Health: The war on germs]** [周三, 04 10月 08:00]
  Tilli Tansey hails a history of Joseph Lister's drive to vanquish post-operative infection and putrefaction.
- **[New in paperback]** [周三, 04 10月 08:00]
  Highlights of this season's releases
- **[Sustainability: China's path to ecotopia]** [周三, 04 10月 08:00]
  Xuemei Bai critiques a critique of the country's eco-city initiative.
- **[Ornithology: All eyes on the 10,000 species]** [周三, 04 10月 08:00]
  Stuart Pimm considers the obsessive, sometimes dark side to the joyous pursuit of watching birds.
- **[Theoretical physics: When the doer met the dreamer]** [周三, 04 10月 08:00]
  Graham Farmelo applauds a study on the productive friendship of two very different physicists.
- **[Technology: Into cyberia]** [周三, 04 10月 08:00]
  Li Gong weighs up three tomes on Silicon Valley's vast influence, for good or ill.
- **[Fossil fuels: Heed local impact of coal mining]** [周三, 04 10月 08:00]
- **[Hurricanes: rescue natural defences]** [周三, 04 10月 08:00]
- **[Hurricanes: enlist nature's protection]** [周三, 04 10月 08:00]

- **[World Heritage Site: UNESCO honour for Polish mining facility]** [周三, 04 10月 08:00]
- **[Food supply: Blockchain could boost food security]** [周三, 04 10月 08:00]
- **[Collaborative software development made easy]** [周三, 04 10月 08:00]
  Save time and protect critical code with 'continuous integration' services.
- **[A taste of Toolbox]** [周三, 04 10月 08:00]
  Nature 's technology editor, Jeffrey Perkel, started blogging about workplace technology in science in 2016. Here are some highlights.
- **[The daughter you've always wanted]** [周三, 04 10月 08:00]
  Family matters.
- **[South Korea cracks down on dirty air]** [周二, 03 10月 08:00]
  Despite huge clean-up effort, scientists say country’s pollution problem could get worse over next five years.
- **[Xenon view, butterfly wings and a strange squid]** [周二, 03 10月 08:00]
  September’s sharpest science shots, selected by Nature ’s photo team.
- **[Europe’s Joint Research Centre, although improving, must think bigger]** [周二, 03 10月 08:00]
  External report criticizes lack of exploratory research.
- **[Make plans to eliminate cholera outbreaks]** [周二, 03 10月 08:00]
  Governments must stop denying the occurrence of cholera and unite in long-term prevention strategies, says Anita Zaidi.
- **[Ethics of Internet research trigger scrutiny]** [周二, 03 10月 08:00]
  Concern over the use of public data spurs guideline update.
- **[Gravitational wave detection wins physics Nobel]** [周二, 03 10月 08:00]
  Rainer Weiss, Barry Barish and Kip Thorne share the 2017 prize for their work at LIGO to detect ripples in space-time.
- **[Risk of human-triggered earthquakes laid out in biggest-ever database]** [周一, 02 10月 08:00]
  Geologists track hundreds of quakes caused by people and the projects that set them off.
- **[Discoveries have awkward first dates]** [周一, 02 10月 08:00]
  Fuzzy timings over a plate-tectonics anniversary highlight the rolling nature of scientific discovery.
- **[Chinese scientists fix genetic disorder in cloned human embryos]** [周一, 02 10月 08:00]
  A method for precisely editing genes in human embryos hints at a cure for a blood disease.

- **[Medicine Nobel awarded for work on circadian clocks]** [周一, 02 10月 08:00]
  Jeffrey Hall, Michael Rosbash and Michael Young unpicked molecular workings of cells' daily rhythms.

Navajo Nation reconsiders ban on genetic research

Tribal leaders are developing a policy for genetic research and data sharing, potentially ending a 15-year moratorium.

06 October 2017

Ricky Carioti/The Washington Post/Getty

Children play on the Navajo Nation's vast reservation in the southwestern United States.

When the Navajo Nation opens its first oncology centre next year in Tuba City, Arizona, clinicians there may be able to offer a service that has been banned on tribal lands for 15 years: analyzing the DNA of Navajo tribe

members to guide treatments and study the genetic roots of disease.

That's because the Navajo, the second-largest Native American group in the United States, are considering whether to lift their longstanding moratorium on genetic research. The tribal government banned DNA studies in 2002 to prevent the misuse of its members' genetic material. Although there is still some apprehension about the risk of allowing researchers access to Navajo DNA, the tribe's leaders increasingly see genetic research as a tool to improve medical care for the 174,000 residents of their sprawling reservation, which is roughly the size of Scotland.

As it now stands, Navajo people who live on the reservation must drive hundreds of kilometres to access specialized medical care off tribal lands, in large cities such as Phoenix, Arizona. “We spend millions of dollars outsourcing [care] for cancer and diabetes,” says Walter Phelps, a delegate to the Navajo Nation Council. As the tribe — a nation independent of the United States — tries to expand the health services it offers to its members, he says, “the moratorium could become a barrier when blood and tissue have to be collected”.

Phelps is working on the effort to create a policy by which the Navajo Nation would approve genetic-research projects and maintain control of DNA samples. The research-ethics board run by the tribal government’s department of health is working with tribal officials and traditional leaders and holding a series of public hearings to solicit opinions on the matter from tribe members. The group hopes to deliver a draft proposal by the end of October. Whatever the tribe decides could influence the hundreds of other Native American groups, who have tended to be wary of genetic studies because of a history of scientists conducting research without consent or adequate privacy controls.

The Navajo Nation's new oncology centre provides part of the impetus for revisiting the genetic-research ban. It will be the first such facility on Native American lands outside of Alaska. Allowing some genetic testing at the centre could help physicians to identify the most effective therapies for each patient, says Lynette Bonar, chief executive of the Tuba City Regional Health Care Corporation in Arizona, which will run the facility.

That would match the standard of care that many Navajo people with cancer

have received at medical facilities off the reservation. And creating a repository for such genetic material on Navajo land would enable research into the genetic and environmental factors underlying a broad range of diseases, not just cancer.

So far, Phelps says, the idea of allowing some genetic research has not drawn major opposition. Many tribe members consulted about lifting the moratorium have generally supported the idea after learning how physicians could use genetic data to diagnose disease and tailor treatments. And the number of Navajo tribe members who are geneticists and medical experts has grown since 2002, bolstering the tribe's ability to evaluate proposed protocols and represent its own interests.

Fraught history

Still, some Navajo have lingering questions about whether the tribal government can protect the privacy of their genetic material and maintain control over its use. Such concerns helped to shape the current ban back in the early 2000s, when the Navajo Nation's department of health conducted an outreach campaign about genetics and medical research. "In the absence of a research code and lack of expertise at the time, they decided it was not a good time to move forward with genetic research until they were able to develop a research policy," says Nanibaa' Garrison, a member of the Navajo Nation who is a geneticist and bioethicist at Seattle Children's Hospital in Washington.

The tribe had reason to be cautious. "As Native Americans, we have a problem with trust because we have been violated so much," says David Begay, a pharmaceutical scientist at the University of New Mexico in Albuquerque and a member of the Navajo Nation's human-research review board. "In the past, our data have been misused."

Native Americans in the southwestern United States want to avoid repeating the experience of the region's Havasupai tribe. In 2004, the group sued Arizona State University in Tempe over alleged misuse of tribe members' blood samples. The Havasupai said that the samples, which had been

collected for diabetes research, had later been used in studies of schizophrenia, migration and inbreeding without their consent. The university made a settlement with the tribe in 2010, paying US$700,000 and returning the blood samples.

Sara Hull, a bioethicist at the US National Human Genome Research Institute in Bethesda, Maryland, says the case helped to change how researchers engage with the people they study, by raising awareness of the complexities of dealing with vulnerable minority populations. For Native Americans, such thorny issues can include privacy. Science-funding agencies and journals often require researchers to put the genetic data they collect into public repositories, but the relatively small size of many Native American tribes can make it easy to identify individual members in a genetic data base. In recognition of this, the US National Institutes of Health sometimes works with researchers it funds to develop methods for sharing data on a minority group without compromising its privacy.

Garrison, who is helping the Navajo Nation develop its new policy, says that the plan is likely to include rules on what types of research will be allowed, who will have access to tribe members' genetic material and information, and who will provide oversight. It is also likely to require that the tribe maintain ownership of its members' DNA samples and data.

The policy that the Navajo Nation ultimately produces could serve as a template for other Native American groups considering how — or whether — to engage with genetic research, says Ellen Clayton, a bioethicist at Vanderbilt University in Nashville, Tennessee. She expects other tribes to watch the development of the Navajo Nation's new policy. "If they reach an agreement, I think it will be influential."

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22780

Comments

Commenting is currently unavailable.

The scientist who spots fake videos

Hany Farid discusses how to detect image manipulations — and the increasing sophistication of forgers.

06 October 2017

Eli Burakian/Dartmouth College

Hany Farid.

Hany Farid, a computer scientist at Dartmouth College in Hanover, New Hampshire, specialises in detecting manipulated images and videos. Farid, who provides his services to clients as varied as universities, media organizations, and law courts, says that image manipulation is becoming both more frequent and more sophisticated. He spoke to *Nature* about the arms race to stay ahead of the forgers.

Where do you start when trying to spot a fake image?

One simple but powerful technique is reverse image search. You give the image to a site such as Google Image Search or TinEye, and they show you all other instances of it. A project at Columbia University, in New York City, is taking this to the next level, and starting to find parts of images that have been repurposed from other images**.**

Generally, we think about which patterns, geometries, colours or structures are going to be disrupted when someone manipulates a photo. For example, when people add an object into a scene, we know that where they put the shadow is usually wrong. A viral video called Golden Eagle Snatches Kid from 2012 is one of my favourite examples. It took us only 15 minutes of analysis to show shadow inconsistencies: the eagle and baby were computer-generated.

What about if fake images make only slight tweaks?

There are a number of analyses we can do. In a colour picture, every pixel needs three values — corresponding to the amounts of red, green and blue at that point. But in most cameras, every pixel records just one colour, and the camera fills in the gaps by taking the average values of the pixels around it. This means that, for any given colour in an image, each missing pixel has a particular correlation with its neighbours, which will be destroyed if we add or airbrush something, and we can detect that**.**

Another technique is JPEG compression. Almost every image is stored in a JPEG file, which throws away some information to save on storage. There is a huge amount of variation in how each camera does that. If a JPEG is unpacked — opened in Photoshop — and then put back together, it is always repackaged slightly differently, and we can detect that. I wish you could just upload any image and we could tell you if it's real or not, but it's still a very

difficult process and requires expertise to understand different components.

Who uses your digital forensic services?

I do analysis for organisations such as the Associated Press, Reuters, and *The New York Times*. There are only a handful of academics worldwide who are specialists in this, so it doesn't scale — and that means you can only do the analysis of really high-stakes images. But there are efforts under way to scale this up. Last year, the US Defense Advanced Research Projects Agency (DARPA) got into this game with a large project of which I'm part. Over the next five years they're trying to create a system that will allow you to analyse hundreds of thousands of images a day. It's a very ambitious programme.

I also do a lot of work in the courts. For example, here in the United States, child pornography is illegal, but computer-generated child pornography counts as 'protected speech' under the First Amendment. If someone's arrested they might say that the offending image isn't real, and I might have to prove that it is. I also get lots of e-mails from people about photo hoaxes — almost daily.

Do you apply your techniques to scientific papers?

I have worked on many cases of scientific misconduct, hired by universities conducting internal investigations. When I visited the US Office of Research Integrity recently, they asked me "how do we get our hands on automated tools?" The reality is we're still not there. But creating something that uses some of the tools, such as clone detection, which looks to see whether parts of an image have been copied and pasted from elsewhere, would be possible as a semi-automated process looking at dozens, not millions, of images a day. It's something my colleagues and I are thinking about, and it's a small but not insignificant part of the DARPA programme.

How about fake videos?

Researchers are now able to splice together footage to create videos of famous people seeming to say things they never said — for instance, this video of President Obama. And they can create fake images or short videos using machine learning techniques: in particular, generative adversarial networks (GANs), which learn to generate fake content. These pit a network that generates fake content against a 'classifer' network that attempts to discriminate between real and fake content, so that the faking network rapidly improves.

I've seen the technology get good enough that I'm now very concerned. In 5 or 10 years, this is going to get really good. At some point we will reach a stage where we can generate realistic video, with audio, of a world leader, and that's going to be very disconcerting. I would say that the field of digital forensics is now behind in video.

How can you detect fake video?

JPEG compression has an analogous construct in video, which is a bit harder to detect because video uses a more sophisticated version. Another approach is to use machine learning for detection. But we're taking an approach similar to what we do with images — which is based on the observation that computer-generated content lacks the imperfections that are present in a recorded video. It's created in almost too perfect a world. So one of the things we look at is, are we not seeing the statistical and geometric patterns we'd expect to see in the physical world?

Another technique is based on some beautiful work by William Freeman and colleagues at the Massachusetts Institute of Technology in Cambridge, who showed how if you magnify really small changes in a video of a person, you can see subtle changes in the colours in their face that correspond to their pulse rate. We showed that you can use this to distinguish real people from computer-generated people.

Couldn’t machine learning algorithms learn to include these features?

Perhaps in principle. But in practice, these algorithms have limited time and training data, and there is little control over which features a neural network will pick up on to discriminate between real and fake videos. A GAN is only trying to fool the classifier it’s trained on. That’s no guarantee that it will learn all aspects of what makes an image or video real or fake, or that it will fool another classifier.

My adversary will have to implement all the forensic techniques that I use, so that the neural network can learn to circumvent these analyses: for example, by adding a pulse in. In that way, I’ve made their job a little harder.

It’s an arms race. As we are developing faster, folks are creating more sophisticated technology to augment audio, images and video. The way this is going to end is that you take the ability to create a perfect fake out of the hands of the amateur. You make it harder, so it takes more time and skill, and there’s a greater risk of getting caught.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22784

Comments

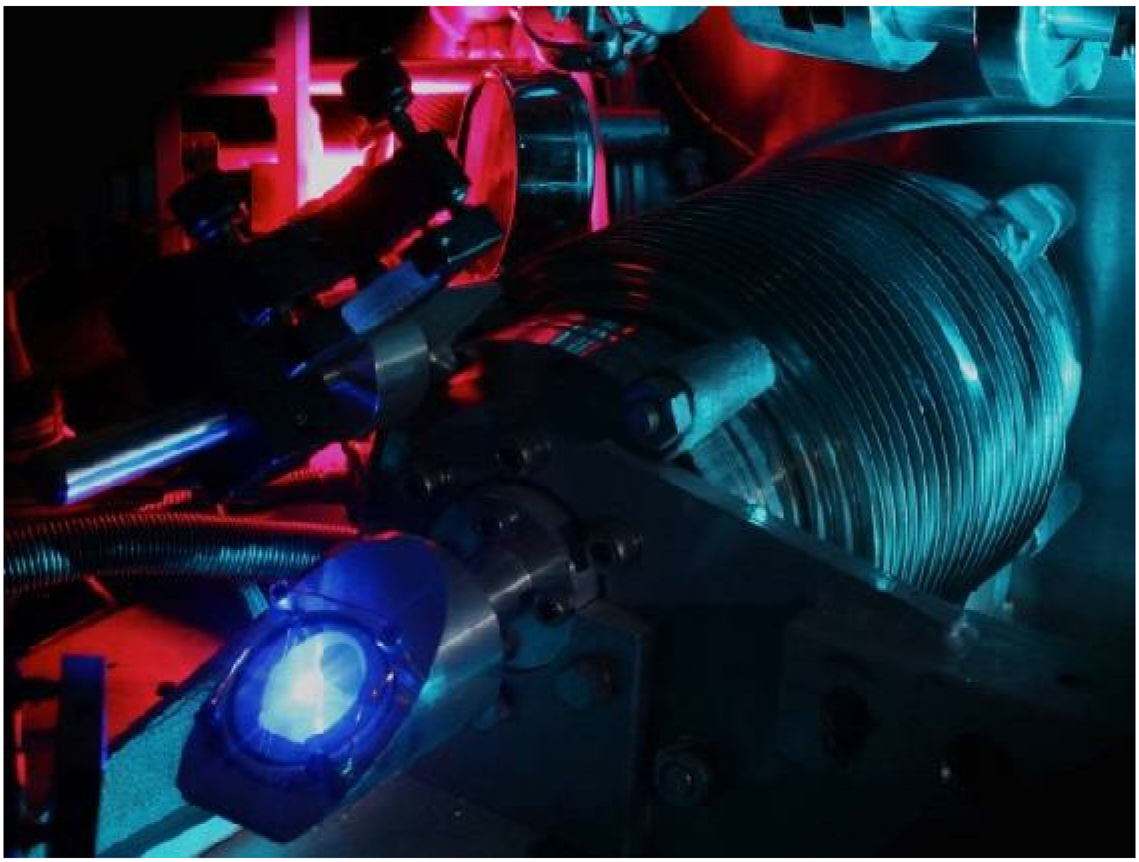
Comments

There are currently no comments.

Proton-size puzzle deepens

Measurement in ordinary hydrogen agrees with a surprising 2010 result on the element's exotic cousin — but gives a smaller value than virtually every other experiment.

05 October 2017



Axel Beyer

Researchers shone lasers at hydrogen atoms in a vacuum chamber to pinpoint the size of the protons inside.

The proton might truly be smaller than was thought. Experiments on an exotic form of hydrogen first found[1] a puzzling discrepancy with the

accepted size in 2010. Now, evidence from a German and Russian team points to a smaller value for the size of the proton with ordinary hydrogen, too.

The results, which appeared on 5 October in *Science*[2], could be the first step towards resolving a puzzle that has made physicists doubt their most precise measurements, and even their most cherished theories.

Still, “before any resolution, this new value has to be confirmed”, says Jan Bernauer, a physicist at the Massachusetts Institute of Technology in Cambridge. If other labs confirm it, he adds, “then we can find why the old experiments were wrong, hopefully”.

Method mix-up

For decades, physicists have estimated the size of the proton using one of two main techniques. Atomic physicists use spectroscopy to measure the energy levels of electrons orbiting an atomic nucleus — consisting of either the single proton in a hydrogen atom, or a bigger nucleus. The size of the nucleus affects those energies because electrons spend some time moving through the nucleus as they orbit it.

Meanwhile, nuclear physicists have used a similar technique to the one that enabled Ernest Rutherford to discover atomic nuclei in the first place. They hit the atoms with beams of fast-moving electrons and measure how the electrons bounce off.

As their precision improved, both methods roughly came to agree on a radius of about 0.8768 femtometres (millionths of a millionth of a millimetre).

But in 2010, a novel kind of experiment completed at the Paul Scherrer Institute in Villigen, Switzerland, disrupted the consensus. After a decade of unsuccessful attempts, a multinational collaboration led by Randolf Pohl, then at the Max Planck Institute of Quantum Optics (MPQ) in Garching, Germany, measured energy transitions not in ordinary hydrogen, but in lab-made ‘muonic’ hydrogen. These are atoms in which the electron has been replaced by a muon — a particle similar to an electron in most of its

properties, but 200 times more massive. The heavier particle spends more time inside the nucleus, which means that the proton's size has a much larger effect on the muon's energies — which, in turn, should lead to a much more precise estimate of the proton's radius.

Pohl's team found the proton to be 4% smaller than the accepted value. Some researchers speculated that perhaps some previously unknown physics could make muons act differently than electrons. This would have required a revision of the standard model of particle physics, which predicts that muons and electrons should be identical in every way except for their masses — and might have pointed to the existence of yet-to-be-discovered elementary particles.

Exciting technique

In the latest paper[2], Pohl, now at the Johannes Gutenberg University in Mainz, Germany, and his collaborators tickled hydrogen atoms — containing ordinary electrons — with two different lasers. The first one sent the atoms' electrons into an excited state, and the second one put them into a higher-energy excitation. The team then detected the photons that the atoms released as their electrons fell back into lower-energy excitation states.

The team combined its data with an earlier, high-precision measurement to calculate the Rydberg constant, which expresses the energy that it takes to rip the electron off the hydrogen atom. Standard theory then enabled the researchers to calculate the radius of the proton from this constant. The value they found was consistent with the muonic-hydrogen measurement, and 5% smaller than the 'official' proton radius.

To ensure that they eliminated any spurious experimental effects, the team spent three years analysing its data, says Lothar Maisenbacher, a co-author of the paper and an atomic physicist at the MPQ.

Bernauer, who works on the electron–proton scattering technique, is impressed. “It's a great experiment,” he says. “I think they really advanced their field with this.”

The care that they took is “very impressive”, and makes their measurement more reliable than many others, says Krzysztof Pachucki, a theoretical physicist at the University of Warsaw who is on the task group of the Committee on Data for Science and Technology (CODATA).

CODATA, the international agency that publishes the best-known values of the fundamental constants, is taking notice of the Mainz experiment. “We will take this result very seriously,” says Pachucki. The committee is due to revise the ‘official’ handbook of universal constants of nature next year. Because of this experiment, CODATA will "most probably” change its values for the proton radius and Rydberg constant, he says.

More evidence needed

But the German–Russian group is not quite ready to claim that the puzzle has been solved, Maisenbacher says. “We have not identified any conclusive reason why the other measurements should not be correct themselves,” he says. “We would like to see more experiments from other people.”

A number of teams around the world are doing just that. Bernauer is interested, for example, in the results of spectroscopy experiments being done at York University in Toronto, Canada. If their measurement is also small, “then I would start to believe that the old data has a problem”, Bernauer says. But that would still leave open the matter of the electron–proton scattering results.

In those experiments, researchers have conventionally used electrons that have a range of different energies. Estimating the size of the proton required extrapolating all the way to an ideal situation, in which electrons had zero energy.

Ashot Gasparian, a particle and nuclear physicist at North Carolina A&T; State University in Greensboro and his team have recently conducted an experiment at the Thomas Jefferson National Accelerator Facility in Newport News, Virginia. They injected cold hydrogen gas directly into their electron accelerator, rather than bombarding liquid hydrogen kept in a plastic box, as

was previously done. This technique enabled them to remove some experimental uncertainties and also to use electrons with lower energies than before. In principle, this could reveal whether and where the previous extrapolations went wrong. They are now analysing their data and hope to have results next year. “The ball is in our court,” says Gasparian.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22760

Comments

Comments

There are currently no comments.

Controversial pesticides found in honey samples from six continents

Neonicotinoids are at the centre of a long-running debate about whether they harm bees.

05 October 2017

Fergus Gill/2020VISION/naturepl.com

Honey is a major source of food for honey bees.

Honey bees on every continent except Antarctica face significant exposure to neonicotinoid pesticides — chemicals that some studies suggest harm bees' health. Researchers who tested honey from nearly 200 sites worldwide found that 75% of their samples contained some level of the pesticides, according to

a report published on 6 October in *Science*[1].

The study is the first attempt to quantify the presence of neonicotinoids in honey on a global scale using standardized methods. Nearly half of the samples tested contained levels of neonicotinoids at least as high as those thought, on the basis of previous research, to impair bees' brain function and slow the growth of their colonies. The study also found that 45% of the samples contained two or more types of neonicotinoid.

"It's not a surprise, in a sense, that we find neonicotinoids in honey. Anybody could have guessed that," says lead author Edward Mitchell, a biologist at the University of Neuchâtel in Switzerland. "What's original is using the same protocol. We now have a worldwide map of the situation."

The research provides additional context for the long-running debate over whether and how neonicotinoids affect bees' health. Some studies have suggested that exposure to neonicotinoids lowers honey bees' nutritional status[2] and impairs their immunity[3]. And in June, a paper published in *Science* reported that neonicotinoids lower honey bees' chances of survival during the winter, and threaten the queen in particular, which can affect reproduction[4].

To assess the scale of honey bees' exposure to neonicotinoids around the world, the authors of the new study collected honey from 198 sites on six continents through a citizen-science project. Then they tested those samples to determine the concentrations of five of the most commonly used neonicotinoids. Honey collected in North America had the highest proportion of samples containing at least one neonicotinoid, at 86%, with Asia (80%) and Europe (79%) close behind.

The extent of the contamination, even in honey from remote places — including islands in the middle of the Pacific Ocean and off the coast of West Africa — is surprising, says Amro Zayed, an insect researcher at York University in Toronto, Canada. The findings suggest that bees the world over are exposed to neonicotinoids constantly over generations, he says, which is worrying because the insects depend so heavily on honey for food. "It's one thing to go out to a restaurant and get a bad meal, but if you have your fridge

at home contaminated with insecticides, that’s an entirely different method of exposure,” Zayed says.

Others say that the widespread presence of neonicotinoids in honey is to be expected, given how commonly the chemicals are used in staple crops such as canola and wheat, as well as in home gardens. “Yes, there is going to be long-term exposure, potentially, to neonics, but that doesn’t say anything about the risk,” says Chris Cutler, an entomologist at Dalhousie University in Halifax, Canada. “Just because it’s there doesn’t necessarily mean there’s a problem.”

Much of the debate about neocotinoids has focused on just this question: how problematic are the pesticides when bees are exposed to them at low levels, but over a long period of time? “One of the issues around assessing the impacts on bees has been the discussion of what a field-relevant level of exposure actually is,” says Nigel Raine, a pollinator-health researcher at the University of Guelph in Canada. “This contributes toward that discussion substantially.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22762

Comments

Comments

There are currently no comments.

Antikythera shipwreck yields statue pieces and mystery bronze disc

Archaeologists think that at least seven life-sized sculptures are hidden nearby.

04 October 2017

Brett Seymour/EUA/ARGO 2017

Archaeologist Brendan Foley discovers a bronze disc, at first thought to be part of the Antikythera mechanism.

Marine archaeologists investigating the ancient shipwreck that yielded the Antikythera mechanism — a complex, bronze, geared device that predicted eclipses and showed the movements of the Sun, Moon and planets in the sky

— have recovered a wealth of treasures, including bronze and marble statue pieces, a sarcophagus lid and a mysterious bronze disc decorated with a bull. The artefacts were trapped under boulders in a previously unexplored part of the site near the island of Antikythera, Greece, and the researchers think that large parts of at least seven statues are still buried nearby.

The discoveries are “extremely exciting”, says Kenneth Lapatin, curator of antiquities at the J. Paul Getty Museum in Los Angeles, California. Only a handful of bronze statues survive from the ancient world, and they have almost invariably been treated and altered by previous conservators, undergoing processes that destroyed much of the information scientists might have gleaned from them. “Technology has improved so much,” says Lapatin. “We can learn from these untreated finds.”

The first-century-BC cargo ship, discovered in 1900 by sponge divers, is famous for yielding a heavily encrusted and corroded geared device that used to predict eclipses and chart the skies. The sponge divers also retrieved many other priceless items, including luxury glassware, jewellery and a two-metre-tall bronze statue, dating from the fourth century BC, nicknamed the ‘Antikythera youth’.

Statue search

Courtesy of ARGO 2017

The bronze arm was one of the most significant recent findings.

The recovery of multiple ‘orphan’ statue pieces — limbs without matching heads or bodies, for example — suggested that several statues still lie buried here. So an international team of archaeologists and divers, co-led by Brendan Foley of the University of Lund in Sweden and Theotokis Theodoulou of the Greek Ephorate of Underwater Antiquities in Athens, is now re-excavating the 50-metre-deep wreck site to look for them.

The team has made a stream of discoveries since work began in 2014, including wine jars, giant anchors, gold jewellery and a human skeleton, which is now being analysed for DNA. But the statues have remained hidden until now.

On 4 October**,** the team announced that during a 16-day dive season the previous month, they found several major statue pieces, including two marble feet attached to a plinth, part of a bronze robe or toga, and a bronze male arm, with two fingers missing but otherwise beautifully preserved. A slim build and “turning hand” gesture suggest that the arm may belong to a philosopher,

says Theodoulou.

In 1900–01, the sponge divers salvaged orphan limbs from a minimum of six bronze statues. The newly discovered arm pushes that total to at least seven, says Theodoulou. The team is particularly excited because the statue pieces were found in an area undisturbed by any previous excavations, buried beneath large boulders dislodged from Antikythera’s steep cliffs over the course of 2,000 years by periodic earthquakes. “We think this means that everything is down there still,” says Foley.

The discovery of seven bronze statues, if they could be recovered, would significantly boost the world’s total from this time period, which stands not much greater than 50, Lapatin estimates. Few of those are complete. And although these ancient figures might look beautiful, they are hard to study because the aggressive treatments by generations of conservators have altered and damaged the bronze.

Technological advances

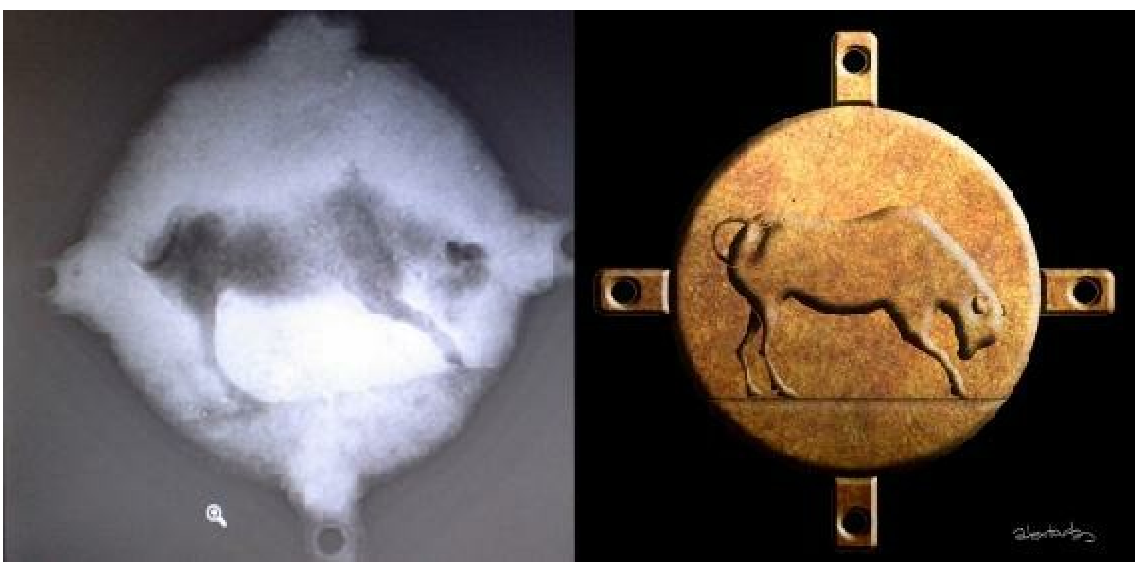
Fresh, untreated finds such as those from Antikythera will give researchers the opportunity to use modern techniques to study a significant aspect of ancient Greek life — for example, by looking at casting methods, which precise alloys were used and whether the statues were made for export or had been previously displayed. Meanwhile, any heads found might enable researchers to identify the people depicted, and to compare their likeness with any existing portraits, for example, marble statues or images etched on coins.

Brett Seymour/EUA/ARGO 2017

The bronze disc, which researchers at first thought might contain some of the lost gears of the Antikythera mechanism.

Foley and Theodoulou’s team also recovered an intriguing bronze disc or wheel, about eight centimetres across, attached to four metal arms with holes for pins. A layer of hardened sediment hides its internal structure, but it superficially resembles the Antikythera mechanism, and researchers had initially hoped that it might be part of that ancient device: perhaps the gearing that calculated the positions of the planets, which is missing from the find.

But preliminary X-ray imaging conducted in an Athens hospital on 25 September revealed a surprise: instead of gear wheels, the image of a bull appeared. The object might have been a decorative element, says Lapatin, perhaps attached to a box or a statue’s shield, or even — because of its sturdy construction — to the doomed ship. More-detailed radiography is planned for the next few weeks.



Left: EUA. Right: Alexander Tourtas.

The X-rays of the bronze disc, and artist's reconstruction of the bull.

Other discoveries this season include a sarcophagus lid made from fine, red marble, more human remains and wooden ship planks and frames that the researchers hope will reveal information about the vessel’s size and shape.

The team plans to return to Antikythera in May 2018, to break up the boulders and excavate beneath. “It’s going to be a major operation,” says Foley. “But we think it will be spectacular.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22735

Comments

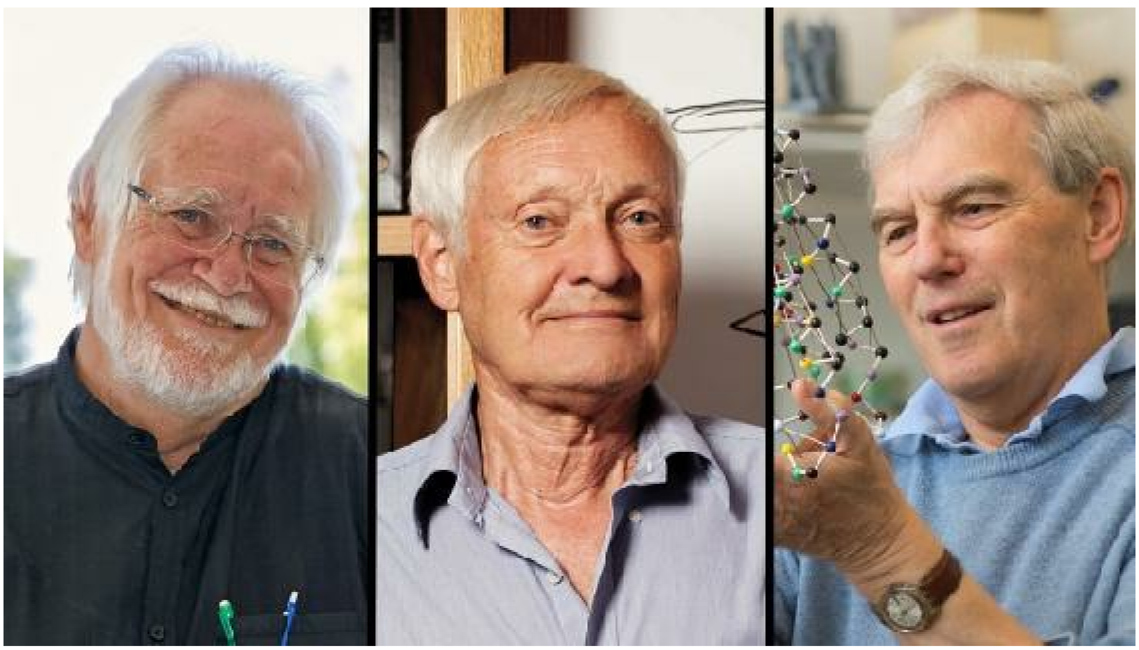
Commenting is currently unavailable.

Cryo-electron microscopy wins chemistry Nobel

Jacques Dubochet, Joachim Frank and Richard Henderson share the prize for developing a technique to image biomolecules.

04 October 2017 Corrected:

1. 05 October 2017



Left: Marietta Schupp/EMBL. Centre: Jorg Meyer. Right: LMB-MRC.

From left: Jacques Dubochet, Joachim Frank and Richard Henderson helped to develop cryo-electron microscopy.

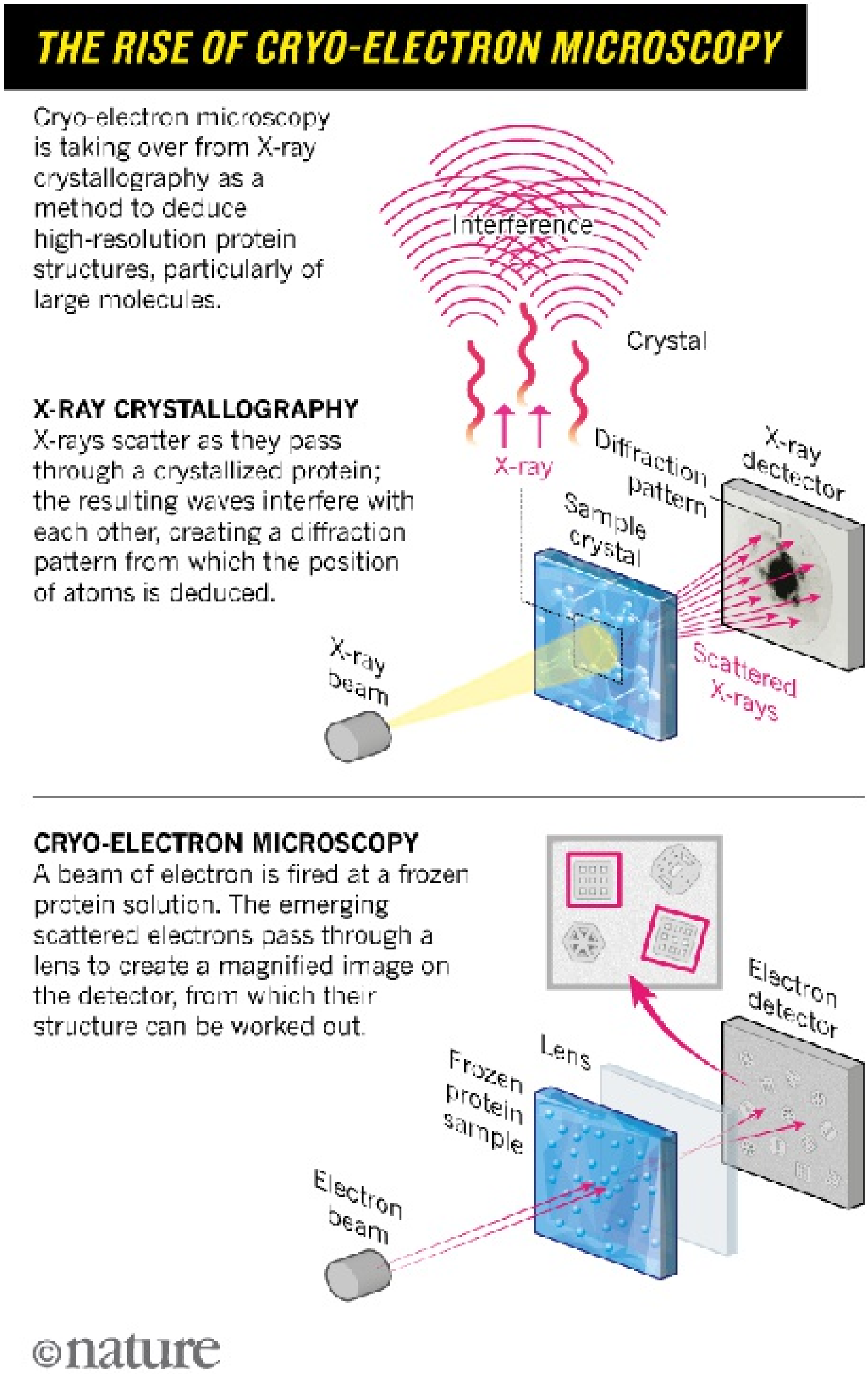
The 2017 Nobel Prize in Chemistry has been awarded for work that helps researchers see what biomolecules look like.

Jacques Dubochet, Joachim Frank and Richard Henderson were awarded the prize on 4 October for their work in developing cryo-electron microscopy (cryo-EM), a technique that fires beams of electrons at proteins that have been frozen in solution, to deduce the biomolecules' structure.

For decades, biologists have used X-ray crystallography — blasting X-rays at crystallized proteins — to image biomolecular structures. But labs are now racing to adopt the cryo-EM method, because it can take pictures of proteins that can't easily be formed into large crystals. The tool has "moved biochemistry into a new era", says the Royal Swedish Academy of Sciences, which awards the prize.

Imaging solutions

In the 1970s, Henderson, a molecular biologist who works at the MRC Laboratory of Molecular Biology in Cambridge, UK, and his colleague Nigel Unwin were trying to determine the shape of a protein called bacteriorhodopsin. The molecule, which uses light energy to move protons across a cell membrane, proved unsuitable for crystallography. So the researchers turned to electron microscopy (see 'The rise of cryo-electron microscopy') and, in 1975, produced their first 3D model of the protein[1].



During the same decade, Frank, a biophysicist who is now based at Columbia University in New York City, and his colleagues developed image-processing software to make sense of the fuzzy pictures that are produced when an

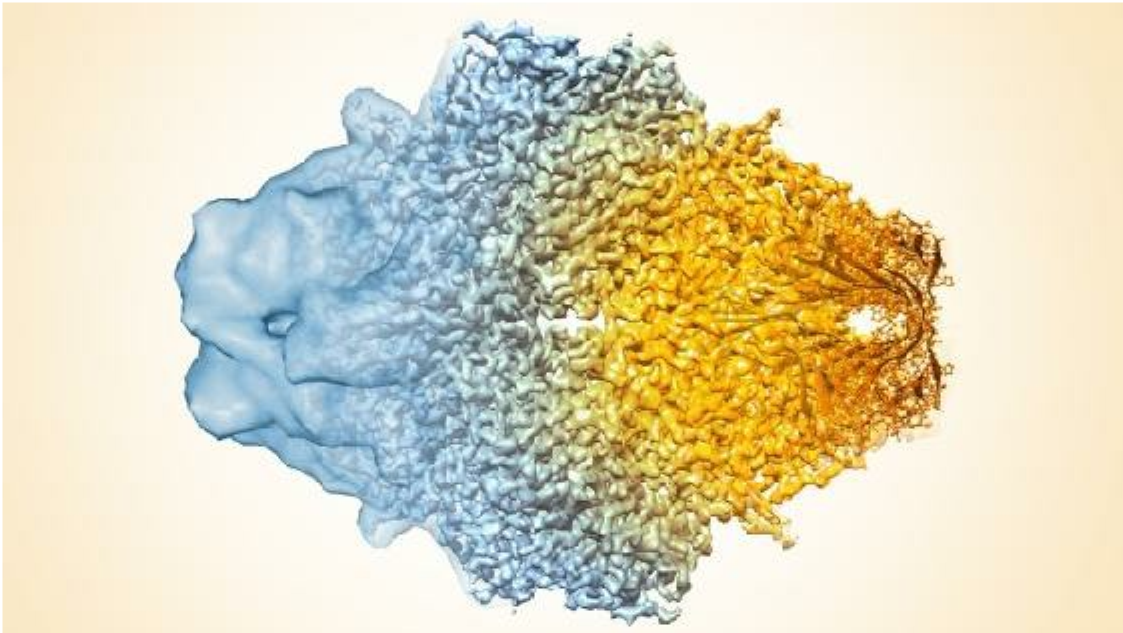
electron microscope is aimed at a protein, and to convert these two-dimensional blurs into 3D molecular structures.

In the early 1980s, a team led by Dubochet, who is now an honorary professor at the University of Lausanne in Switzerland, worked out how to prevent water-soluble biomolecules from drying out in the vacuum of an electron microscope, allowing the molecules to retain their natural shape during imaging. His team found a way to flash-freeze solutions of proteins using liquid ethane, keeping the molecules relatively still when they were pummelled with electrons. This allowed researchers to use electron microscopes to determine the structures of proteins at much higher resolution than before.

These and other improvements enabled Henderson to create the first atomic-resolution images of a protein using cryo-EM in 1990[2].

Resolution revolution

Although the research recognized by the Nobel Committee was conducted in the 1970s and 1980s, it laid the groundwork for what many scientists have dubbed a revolution in recent years. Subsequent improvements in the sensitivity of electron microscopes and in software used to transform their images into 3D structures have caused many labs to favour the technique over X-ray crystallography.



V. Falconieri, S. Subramaniam, NCI-NIH

Cryo-electron microscopy of proteins such as this β-galaxtosidase enzyme has progressed from the low-resolution density map on the left to the atomic coordinates on the right.

Frank told journalists gathered at the Royal Swedish Academy of Sciences in Stockholm that technological innovations can have a larger impact than discoveries. “Cryo-electron microscopy is about to completely transform structural biology,” he said. He added that the ribosome — the machinery that makes proteins inside cells — was the “coolest” molecule he had imaged.

Venki Ramakrishnan, a structural biologist at the Laboratory of Molecular Biology who shared the 2009 Nobel Prize in Chemistry for his work to reveal the structure of the ribosome using X-ray crystallography, is one of many converts to cryo-EM. After learning about the award from a *Nature* journalist, he said: “Oh, fantastic! Those are exactly the people I thought should win the Nobel prize.”

Benoît Zuber, a structural biologist at the University of Bern in Switzerland, who did his PhD with Dubochet, says his mentor was always confident that

cryo-EM would become a vital tool, even as others derided the field as “blobology” for the low-resolution molecular images it captured.“He had a vision and he was convinced about it, even when everybody was telling him that this was just a dream," says Zuber.

“It’s a great recognition for all the developments that have happened in the past. It’s fantastic,” says Sjors Scheres, a cryo-EM specialist who works alongside Henderson. The two were returning from a conference in Leicester, UK, yesterday, when Scheres asked Henderson whether he would keep his phone close in case the Nobel Committee called. “He said, ‘I think they should give it to Jacques Dubochet.’ He would never say that he should get one,” Scheres says. “It’s a well-deserved trio.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22738

Corrections

Corrected:

> This story originally indicated that bacteriorhodopsin moves proteins across the cell membrane. In fact, it moves protons.

Comments

Commenting is currently unavailable.

Crash in sea-turtle births stumps ecologists

Leading suspect — climate change — doesn’t fully explain what is happening to leatherback turtles in the US Virgin Islands.

04 October 2017

Jurgen Freund/NPL/Getty

While buried in the sand, sea-turtle eggs are very sensitive to several environmental conditions that affect whether they hatch or not.

The mystery behind a dramatic fall in the number of leatherback sea-turtle (*Dermochelys coriacea*) hatchlings in the US Virgin Islands remains unsolved, despite the latest efforts of researchers. Rising temperatures and

changes in rainfall patterns — the top two suspects — don't seem to be connected to the decline, according to a study published on 4 October[1]. The finding contradicts previous work, leaving researchers scratching their heads over what could be happening.

The latest study focused on a nesting beach in the Sandy Point National Wildlife Refuge on St Croix island in the Caribbean Sea. The researchers found that about 74% of the leatherback sea-turtle eggs laid there in 1990 hatched, but that rate had plummeted to 55% by 2010.

The study analysed detailed temperature and precipitation data at these nests over the 20 years, and found no corresponding trend in either climate-change factor that could fully account for the decline. The researchers reported their results in *Royal Society Open Science*.

Increases in temperature and more-erratic precipitation patterns do affect the nests, but they aren't the sole reason for the hatching declines, says Anthony Rafferty, a marine biologist at Monash University in Melbourne, Australia, and a study co-author.

This trend is especially confusing in light of the increase in the adult sea-turtle population. "The number of nesting females and the population size has been trending upwards at this site," Rafferty says. "But there's been a decrease in hatching success that we are worried about." That could have negative effects on leatherback populations within one or two decades, he says, when those hatchlings come of age.

Conundrum continues

"It's hard to say how much of that is happening because of climate change," says Vincent Saba, a climate scientist at the US National Oceanic and Atmospheric Administration in Princeton, New Jersey. He co-authored a 2015 study[2] that did find a relationship between air temperature, precipitation patterns and declines in leatherback hatching success. That study examined data from 1982 to 2010 and looked at seasonal rainfall, unlike the latest paper, which analysed rainfall only during the nesting season. The study predicted that, by 2100, Sandy Point would have the most unfavourable climate conditions out of all leatherback nesting sites around the world.

“I like the study. They looked at the effect of climate in finer detail,” says Pilar Santidrián Tomillo, a marine biologist and science director of the Leatherback Trust, based in Playa Grande, Costa Rica. She was a co-author on the 2015 study, and appreciates the fuller picture of what could be happening at Sandy Point that the most recent study has provided.

Sea-turtle eggs are exquisitely sensitive to climate because heat, carbon dioxide, oxygen and water all pass freely through their permeable shells. The surrounding temperatures determine the sex of the hatchlings: warmer conditions produce more females, whereas cooler conditions yield males. And rainfall can influence hatchling development and their ability to escape the nest, says Rafferty. Too little rain might mean that the sand is too dry for the young turtles to climb out of it; too much rain during the early stages of egg development might lead to a reduction in oxygen supplies to the growing embryo.

“I think changes in precipitation levels or patterns could explain the decline in hatching success partially, but there could be other reasons, too, like decline in fertility or increase in pollutants, for example,” Santidrián Tomillo says.

Rafferty, who specializes in embryo research, now plans to look at how the age and health of a female sea turtle might affect her fertility, or where she lays her eggs.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22748

Comments

Comments

There are currently no comments.

| 章节菜单 | 主菜单 |

Scientists plead with Brazilian government to restore funding

If officials don't act soon, research institutions could start shutting down next year.

04 October 2017

Leonardo Benassatto/Reuters

Protests against Brazilian president Michel Temer's policies have consumed the country amid severe budget cuts this year.

Anxiety is growing in Brazil over the country’s collapsing research budgets. President Michel Temer had slashed funding for science by 44% in March and has proposed additional decreases for 2018 — even as some science

institutes run out of money for basic needs, such as paying electricity bills. The 2017 science budget, at 3.2 billion reais (US$1 billion), is the lowest the country has seen in at least 12 years.

On 3 October, the government announced that it will release 440 million reais to science agencies to help keep them afloat until the end of this year. But the money is only about 20% of what's needed, said the Brazilian Society for the Advancement of Science in a statement.

Researchers continue to voice their alarm, with a march scheduled for 8 October in São Paulo — the third such demonstration this year protesting the funding shortfalls. And on 10 October, a public awareness campaign called *Conhecimento Sem Cortes* (Knowledge without cuts) will deliver a petition to Congress with more than 80,000 signatures protesting both the cuts and a 2016 constitutional amendment that put a 20-year cap on federal spending.

Last week, 23 Nobel laureates and nine of the country's scientific societies warned Temer that continued budget reductions will seriously jeopardize Brazil's future. They say that the ongoing uncertainty over science funding risks dismantling research groups and prompting a brain drain.

They all hope to influence a revision of the 2018 budget proposal — first submitted to Congress by the executive branch in August — which included a 16% cut to the Ministry of Science, Technology, Innovations and Communications (MCTIC). The Temer administration has promised to release a revised budget in the coming weeks.

On life support

If the 16% cut remains, it would leave a total of about 2.7 billion reais for 22 federal laboratories and research institutes, 73 National Science and Technology Institutes and Brazil's major science funding agencies, the National Council for Scientific and Technological Development (CNPq) and the Funding Authority for Studies and Projects. "This means institutions will shut down by August next year", says physicist Luiz Davidovich, president of the Brazilian Academy of Sciences.

Davidovich's estimate is based on what has happened this year. MCTIC started 2017 at 5 billion reais, its smallest budget in a decade when adjusted for inflation. In March, after the 44% cut, the ministry was left with 2.8 billion reais, not including money for special projects such as the Sirius synchrotron. The budget rises to 3.2 billion reais with those projects. As a result, institutions began running out of cash in September.

“We don’t have money for electricity bills or for buying radiopharmaceuticals”, says José Augusto Perrotta at the federal Institute of Nuclear and Energy Research. Perrotta is the coordinator of the multi-purpose reactor, a 1.6-billion-reais project that is facing delays because of a lack of funding. This year, the reactor was supposed to receive 106 million reais but got nothing.

The Brazilian Center for Physics Research isn’t doing much better. “We‘ll be able to see it through December without layoffs, but next year I’ll have to cancel all equipment maintenance contracts”, says Ronald Shellard, the centre’s director. The institution’s proposed 2018 budget is 7.8 million reais — well below the 12.7 million reais Shellard says it needs to survive.

Brazil’s 1.6-billion-reais Sirius synchrotron is also in jeopardy. The 2018 budget proposal doesn’t provide funding for the facility’s construction, which is slated for completion in mid-2018.

The build is still on schedule after science minister Gilberto Kassab unfroze 85 million reais this month, says Antonio José Roque da Silva, director of the Brazilian Synchrotron Light Laboratory and head of the project. However, the synchrotron will need an additional 331 million reais to complete construction. “I pay contractors with cash, not with promises,” says Roque.

A skeleton crew

Also at risk is Brazil’s collaboration with CERN, Europe’s particle-physics laboratory near Geneva in Switzerland. The 2017 budget cuts eliminated Brazil’s financial support for CERN, and the proposed 2018 budget doesn’t resume those payments.

The biggest threat, however, is to CNPq, Brazil's main source of federal research grants. The agency hasn't paid out the grants it green-lit last year, didn't launch its annual call for project proposals this year and is 400 million reais short of what it needs to honour its commitments in 2017. If the situation isn't sorted, Marcelo Morales, a CNPq executive director, fears a repeat of 2016, when scholarships for undergraduates and scientists abroad were suspended.

The continuing funding crisis is already driving away students and young scientists. Sergio Ferreira, a neuroscientist at the Federal University of Rio de Janeiro, runs a lab whose budget has gone downhill since 2014. It's now an average of 85,000 reais — one-tenth of what it used to be. This year, five of Ferreira's graduate students had to spend six months abroad working with his collaborators because he couldn't afford the materials the students needed for their research.

"In my group I have several people who have left or are about to leave for good, with no plans to come back", Ferreira says. "I can't keep a skeleton colony of students."

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22757

Comments

Comments

There are currently no comments.

Supercomputer redesign of aeroplane wing mirrors bird anatomy

Bird-bone structures emerge from an evolution-like algorithm.

04 October 2017

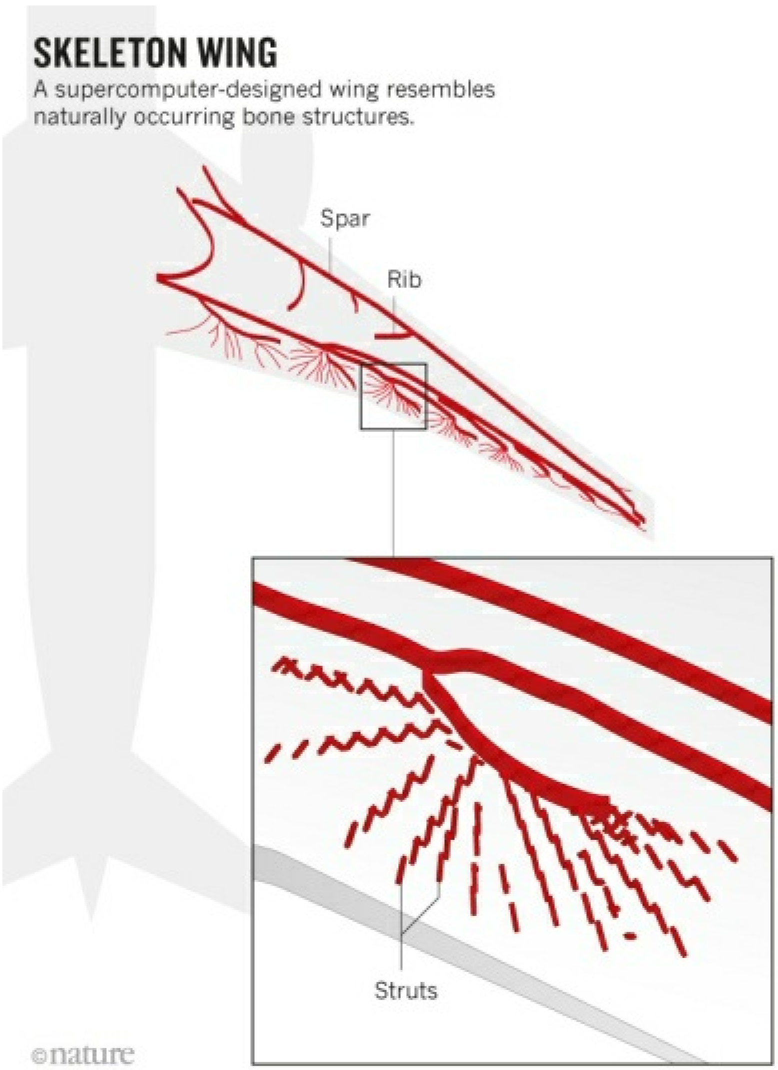
Samuel Taylor/Alamy

Conventional aeroplane wings are supported by straight bars and struts, but a supercomputer has suggested a more organic design.

Engineers have used a supercomputing technique that mimics natural selection to design the internal structure of an aircraft wing from scratch. The

resulting blueprint is not only lighter than existing wings, it also resembles natural formations, such as bird wing bones, that are not present in current aeroplanes. The organic-looking product is as stiff as a conventional aircraft wing but lighter, which could save up to 200 tonnes of fuel per year per plane.

“This is a really nice illustration of how to employ computing-based optimization methods at immensely high resolution,” says Matthew Santer, an aerospace engineer at Imperial College London. The method could feed into the design process, although there are a number of hurdles to using it in aerospace applications in its present form, he adds.



Engineers have been using these kinds of optimization techniques for around

20 years, but only for smaller-scale problems, such as individual wing components, or much simpler structures, says Niels Aage, an engineer at the Technical University of Denmark, near Copenhagen, who led the work[1]. Aage and his colleagues used the Curie supercomputer in Bruyères-le-Châtel near Paris to increase the resolution, enabling them to model the entire 27-metre-long wing of a Boeing 777.

The team started with a wing outline already optimized for maximum lift and minimum drag, known as an aerofoil, and split it into 1.1 billion 3D pixels or ‘voxels’. Each is about the size of the smallest Lego brick — a resolution roughly 200 times greater than previous efforts. The algorithm began by simulating the force exerted on every block and distributing material in response to where the wing experienced a load. Without any human guidance, the program then repeated the analysis several hundred times, adding or removing material depending on the strain felt by each brick, until it reached a final optimum design. “The structure evolves through each design cycle," says Aage. "The process has many similarities to nature’s own evolution."

Organic flight

Unlike conventional wings, the resulting structure did not contain the usual straight beams running the length of the wings, interspersed by crossing supports. Instead, the design looks organic, says Aage. Curved supports fan out at the trailing edge of the wing, resembling the bones in birds’ wings, and intricate support structures in the leading edge look like the internal structure of a beak.

Without compromising stiffness (resistance to deformation), the design weighs 2–5% less than conventional wing structures. That translates into 200–500 kilograms per wing, potentially saving each plane between 40 and 200 tonnes of fuel per year, say the authors. The technique could also be applied to other industries, says Aage, for example, to design high-rise buildings in earthquake-prone zones that maintain their stiffness yet can withstand the dynamics of a quake. It could be used to optimize acoustics, ventilation systems and antennas, as well, he adds.

The technique’s high resolution, which allows the computer to design structures that include features that range in size from millimetres up to tens of metres, could lead to more-innovative designs in these other disciplines, says Liang Xia, a computational engineer at the Huazhong University of Science and Technology in Wuhan, China. But he stresses that running the algorithm requires a heavy computing burden — the equivalent of running a single standard computer for 100 years. This computing cost could be reduced, however, if the team were to employ more-advanced simulation methods, used in artificial intelligence, which in effect model only parts of the wing in such high resolution.

The design is also too intricate to be made by existing manufacturing methods, and would require a giant 3D printer to build. But for now, key aspects of it could be fed into structures produced using conventional methods, says Aage. “We’re speeding up evolution rapidly, meaning we can see how designs should be, and then extract the key features — or those we can afford.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22759

Comments

Commenting is currently unavailable.

Elite Hungarian university may be saved

Hungary-New York agreement could allow Central European University to sidestep law change.

04 October 2017

Bernadett Szabo/REUTERS

Seventy thousand people protested in Budapest last April against a law apparently targeting the Central European University.

The prestigious Central European University (CEU) in Budapest, Hungary, seems to have found a way around a threat to close it down. The university had been affected by a law change that is widely thought to be politically

motivated.

The threat arose in April, when the government rushed through an amendment to its higher-education law, requiring that all international universities operating in Hungary had also to operate as higher-education institutes in their countries of origin.

The law change seriously affected only the CEU, which is legally registered in New York state. The university was founded in 1991 by Hungarian-born philanthropist George Soros, whom Hungarian Prime Minister Viktor Orbán has described as an enemy, because of Soros's statements in support of refugees, which run counter to Orbán's policies. The revised law, which includes other, smaller amendments, comes into effect on 11 October.

New York connection

A CEU spokesperson said on 3 October that the university has now signed a Memorandum of Understanding with Bard College in Annandale-on-Hudson, New York, to provide educational activities. She added that negotiations between the State of New York and the government of Hungary, which opened at the end of June, have now concluded, although the agreement still has to be signed off by Hungary's government and Parliament.

The law change sparked immediate protest last April, when 70,000 protestors took to the streets in Budapest, and the Hungarian Academy of Sciences expressed concern. The European Commission is pursuing an infringement procedure against what it sees as an illegal restriction of academic freedom, and an investigation by legal experts of the Council of Europe, a powerful human-rights organization with 47 member states, published a preliminary opinion in August indicating that the law was inappropriate.

"It's no secret that it has been a hell of a way to treat a university," says CEU rector Michael Ignatieff.

The university has nearly 1,500 mostly postgraduate students from more than a hundred countries, including a large number from Hungary. It operates mainly in the humanities, but recently expanded to include the cognitive and

network sciences.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22761

Comments

Comments

There are currently no comments.

Science without walls is good for all

International mobility and collaboration are linked to stronger research.

04 October 2017

David Williams/Bloomberg/Getty

New studies highlight how closing borders would be bad for science.

Some US biotechnology labs have responded to President Donald Trump’s attempts to restrict immigration by releasing contrasting group photographs showing what less-open international borders would do to their workforces. A first image typically shows everyone who works in the lab. A second image includes only those who are permanent US residents, then just US citizens, and then only those who were born in the United States and whose parents also were (see, for example, go.nature.com/2ft02xj). The shrinkage

from the first to the last image is striking — in some cases, about two-thirds of staff are lost. This reflects a widespread reality in research. A 2012 analysis showed that more than 60% of postdocs in the United States grew up overseas (see *Nature* **490,** 326–329; 2012).

When it comes to co-authorship, researchers in Europe are the most international. In 1981, only about one in six papers by a European scientist included co-authors from a different country. By 2011, that had risen to one in two. Papers with authors from more than one country also tend to be more highly cited (J. Adams *Nature* **497,** 557–560; 2013) .

This week, *Nature*'s Comment section publishes two bibliometric analyses that suggest international mobility has similar science-boosting effects.

The first finds that researchers build strong links between nations as they travel around the world. The authors track 16 million individuals who published papers in 2008–15. Only about 4% of these people changed countries, but those who did had 40% higher average citation rates than those publishing solely in one region, a trend that held true across 13 regions. Importantly, mobile scientists retained ties in the countries they left.

The second argues that countries with mobile scientific workforces produce papers that are more highly cited. (These are the same countries that have the greatest fraction of internationally authored papers.) The analysis shows that a nation's willingness to let scientists cross borders was a better predictor of highly cited papers than was the proportion of its gross domestic product that it spent on research.

These are complex issues. Citation rates are not necessarily a sign of quality, influence or long-term importance. And many confounding factors hamper attempts to link policies to impact. Still, such studies are necessary to provide evidence for policies on how to best support the scientific system.

The benefits of international movement are not entirely clear-cut. Leading scientists who change institutional affiliation (but not country) seem to boost both output and impact (G. Halevi *et al. Publ. Res. Q.* **32,** 22–37; 2016). Further work could reveal whether international papers — or more-open countries — prompt more innovative or worthy science. Details of the

relative benefits of collaboration, or how the effects of an international move are mediated by discipline or career stage, must be teased out. So must the effects of particular policies, such as the ease with which potential trainees and working scientists acquire visas or other travel support.

There is a bigger question: does the flow of leading scientists into a country bring tangible benefits for the citizens whose taxes fund their work? What about when one country's funds flow to a scientist's international collaborators? Evidence from patents and technological advances suggests that such investment is rewarded. But attention must be paid to ensure that a nation's connection to elite international scientists also supports work on local interests and needs.

Meanwhile, the scientific powerhouses of the United States and the United Kingdom seem determined to close their doors. US travel restrictions put in place last week tell working scientists from eight countries to stay away. And Britain's departure from the European Union puts scientific collaboration and access to European funds at serious risk.

Many nations with more-welcoming attitudes are poised to benefit. One long-term trend is clear: existing scientific powerhouses are not destined to stand forever. The picture can change — and quickly.

Journal name:
Nature
Volume:
550,
Pages:
7–8
Date published:
(05 October 2017)
DOI:
doi:10.1038/550007b

Comments

Comments

There are currently no comments.

Nobel prizes, giant telescope and buried treasure

The week in science: 29 September–5 October 2017.

04 October 2017

Events | Research | Funding | Facilities | People | Trend watch

EVENTS

Antikythera wreck yields more treasures Marine archaeologists investigating an ancient shipwreck near the island of Antikythera, Greece, announced on 4 October that they have recovered bronze and marble statue pieces, a sarcophagus lid and a mysterious bronze disc decorated with a bull. The cargo ship, which dates to the first century bc and was rediscovered in 1900, is famous for yielding the Antikythera mechanism, a complex bronze geared device that showed the movements of the Sun, Moon and planets in the sky. A team led by archaeologists Brendan Foley of Lund University, Sweden, and Theotokis Theodoulou of the Greek Ephorate of Underwater Antiquities in Athens found the latest artefacts under boulders in a previously unexplored part of the site. They think that at least seven complete statues are still buried nearby.

Brett Seymour/EUA/ARGO 2017

The bronze disc found near the shipwreck.

Volcano threats More than 100,000 residents on the Indonesian island of Bali have reportedly been evacuated to shelters following increased seismic activity from Mount Agung. The government’s Center for Volcanology and Geological Hazard Mitigation said on 29 September that, on the basis of the latest information, an eruption was still a probability. Meanwhile, in Vanuatu, the government ordered the evacuation of all residents of Ambae island — about 11,000 people — on 28 September, after Manaro Voui started ejecting lava, poisonous gas and ash. On 1 October, the Vanuatu Meteorology and Geo-hazards Department said the volcano’s activity was settling, and a large eruption was less likely. However, as *Nature* went to press, evacuations continued.

Time capsule On an Arctic island, scientists have buried a stainless-steel tube stuffed with artefacts that they say sum up science and technology in 2017. The time capsule, placed in an out-of-use borehole near the Polish

Polar Station in Hornsund, Svalbard, contains samples that include DNA, silicon-based electronics, an ancient meteorite fragment and other items to inform a future discoverer of our present understanding of technology, geology and biology. A team with the Polish Academy of Sciences described the capsule — created to celebrate the sixtieth anniversary of Poland's polar station — in a report in *Gondwana Research* on 28 September.

RESEARCH

Space-time ripples Physicists have announced the first discovery of gravitational waves made together by observatories in Europe and the United States, and the fourth-such discovery overall. At a 27 September press conference, researchers said that on 14 August, both the Virgo observatory near Pisa, Italy, and the twin laboratories of the US Advanced Laser Interferometer Gravitational-Wave Observatory (LIGO) in Livingston, Louisiana, and Hanford, Washington, had picked up gravitational vibrations emanating from a pair of merging black holes 540 million parsecs (1.8 billion light years) away. Observing the event with three detectors, rather than LIGO's two, enabled scientists to pinpoint the location of and distance to the black holes with much greater accuracy. Virgo rejoined the hunt for the waves only on 1 August, after a five-year upgrade.

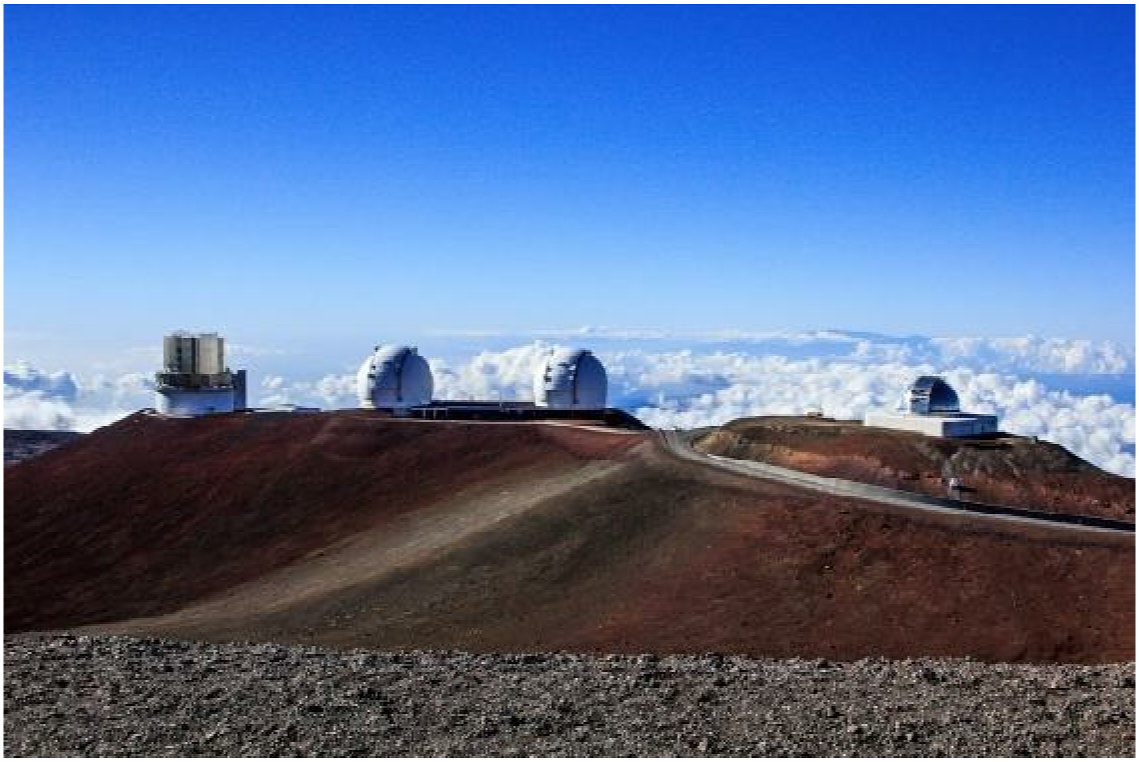
Monkey research The US Food and Drug Administration (FDA) has suspended a study on the effects of nicotine on monkeys after activists, including primatologist Jane Goodall, decried the experiments as cruel. On 25 September, FDA commissioner Scott Gottlieb responded to a 7 September letter from Goodall that called the experiments unnecessary, given that the effects of smoking are well known. The study, which began in 2014 at the FDA's lab in Jefferson, Arkansas, allows monkeys to self-administer nicotine. Gottlieb told Goodall that it would be halted while a team of experts assesses the monkeys' health and determines whether more precautions are needed. The team will also decide whether the study should resume.

FUNDING

French budget French research funding is set for a heartening increase in the country’s first budget under President Emmanuel Macron, if draft 2018 plans released on 27 September are voted into law. The research portfolio of France’s ministry of higher education, research and innovation would rise by more than 6%, to €8.4 billion (US$9.9 billion) in 2018. And a giant economic-recovery plan unveiled on 25 September by Prime Minister Edouard Philippe should divert an extra €2.4 billion to research over the next five years. Separately, in a 26 September speech, Macron backed the idea of a European Union funding agency to accelerate the commercial applications of basic science, an idea also suggested by EU research commissioner Carlos Moedas.

FACILITIES

Hawaii telescope Hawaii’s board of land and natural resources granted a new construction permit to the Thirty Meter Telescope (TMT) on 28 September, reviving the chances that it could be built on the Hawaiian mountain of Mauna Kea. Some Native Hawaiians oppose the TMT, saying that its construction would further violate the sacred mountain, which already hosts multiple telescopes. Hawaii’s supreme court invalidated the TMT’s first construction permit in December 2015, ruling that the board had not followed appropriate procedures. The new permit gives the project the right to proceed on Mauna Kea, but telescope opponents have filed motions that would put the permit on hold until the state supreme court can hear an appeal.



Julie Thurston/Getty

PEOPLE

Nobel prizes Three biologists were awarded this year's Nobel Prize in Physiology or Medicine for their work on circadian clocks. Jeffrey Hall and Michael Rosbash, both at Brandeis University in Waltham, Massachusetts, split the award with Michael Young at Rockefeller University in New York City. The physics prize was awarded to Rainer Weiss, at the Massachusetts Institute of Technology in Cambridge, and Barry Barish and Kip Thorne, both at the California Institute of Technology in Pasadena, for their work on detecting gravitational waves. *Nature* went to press before the chemistry prize was awarded, but full details will be available at go.nature.com/chem2017.

Science adviser On 26 September, Canadian prime minister Justin Trudeau appointed biochemist Mona Nemer as his country's chief government science adviser, fulfilling his campaign promise to establish the position. Nemer was

most recently vice-president of research at the University of Ottawa and director of the Molecular Genetics and Cardiac Regeneration Laboratory there. Her scientific work has focused on the genetics of cardiovascular disease and birth defects. In her new role, Nemer will have a budget of Can$2 million (US$1.6 million) and report to Trudeau and science minister Kirsty Duncan. The country has been without a science adviser for nearly a decade; the last time such a post existed was from 2004 to 2008.

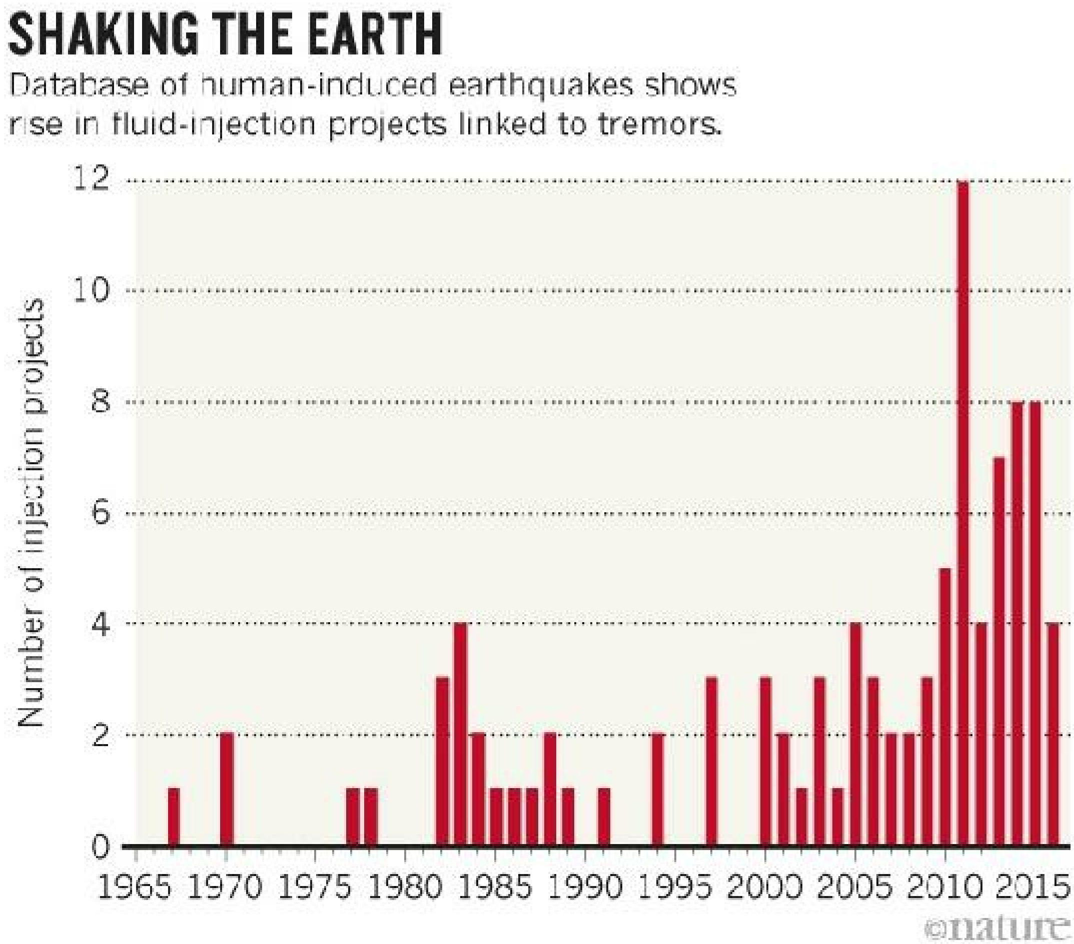
Russian academy After almost six months without a head, the Russian Academy of Sciences (RAS) has a new president: Alexander Sergeyev, a laser physicist and director of the RAS Institute of Applied Physics in Nizhny Novgorod. The academy, which operates a network of hundreds of institutes, is undergoing controversial reforms. In March, its planned presidential elections were unexpectedly cancelled at the last minute, allegedly following a row over voting procedures (see *Nature* **543,** 601; 2017). In the latest elections announced on 26 September, Sergeyev won a majority of votes from the academy’s general assembly. A new state law requires that Russia’s president Vladimir Putin must also approve the post, which he did the following day.

Defraud alert The FBI has charged bioengineer Yiheng Percival Zhang with defrauding the US government and his employer, the university Virginia Tech in Blacksburg. Zhang was arrested on 20 September and will remain in custody pending a trial, according to court documents. In an affidavit in support of a criminal complaint filed on 18 September, the FBI alleged that Zhang and two of his colleagues at the Tianjin Institute of Industrial Biotechnology in China — Zhiguang Zhu and Chun You — conspired to win US National Science Foundation (NSF) grants for studies that had already been completed in China. The affidavit also claims that Zhang withheld a portion of funds owed to his university from NSF and Department of Energy grants.

TREND WATCH

A database of human-induced earthquakes reveals a rise in tremors linked to wastewater injected into the ground by oil and gas operations. Such projects

spiked in the early 2010s, particularly in the central United States. The HiQuake database is described in *Seismological Research Letters*. Of 728 entries, 37% are linked to mining, 23% to water piling up behind a dam and 15% to conventional oil and gas development. Just 4% are linked to hydraulic fracturing, or fracking, for oil and gas.



Source: M. P. Wilson et al. Seismol. Res. Lett. http://dx.doi.org/10.1785/0220170112 (2017)

Journal name:
Nature
Volume:
550,
Pages:

12–13
Date published:
(05 October 2017)
DOI:
doi:10.1038/550012a

Comments

Comments

There are currently no comments.

Why fake islands might be a real boon for science

The seasteading movement is getting close to building its first prototype, an artificial archipelago where people will live, play and do research.

04 October 2017

Blue Frontiers

Early designs for a floating island in Tahiti aim to mimic a natural landscape.

The view is unbeatable. To the right, steep volcanic mountains, draped in green, rise up from a beachside coconut grove. To the left, the Pacific Ocean glitters turquoise under the midday sun. It is here in this Tahitian lagoon that a group of entrepreneurs plans to build an artificial island — three-quarters of a hectare of floating housing and research space, made up of linked platforms. If the team is successful, the vision could become reality by 2020. But it would be just the first step, says self-described “seavangelist” Joe Quirk. The ultimate goal is to build whole sovereign nations on the open seas, composed of modular floating units.

“French Polynesia has all the stepping stones: lagoons, atolls, shallow waters

right next to deeper waters," Quirk says.

Quirk, one of five managing directors for the company behind the project, and his colleagues propose that artificial islands could serve as laboratories for testing out new technologies and exploring different social structures, or act as life rafts for coastal peoples displaced by sea-level rise.

The non-profit Seasteading Institute was founded by former Google engineer Patri Friedman in 2008, and it has garnered support from influential people in the linked worlds of Silicon Valley, libertarian politics and the anything-goes desert festival, Burning Man. Most media reports have been sceptical, however. The project has been characterized as the dream of "two guys with a blog and a love of Ayn Rand"[1] and "a hacker's approach to government with a *Waterworld*-esque conception of Manifest Destiny"[2].

But the Seasteading Institute and the new for-profit spin-off, Blue Frontiers, have racked up some real-world achievements in the past year. They signed a memorandum of understanding with the government of French Polynesia in January that lays the groundwork for the construction of their prototype. And they gained momentum from a conference of interested parties in Tahiti in May, which hundreds of people attended. The project's focus has shifted from building a libertarian oasis to hosting experiments in governance styles and showcasing a smorgasbord of sustainable technologies for, among other things, desalination, renewable energy and floating food-production. The shift has brought some gravitas to the undertaking, and some ecologists have taken interest in the possibilities of full-time floating laboratories.

LISTEN

Reporter Geoff Marsh investigates ambitious plans to build artificial floating cities.

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But the project still faces some formidable challenges. The team must convince the people of French Polynesia that the synthetic islands will benefit them; it must raise enough money to actually build the prototype, which it estimates will cost up to US$60 million; and once it is built, the group must convince the world that artificial floating islands are more than just a gimmick. Producing solid science and broadly useful technology would go a long way towards making that case.

“What we are dreaming is that this structure will be a scientific laboratory,” says Winiki Sage, head of the Economic, Social, and Cultural Council of French Polynesia in Tahiti, who has been concerned about brain drain from his country.

Aesthetic appeal

Designs are surfacing for the prototype island, and its look is a key part of Blue Frontiers's public-relations strategy. The company's current plans don't entirely align with the concept art on the Seasteading Institute's website, which swings from tiki bar to Tomorrowland in various iterations. Bart Roeffen, a 'water pioneer' at the Dutch design firm Blue21 in Delft, has been drawing up new plans that fit with the landscape and culture.

“We are working together with Tahitian designers to make something that is not like an alien invasion,” Roeffen says. In particular, he plans to take cues from Polynesian shipbuilding. The elegant outrigger canoes, or *va'a*, used by islanders are stable and light; oceangoing versions are the type of boat rowed by the Tahitian voyagers who discovered Hawaii and New Zealand around AD 1100. Linked platforms would be arranged to ensure that no coral below is completely shaded and killed. The goal is to actually expand the habitat for reef species (see 'Seasteaders in paradise').

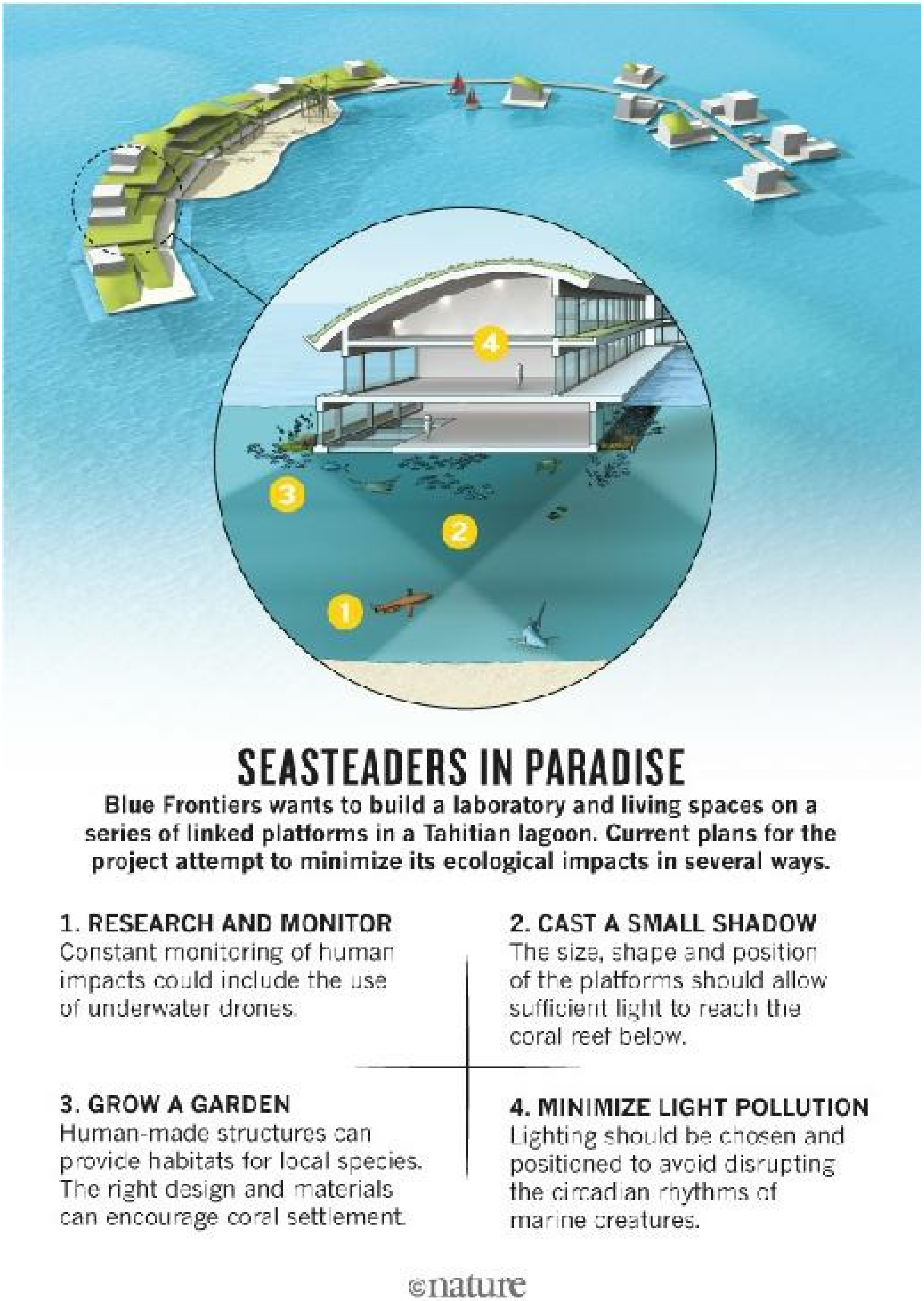


Illustration by Emily Cooper

The team would not provide direct information about funding. Paypal

founder and one-time Donald Trump enthusiast Peter Thiel provided a reported $1.7 million to the Seasteading Institute, but he last contributed to the project in 2014, and any recent investors are keeping a low profile. Quirk says that they have “a nice amount” of seed money and are preparing for what is called an initial coin offering — an investment mechanism that uses digital cryptocurrency. Looking ahead, the company hopes to generate revenue by renting out space on the island and acting as consultants for other would-be island builders. Along with hiring Quirk and the other four managing directors, Blue Frontiers has recruited ten staff members and commissioned environmental, legal and economic studies on the impacts of the project for investors and the government.

The “why?” — everyone's first question about seasteading — is answered differently by everyone involved. Some are captivated by the project because it is an excuse to push sustainable design to the next level. For people on low-lying islands, it looks like a life raft. Félix Tokoragi, mayor of Makemo, an atoll in the Tuamotu archipelago in French Polynesia, told Blue Frontiers that he's interested. The Tuamotus have experienced widespread flooding, and Tokoragi is worried that his people will become climate-change refugees. “We are attached to our atoll; we are attached to our culture,” he says. “We are not against this idea, since the technology can respond to the problems that we face.”

For others, the pull of the project comes down to autonomy and self-reliance, particularly with respect to governance: anyone who decides their island's political style is not for them can detach and depart for another system that they like better.

For at least one scientist advising the project, Neil Davies, executive director of a field station of the University of California, Berkeley, on the neighbouring island of Moorea, the island's appeal is as a base for research that would “fill the gap between oceanographic-research vessels and coastal marine labs”. Ships are on the water, but they are “phenomenally expensive”, he says, and they don't stay put. Coastal labs can gather long time-series of data in one place, but don't provide access to deeper water. Davies dreams about floating “sea stations” that would allow low-cost, long-term access to the ocean for research, especially for students in tropical countries “where

natural systems are among the most sensitive to human activities”, he says. Experiments could include modifying pH or temperature on small sections of a reef to simulate future environmental conditions, and 'planting' different corals to investigate which will thrive best in the future. Data could be gathered using semi-permanent sensors and cameras, along with regular biological-sample collection.

Some scientists not involved in the project see value in the concept, as well. “If you have a floating island and you want long-term study, that is a perfect way to do it,” says Ross Barnes, marine-operations superintendent at the University of Hawaii Marine Center in Honolulu, who oversees two large research vessels and on-shore labs. The university has been conducting research at a spot in the ocean that it calls Station ALOHA, which scientists have visited nearly 300 times by boat since 1988. A floating platform, he says, would mean that scientists could leave behind some instruments — and that some of them could stay as well — allowing for continuous measurement. “It's a good idea,” Barnes says.

Currently, Davies is advising the seasteaders on site selection and environmentally positive design choices. He also plans to help them to document the installation's performance using sensors that measure things such as energy expenditure and waste generation on the platforms, as well as water temperature and quality. And he sees it as a great teaching opportunity for the many students who visit his station. “Seasteading raises many social, legal, ethical, environmental issues, even if it never gets anywhere,” he says.

Whether the seasteaders make progress depends on whether the project is embraced by French Polynesia, a largely autonomous 'overseas collectivity' of France with a population of 287,000 on 67 islands spread out across an area nearly the size of Europe. At one level, a grand floating project could appeal to a nation of voyagers and boat builders. But French Polynesia has been burnt by big-science and technology projects before. From 1966 to 1996, France conducted 193 nuclear tests in its Polynesian possessions, many in the atmosphere. In February 2016, then-president of France François Hollande admitted that the testing had harmed the environment and human health. And the place is littered with defunct projects and closed hotels.

“We have a history of being taken for fools,” says Pauline Sillinger, a

sustainable-development specialist at Te Ora Naho, a federation of environmental groups in French Polynesia, who took a job with Blue Frontiers this year, and also teaches Tahitian dance. “Nuclear testing, big hotels, nice, smiling, white, intelligent people telling us it'll be good for us.”

But their wariness vies against their desperation for new revenue streams, Sage says. After winding down nuclear testing, France began paying French Polynesia more than US$100 million per year in compensation for lost income from military activity. But in 2016, that amount was reduced. Meanwhile, tourism revenues have never recovered from the 2008 recession. Thanks to increased political stability and other factors, things have improved since 2014, when the collectivity was so broke that it risked not being able to pay its civil servants, according to Sage. But it is still dangerously reliant on a small number of income sources — tourism, pearls, coconut oil. Unemployment stands at nearly 18%. “We are looking for new ideas,” Sage says. “We are really open to any ideas, any investors.”

If Sage is sceptical but willing to give it a shot, there are others who have had enough of grandiose project ideas. Among them is a religious leader in Tahiti, Frère Maxime Chan, who heads Association 193, which advocates on behalf of those harmed by nuclear testing. Chan is also vice-president of Te Ora Naho. (Sage, incidentally, is the organization's president.) Chan says that his old friend Sage and the rest of the government are “dazzled” by the flash and money of the Seasteaders. He talks about recent projects — including a tourist resort, an aquaculture scheme and an eco-resort — that were all announced with fanfare and optimistic job projections, only to be cancelled, scaled back or put on indefinite hold. Chan wishes the government would admit that the standard of living for the average Tahitian has been artificially inflated by nuclear-test payments and must come down. This can be done without suffering, Chan contends, by gracefully returning to a version of the pre-1960s subsistence economy. “Small is beautiful,” he says.

Convincing French Polynesia to support the project will fall mainly to Marc Collins, another managing director of Blue Frontiers. Collins is Tahitian and lives there now, but in the early 1990s he lived in Silicon Valley, and fell in love with its fast-paced culture of big ideas and endless possibility. Ever since, he's kept his toe in those waters in part by maintaining a subscription to

Wired magazine. In May 2015, the digital lifestyle glossy ran a story[3] about how the seasteading movement planned to scale back its grand, high-seas concept, reorienting towards safer, shallower waters and looking for “cost-reducing solutions within the territorial waters of a host nation”.

Collins, a serial entrepreneur who has dabbled in every major French Polynesian industry, from hotels to black pearls and telecommunications, saw an opportunity to, as he puts it, “bring some of the DNA of Silicon Valley to Tahiti”. Tahiti joined the world of high-speed Internet in 2010, with the completion of an undersea fibre-optic cable linking it to Hawaii. It has calm lagoons aplenty and daily flights from Los Angeles, California, and, as a minor bonus, is widely regarded as paradise on Earth. Collins fired off a LinkedIn request to the Seasteading Institute's executive director, Randolph Hencken.

The Seasteaders were interested in Collins's pitch, but they wanted a more official gesture of support. So Collins, who served as French Polynesia's minister of tourism in 2007 and 2008, began working his government contacts. By August, the president of French Polynesia, Édouard Fritch, signed a letter formally inviting the Seasteaders to present their ideas. A delegation of nine took him up on the offer the next month, and by January, a memorandum of understanding with pledges of cooperation was signed.

The next step in making the island a reality will be the passage of a law defining the 'special economic zone' that will cover the synthetic island. Blue Frontiers isn't asking French Polynesia for any subsidies to build the island, but it is asking for a 0% tax rate, among other regulatory exceptions. It has hired French firm GB2A, based in Paris, to prepare legal research and a set of requests, which Blue Frontiers presented to the government at the end of September. The team hopes to see a bill emerge before the end of the year.

In the meantime, the Seasteading Institute is building excitement and courting potential investors with a series of gatherings. In May, it held talks, networking events and tours in Tahiti. Speakers included Fritch; Tony Hsieh, chief executive of online retailer Zappos in Las Vegas, Nevada; Tua Pittman, a master canoe navigator from the Cook Islands; and engineers, nanotechnologists and a 'blockchain strategist', a specialist in the distributed information systems behind cryptocurrencies. The seasteaders hope to use

such systems to handle their financials, as well as any scientific data that they generate. But the event wasn't all work. An announcement for a party on outrigger canoes cheerfully suggested: “Do not wear heels. Bring a swimsuit for an optional moonlight swim.”

On 22–29 October, Blue Frontiers will hold an Insiders Access Week for supporters and potential investors, a mix of tours, discussion and morning yoga with Hencken. Always ambitious, the team hopes to have draft legislation from the Polynesian government by then, and some detailed architectural plans. The goal is to break ground — or rather, sea — in 2018.

While all this work goes on behind the scenes, the lagoon remains fairly quiet. On a day in July, locals compete in a stand-up paddle-board race while families play on the shore and young women drink beer with their feet in the waves. By the roadside, freshly caught tuna are for sale. On one level, it is hard to imagine this place being improved upon.

Time will tell whether the Seasteaders' island becomes a refuge for Polynesians facing rising seas and an incubator for Polynesian science and business, or merely a playground for wealthy foreigners who want to dodge bothersome regulations. That is, if it materializes at all.

Journal name:
Nature
Volume:
550,
Pages:
22–24
Date published:
(05 October 2017)
DOI:
doi:10.1038/550022a

Comments

Comments

There are currently no comments.

How fracking is upending the chemical industry

As shale-gas compounds flood the market, chemists are working out the best ways to convert them into the ingredients of modern life.

04 October 2017

Jeff J Mitchell/Getty

A ship carrying US shale gas, the *Ineos Insight*, approaches port in Scotland in September 2016.

As the *Ineos Intrepid* cruised slowly through the sapphire waters of Norway's Frierfjord, chaperone tugboats sprayed jets into the sky to herald her arrival. In giant refrigerated tanks below decks, the ship carried 27,500 cubic metres

of liquid ethane — enough to fill 11 Olympic swimming pools. *Intrepid* also brought a message, painted in giant capital letters along her side: “SHALE GAS FOR PROGRESS”.

The vessel's arrival in March 2016 brought the first ever shipment of shale gas from the United States to Europe — and marked the start of a burgeoning business. More of these 180-metre-long 'Dragon'-class vessels have followed in her wake, forming a 'virtual pipeline' for ethane across the Atlantic Ocean. This gas, which is extracted from the ground through the hydraulic fracturing of shale deposits, isn't destined to fuel power stations or domestic stoves. Instead, it will be transformed into the chemical building blocks needed to make a panoply of products, including plastics, clothes, adhesives and medicines.

Intrepid's voyage is a striking demonstration of how cheap US shale gas is reshaping the chemical industry and changing the origin of countless manufactured objects. For decades, the industry's raw ingredients have mostly come from crude oil. Chemical plants break down long hydrocarbon molecules in crude to produce a smorgasbord of smaller molecules, such as ethene, propene and benzene — all important precursors to polymers.

But shale gas, which is composed mainly of methane, ethane and propane, is turning that pathway on its head. The abundance of the gas has slashed the costs of these molecules. As a result, some are now usurping large hydrocarbons as the preferred starting point for industrial synthesis.

This shift from oil to gas brings enormous opportunities. According to the American Chemistry Council, a trade group based in Washington DC, the shale boom has attracted about US$160 billion in investment from the US chemical industry since 2011, and will help to create half a million jobs in plastics manufacturing over the coming decade[1]. But it also poses huge challenges. Some of the main techniques that are used to turn the components of shale gas into more valuable compounds — processes generally known as upgrading — are decades-old, dirty and energy-intensive. And they rarely produce the same mix of chemicals as conventional oil-based routes, which means that some relatively minor, yet valuable, chemicals such as butadiene, an ingredient of synthetic rubber, are becoming scarcer.

These challenges are driving an intensive research effort, spanning industry and academia, to develop catalysts and reactors that can transmute small hydrocarbons in cleaner, cheaper and more efficient ways.

Translating that research into commercial production will depend on the finely balanced economics of a changeable market. It will also require a reliable supply of gas. The US Energy Information Administration predicts that natural-gas extraction in the United States will continue to grow until at least 2040, but that might be too optimistic (see Nature 516, 28–30; 2014). Meanwhile, concerns that fracking can contaminate groundwater — along with the broader climate implications of extracting fossil fuels — continue to dog the technology. If the glut does persist, however, it could usher in technologies that would form the foundations of a much more sustainable chemical industry. “We could totally redesign our chemical plants,” says Bert Weckhuysen, a chemist at Utrecht University in the Netherlands.

The ethane revolution

Shale gas is extracted from kilometres below ground, and typically contains about 70–95% methane, less than 15% ethane and less than 5% propane. After traces of oil, water and other impurities are cleaned out, the gas is chilled so that ethane and propane can be separated in liquid form, leaving methane behind.

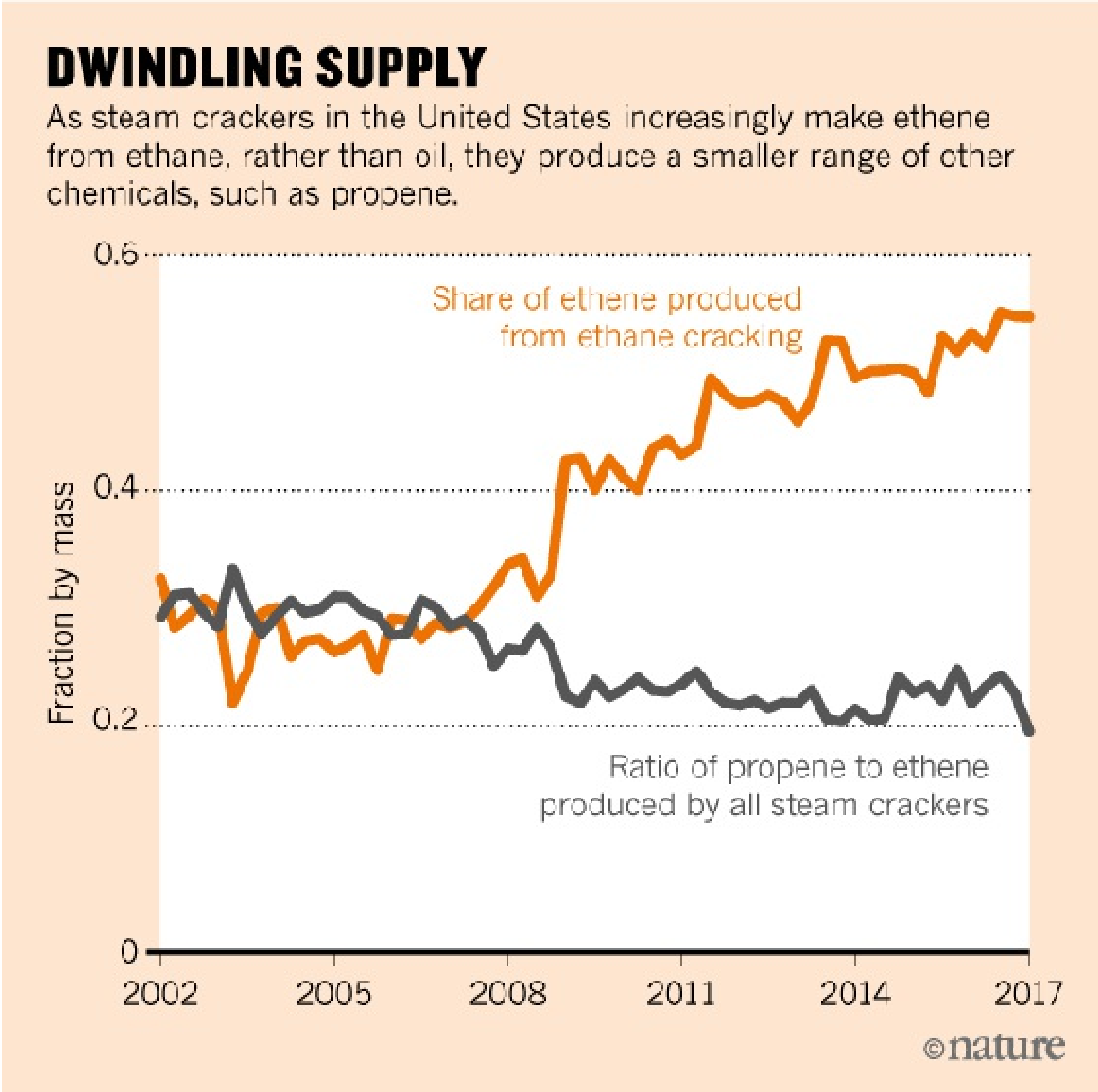
Although ethane makes up a small proportion of shale gas, it has so far had the biggest impact on the chemical industry. That's because chemists can easily use it to make ethene, also known as ethylene. Ethene is used to make various types of polyethylene and the precursors to other plastics, such as polyvinyl chloride (PVC) and polystyrene. So voracious is the world's appetite for these plastics that the chemical industry produces roughly 150 million tonnes of ethene every year, more than any other chemical building block.

Most processes in the chemical industry use catalysts. But ethene can be produced simply by steam cracking ethane or larger hydrocarbons. First developed in the 1920s, steam cracking is a blunt, energy-intensive process

that requires little more than water and 850 °C temperatures. “You basically just heat the snot out of it,” says Jeffrey Plotkin, an industry analyst at IHS Markit in New York City. “The heart and soul of the thing is this gigantic furnace, that's where all the chemistry happens.”

The boom in shale-gas-derived ethane has driven the chemical industry to invest nearly $45 billion in extra steam-cracking capacity[2]. But the transition to this feedstock is also creating a headache. When steam crackers are fed with mixtures of long hydrocarbons from crude oil, they make an array of useful by-products. But when they are supplied with ethane, the output is almost entirely ethene. “So there is a shortage of other building blocks,” says Weckhuysen.

One of those building blocks is propene, arguably the second most important product of the chemical industry after ethene. Propene is turned into polypropylene, a plastic used in packaging and textiles, along with other polymer ingredients such as acrylic acid. But by one estimate, propene production by US steam crackers dropped by almost half between 2005 and 2014, even as global demand rose (see 'Dwindling supply').



Source: S&P; Global Platts

To combat the shortfall, the industry is rolling out alternative ways to make propene. One of the leading routes starts with the shale-gas component propane. A combination of heat and a catalyst to remove two hydrogen atoms can be used to turn it into propene.

The conversion is becoming more profitable: more than 20 of these propane-dehydrogenation units are already operating worldwide, and at least 40 more have been ordered since 2011. But Weckhuysen says that there is much scope to improve the process, which tends to chew up catalysts quickly, requires a

time-consuming and costly catalyst-regeneration step, and can use harsh reagents.

The methane question

Although ethane and propane are already making waves as commercial feedstocks, the big prize for chemists is to upgrade the most abundant component of shale gas: methane.

Most of the world's methane is currently burnt as fuel, its lowest-value application. The gas can also be used as a chemical feedstock, but it contains strong carbon–hydrogen bonds that are difficult to break in a controlled way. When methane is converted into other molecules, it is done mainly through an inefficient sledgehammer of a process called steam reforming. First commercialized in the 1930s, this involves smashing methane and water together at up to 1,100 °C, over a metal catalyst. It produces an extremely useful mixture of carbon monoxide and hydrogen called syngas — and also emits several hundred million tonnes of carbon dioxide per year, accounting for roughly 3% of all industrial emissions[3].

Syngas is the world's principal source of hydrogen, much of which goes to make the ammonia in fertilizer. Syngas can also be used to produce longer hydrocarbons, such as basic components of diesel and waxes.

Such upgrading is typically done through a technique called the Fisher–Tropsch (FT) process, which uses cobalt or iron catalysts and heat to create daisy-chains of carbon atoms. FT was developed in Germany in the 1920s to make petrol and a wide range of other hydrocarbons from syngas derived from coal.

Producing transport fuels in this way is generally more expensive than refining oil. There are just six large-scale FT plants in the world, made economical only thanks to their proximity to huge coal or gas fields and the mind-boggling scale of the plants themselves: the world's largest, in Qatar, cost $19 billion to build and munches through 45 million cubic metres of methane every day, on a par with the natural-gas consumption of Belgium.

Courtesy Velocys

A plant in Oklahoma City owned by ENVIA Energy uses compact reactors developed by Velocys to turn methane-derived gas into products such as diesel.

But the shale boom has prompted chemical engineers to take a fresh look at the FT process. Shale-gas wells typically don't produce enough gas to support a conventional FT plant, so research teams and companies have been developing smaller reactors that can process modest gas flows. One of those is Velocys, based in Houston, Texas, which developed a 5-metre-long reactor that can convert syngas into substances such as naphtha, diesel and wax. Its reactor technology is being used in Oklahoma City in the first commercial mini-FT plant in the United States. The plant, which is owned by ENVIA Energy, started production earlier this year.

Temperature control is a big challenge for the FT process: the reaction kicks in at about 180 °C, then generates huge amounts of heat. If not carefully controlled, it will run away with itself, turning carbon atoms into useless soot. To address this, Velocys's reactor contains corrugated layers of channels that

are alternately stuffed with catalyst or filled with water. This keeps the reaction running at a steady 200 °C, so that the reactor can use an efficient catalyst without risking a runaway reaction. “It allows you to pack a lot of reaction in a very small space,” says Neville Hargreaves, business-development director for Velocys in Oxford, UK.

The reactor in Oklahoma City pulls methane from a landfill site, an activity that comes with renewable-energy credits. But Hargreaves thinks companies could ultimately profit by tapping remote and relatively small natural-gas reserves that are unlikely to get a pipeline. Another potential target is unwanted gas from oil wells, which is often simply burnt off. Such 'flaring' puts about 350 million tonnes of CO_2 into the atmosphere every year. According to the World Bank, it carries enough energy to meet Africa's entire current electricity requirements.

The direct route

The high temperatures involved in producing syngas will always make it a costly way to create complex chemicals — as well as a major source of CO_2 emissions. Researchers have spent decades looking for ways to convert methane directly to methanol or other products, cutting syngas out of the route altogether. The shale boom has given this effort fresh urgency, along with a burst of investment in research and development in both academia and industry.

Turning methane into methanol — itself a key precursor to a wide range of other compounds — involves adding only a single oxygen atom. But first, one of methane's strong carbon–hydrogen bonds must be broken, and the high temperatures or strong oxidants needed to do that can set the molecule on a one-way journey down a thermodynamic roller coaster with a messy end. Methanol sits on a brief crest about halfway down, but it is all too easy to race downhill as the reaction goes too far, producing a mixture of other molecules, including formaldehyde, formic acid or carbon monoxide.

In 2005, however, a team led by Robert Schoonheydt at the University of Leuven in Belgium, found[4] that copper seeded onto a porous material called a

zeolite could unite oxygen and methane to make methanol at less than 200 °C. Crucially, the methanol became trapped in the zeolite's pores, preventing further reactions. But extracting methanol from the pores and reactivating the catalyst would have proved expensive and impracticable in a commercial setting.

Since then, research groups have developed a range of copper–zeolyte catalysts that are more industry-friendly. Others have focused on completely redesigning chemical reactors. The European Union-funded project Adaptable Reactors for Resource- and Energy-Efficient Methane Valorisation, for example, aims to build small reactors that use renewable electricity, rather than heat generated from fossil fuels, to turn methane into compounds such as ethene and methanol. One approach uses microwaves to generate intense hotspots in the catalyst, lowering the heating requirements for the incoming gas.

Another approach to direct methane upgrading aims to couple pairs of the molecule together to make ethene. Since 2015, Siluria Technologies, a start-up in San Francisco, California, has been running a demonstration plant for this process in La Porte, Texas. It relies on a catalyst made of metal-oxide nanowires that collectively offer a surface area of about 200 square metres per gram of catalyst, hundreds of times more than a bulk catalyst could offer.

The company builds its catalysts in a unique way, based on a technique[5] developed by co-founder Angela Belcher, a materials scientist at the Massachusetts Institute of Technology in Cambridge. First, viruses are genetically engineered to express proteins that bind to dissolved metal ions. The ions form orderly arrangements as they stick to the surface of the virus. When the biological template is burned away, it leaves behind a highly stable, crystalline nanowire.

Rahul Iyer, Siluria's vice-president of corporate development, says that the process is cost-competitive with steam cracking ethane, and produces far fewer CO_2 emissions than steam reforming methane. Siluria has already licensed the technology to some chemical companies, and expects the first commercial facilities to be operating in 2019.

Plotkin says that Siluria is currently in the lead in the race to commercialize direct methane upgrading, and is backed by multimillion-dollar investments from big players in the industry. “People are keeping a watchful eye on it,” he says.

Gas that's greener

The shale-gas boom is credited with spurring a major renaissance in the US chemical industry, which has invested heavily in chemical plants and other infrastructure, as well as research and development. Enthusiasm for shale-gas upgrading has fostered major collaborations between academia and industry.

Translating laboratory results into commercial production is an ongoing challenge, although the trend towards small, modular reactors is helping to make it less daunting. The chemical industry is notoriously conservative: if a process succeeds in the lab but fails at commercial scale, tonnes of catalyst can be wasted and a plant shut down for months. “Industry will not take the risk unless they are sure it will work,” says Weckhuysen.

Despite these challenges, he is optimistic that gas upgrading could have a huge impact — not only on the chemical industry's processes, but also on its environmental footprint. Some of the reactor technologies being developed to feed on shale gas could be adapted to use bio-based feedstocks, such as methane from landfills, as Velocys has found. Meanwhile, shortages in some compounds caused by the shift to shale gas could improve the economic case for starting with ethanol from crops, or lignin from wood[6]. There has already been movement along these lines. In 2013, for example, French tyre-maker Michelin and partners launched a €52-million (US$61-million) project to make butadiene from bioethanol.

But for now, US shale ethane continues its relentless march around the world. More chemical companies are commissioning ships to transport the gas to destinations in Europe, Brazil and India. By 2022, according to one estimate, about 8 million tonnes of ethane will flow through these virtual pipelines each year. They will carry this revolution in the US chemical industry to the rest of the globe — both its challenges and its opportunities.

Journal name:
Nature
Volume:
550,
Pages:
26–28
Date published:
(05 October 2017)
DOI:
doi:10.1038/550026a

Comments

Commenting is currently unavailable.

Scientists have most impact when they're free to move

04 October 2017

An analysis of researchers' global mobility reveals that limiting the circulation of scholars will damage the scientific system, say Cassidy R. Sugimoto and colleagues.

Spencer Platt/Getty Images

Measuring the global movements of researchers will help to assess the effects of political actions on science.

Recent political upheavals portend an era of increased isolationism in

science, with a chilling effect on collaboration and mobility. Last month, US President Donald Trump issued his third travel ban in a year, suspending entry of individuals from several countries into the United States, and placing restrictions on many more for visa renewals. These orders have stranded scholars abroad and prevented those who were in the country from engaging in international work. In March, UK Prime Minister Theresa May began the process of formally severing ties with the European Union. As a result, British institutions face a potential exodus of non-resident EU researchers and will have to overcome barriers to participating in and receiving funding for European collaborative projects. The list of countries engaging in these isolationist actions, and the list of actions themselves, grows longer.

To assess the impacts of such political actions, we need better ways to measure researcher mobility. Although the size and composition of the scientific workforce is fairly well established through national surveys and registries[1], less is known about how often researchers move, where they go, what networks they form, and how important their movement is to the scientific impact of their work[2].

We present here a new analysis based on the records of 14 million papers from nearly 16 million unique individuals who published between 2008 and 2015. In our study, some 96% of researchers had only one country of affiliation; we classed these as non-mobile. About 4% (more than 595,000 researchers) were mobile — meaning that they had more than one affiliation during that period. Our analysis revealed surprising trends.

Chain reaction

Over the study period, Europe and Asia saw a dramatic net loss of researchers, whereas North America saw large gains. Many commentators have anguished about 'brain drain' or 'brain gain', assuming that receiving countries get the lion's share of scientific capital at the expense of the nations from which researchers originate. The reality is more complicated (see 'Brain circulation').

We found that the majority of scientists didn't cut ties with their country of

origin but instead built a chain of affiliations that linked nations together. Many researchers returned to their home country. Brain circulation may be a more apt term for the movement of contemporary scholars[3].

Different nations have different roles in the circulation of elite scholars (for which our proxy is highly cited researchers). But wherever they are, wherever they stop off and wherever they come from, mobile scholars have about 40% higher citation rates, on average, than non-mobile ones (see Supplementary Information; Table S7). Closing borders takes these elite scholars out of circulation.

Origin stories

Our study looks at the country stated in a researcher's affiliation when they published their first paper, and uses this as their country of scientific origin (this should not be confused with where they were born). We then track whether they moved or gained new affiliations in other countries over the eight years of this study.

The conventional idea of mobility focuses on migrant researchers — those who begin publishing in one country and then move to another, at some point discontinuing their attachment to the previous country. This group made up less than one-third of the mobile researchers in our study (27.3%, or 162,519 researchers). By far the largest proportion were those we call travellers: scholars who retain a footing in their country (or countries) of scientific origin throughout their career, while gathering up more international affiliations to add to their name (72.7%, or 433,375 researchers). Nearly half of the travellers are 'non-directional': they have more than one affiliation in their first year of publication, and they retain all these affiliations in each publication year.

Circulation networks that map the number and flow of researchers reveal the importance of the United States, United Kingdom, France, Canada and Germany as prominent nodes in the global scientific network (see Supplementary Figure S2). Isolation of these countries would have dramatic consequences. Although the United Kingdom is not particularly central to researcher migration in the European Union, it serves a crucial function in providing a bridge for European scientists to other areas of the world (see Supplementary Figure S2). Isolationist policies in the United Kingdom could deconstruct this network, redirecting scholars through other countries.

More patterns emerge if we look only at migrants and directional travellers who moved between and within continents, who first published in 2008, and who published at least eight papers during the study period. Admittedly, our short time window means that we focus on junior scholars. But it avoids conflating them with senior scholars whose movement and networking are likely to differ.

This group comprised 12,046 researchers. Europe provides the largest share (35%) followed by about one-quarter each from Asia and North America (see 'Making tracks'). The relationship between these latter continents is strong:

the majority of mobile scholars associated with an Asian address in their first publication in 2008 have a North American address by 2015, and more than one-third of mobile North American scientists end up in Asia. Both of these trends can probably be explained by the same underlying phenomenon — the influx of Asian students into the United States (some of whom publish before their arrival, and others of whom do so afterwards), and their subsequent moves back to Asia.

We see a 22% net loss of researchers from Europe, a 20% loss from Asia, and a nearly 50% gain for North America (see Supplementary Table S4). European scholars make up the largest population of mobile scholars in nearly every country, with the exception of Asian countries, where most scholars are drawn from North America (see 'Scientist shuffle').

It is also of interest to know the degree to which certain countries are responsible for the production and cultivation of high-impact scholars. We assess this by looking at citation scores for mobile researchers before and after their moves (see 'Trip adviser').

Countries in North America and Northern Europe act as strong producers: they put into circulation scholars who are well-cited before they move. The same countries are also strong cultivators, identifying talent early and providing fertile ground for scholars to achieve high impact once they arrive. Asian regions are strong recruiters, gaining affiliations with established scholars who were well-cited before their arrival. Oceania is a notable incubator, affiliated with scholars who realize high potential once they move on.

Some migratory routes tend to be associated with highly cited scholars. Those from North America with the highest impact tend to land in Northern and Western Europe and, to a lesser extent, in Southeastern Asia. Mobile, high-impact Northern Europeans are recruited to Southern Europe; mobile, high-impact Western Europeans are recruited to Oceania and Eastern Asia.

Mobile scholars from Oceania produce particularly high-impact work when they arrive in North America and Southern Europe. Central and Western Asian scholars (including those from countries implicated in the US immigration ban) realized their highest citation rates for work done in North

America and Europe. Barring scholars from these countries is likely to displace high-impact ones to other nations.

Regardless of region, mobility pays in terms of citations. Across all regions, mobile scholars are more highly cited than their non-mobile counterparts. The advantage varies by region. Mobile North Americans see only a 10.8% boost in citations over their non-mobile colleagues. For Eastern European scholars, the gulf is 172.8%.

Mobility measures

Of course, our method has limitations. We cannot tell if our 'country of academic origin' represents country of birth, of academic training or of academic employment — it reveals solely where an individual began publishing. If researchers from some countries tend not to publish first in a journal indexed in the Web of Science, then our measures would underestimate mobility from these places. Those we have counted as 'non-mobile' might really be 'pre-mobile' — meaning that they have not yet moved. Furthermore, examining less than a decade of papers, focusing on journal articles and adding restrictions for number of publications may privilege certain disciplines in the analysis. And our study does not look at mobility rates within each country: for large nations such as the United States, these might be significant and interesting.

Internationally comparable mobility indicators for the scientific workforce are particularly necessary in an era in which mobility is growing, complicated and increasingly threatened. We need indicators that provide more nuanced and dynamic assessments of the exchange of human capital and the effect of this exchange on the knowledge economy, particularly given that the 'travellers' in our analysis account for the majority of mobile scholars. This study provides a start.

It might be argued that collaboration can continue, even when mobility is restricted. However, despite advances in computing, collaboration tends to be initiated and sustained through interactions that happen in person[4]. Limiting mobility is likely to have adverse effects on the scientific system, which is

increasingly dependent on international collaboration[5].

Disruption of the existing network would have serious effects on many nations, including large science producers and cultivators such as the United States. The country benefits significantly both from its centrality in the global knowledge network, and from the educational investments of other countries. Its exceptional contributions are disproportionately made by researchers who are both foreign-born and foreign-educated[6]. Disconnection would also seriously affect those nations that benefit from the United States' role as a cultivator — it invests in researchers who come from Asia and elsewhere and later return home.

Some countries may see benefits, however: isolationism among central countries can lead to advantages for other competitive nations. For example, the number of graduate-student applicants to Canada has risen since the change in the US administration (see go.nature.com/2fjc4i). However, if adequate scientific capacity does not exist in these other countries, global talent will not be cultivated to the extent it is today. With good bibliometric standards to measure the impact of mobility, we can test the effects of these political changes in the decades to come.

One thing is already clear. Internationally mobile scholars are in the minority, yet show the highest impact across the globe. Limiting the circulation of scholars will damage the entire scientific system.

Journal name:
Nature
Volume:
550,
Pages:
29–31
Date published:
(05 October 2017)
DOI:
doi:10.1038/550029a

Supplementary information

PDF files

1. Supplementary information (1.6M)

Comments

Comments

There are currently no comments.

Open countries have strong science

04 October 2017

Caroline S. Wagner and Koen Jonkers find a clear correlation between a nation's scientific influence and the links it fosters with foreign researchers.

Spencer Platt/Getty

Nations that welcome international researchers and encourage cross-border collaboration tend to produce papers with high scientific impact.

International projects account for at least 20% of national government spending on scientific research. Some countries spend as much as 50% of these funds on international collaborations[1, 2]. The number of internationally co-authored papers is growing rapidly[2]. For countries at the forefront of

research, the fraction of papers that are entirely 'home grown' is falling[3].

Is there a connection? We analysed publication and citation data for 36 nations, along with government expenditures on science. We found that although government spending on research and development (R&D;) does correlate with the number of publications produced, it does not correlate with scientific impact — at least as assessed by citations, one of the few practical metrics available. What does correlate with impact is a country's openness, which we approximated by combining metrics of international co-authorship and the mobility of each nation's research workforce.

In 2016, we partnered with Jeroen Baas, head data scientist at Elsevier, the publication house that also runs the citation database Scopus, to examine nearly 2.5 million publications that were published in 2013 across all scholarly fields and that had three years' worth of citation data available. Publications and a field-weighted citation index were apportioned to countries according to authors' locations. (So if two-thirds of the authors on a publication were in the United Kingdom and one-third in Singapore, those fractions were applied to determine the publication count and citations assigned to those countries for that paper.)

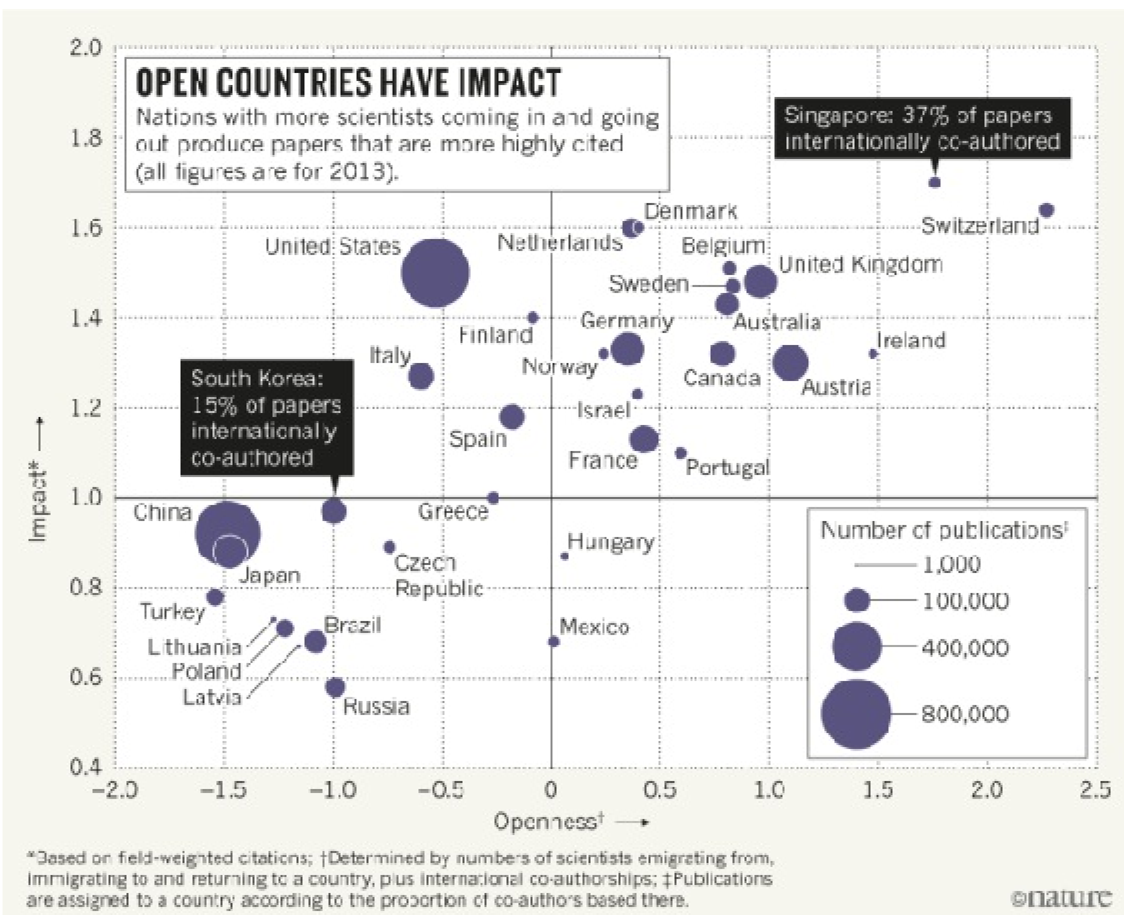
In terms of papers published, the United States and China dominate. For 'international papers' (those with authors from more than one country), the United States still leads, followed by the United Kingdom, China, Germany, France and Canada. When international papers are considered as a percentage of all of a country's papers, Switzerland (42%) appears as the most connected country, followed by Belgium (38%), Singapore (37%), Austria (36%) and Denmark, the Netherlands and Sweden (all 34%). In terms of impact for international papers, Singapore tops our list, followed by the United States, and then Sweden, Belgium, Switzerland and the Netherlands.

We looked for factors that could explain this. In addition to international collaboration, scientific mobility was expected to contribute to impact[4]. So we also considered new researchers coming in, returnees and emigrating researchers, all of which are tracked by the Organisation for Economic Co-operation and Development (OECD). These variables, together with collaboration, proved to be highly correlated as measures of international

engagement; so we used them to create an index of openness and were able to assign values to 33 of the countries that we looked at (data available at go.nature.com/2fzrnt3).

To assess whether government R&D; spending (as tracked by the OECD and Eurostat, the statistical office of the European Union) and our openness measure explained the relatively higher impact for smaller countries, we used a Pearson correlation analysis, which allows comparisons to be made across a large quantitative range, such as the publication output of the United States versus that of Singapore.

Public R&D; funding is tied to publication output: the more money spent, the more articles produced (counting sole-authored, co-authored and internationally co-authored). But we found only a weak correlation between spending and impact. In other words, more government funds spent does not necessarily result in more citations.



Countries that are highly 'open' and that produce high-impact research seem to benefit from participating in international collaboration. This is seen in the higher impact of smaller nations, which cluster in the top-right quadrant of the graphic (see 'Open countries have impact'). Singapore, the United Kingdom, the Netherlands, Switzerland, Sweden and Denmark all scored highly on this measure as well as on citations. The correlation between openness and citation impact was tight ($r^2 = 0.7$ according to a regression analysis) regardless of R&D; spending or numbers of articles published.

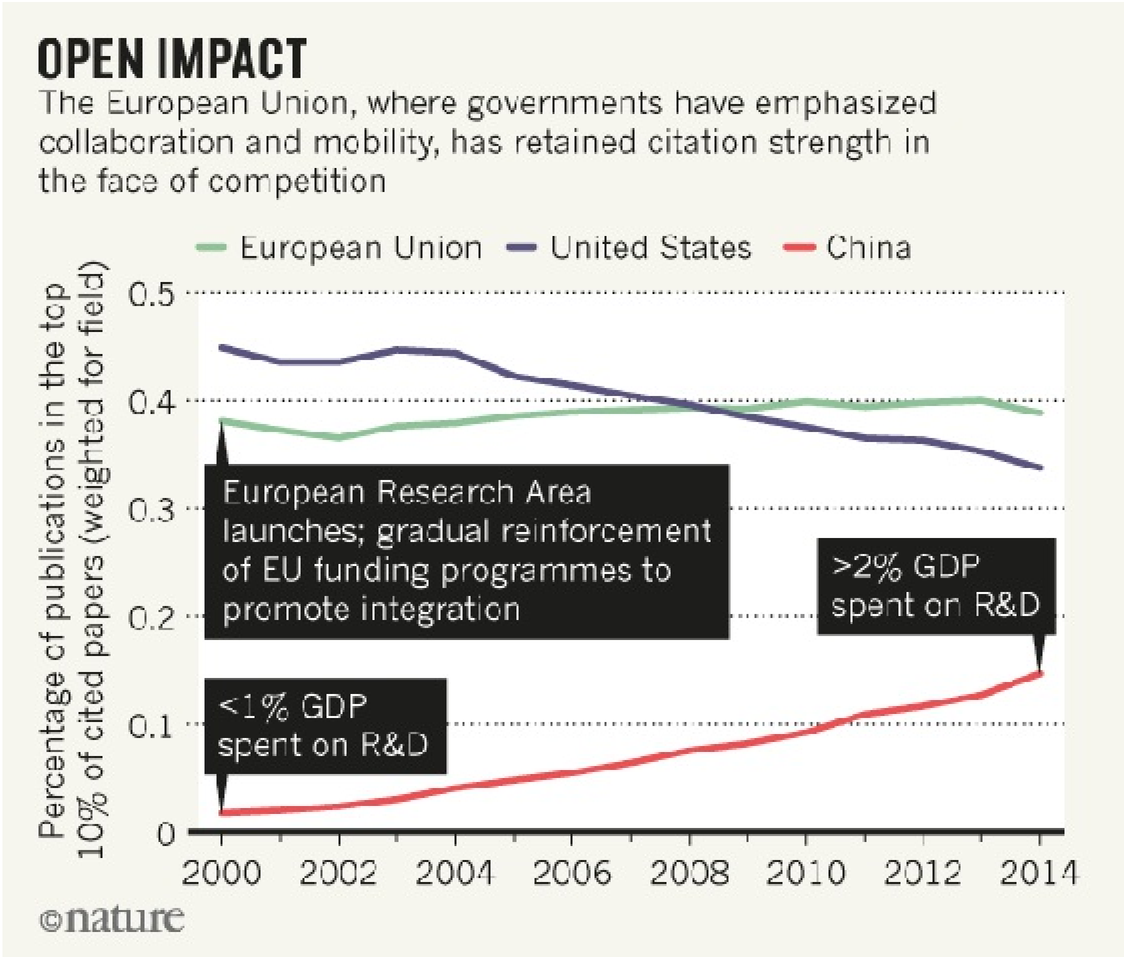
Countries with low openness and low impact include Russia, Turkey and Poland, China, Japan, Latvia, Lithuania, the Czech Republic and, against expectations, South Korea (which spends a higher percentage of its GDP on R&D; than almost every country, including the United States) These countries are shown in the lower-left quadrant.

The United States scores highly on impact, but less so on openness — perhaps because of the magnitude of its scientific enterprise and its geographic distance from possible collaborators. Of our 33 countries, only 4 (the United States, Italy, Spain and Finland) have low openness and high impact, and only 2 (Hungary and Mexico) have high openness and low impact.

Our analysis suggests that openness is related to impact, although we recognize that correlation is not causation. Nevertheless, we note that many of the countries whose scholarship has high impact, and whose policies encourage international engagement, are from Europe. The EU has established the European Research Area (ERA). Its governments have been implementing measures to strengthen domestic research systems while also promoting both international collaboration and mobility. The EU's Framework programmes have similar aims — one of the current stated objectives of EU research policy is to be more “open to the world”.

Analysis of citation strength for countries in Europe shows that they have greatly enhanced their impact compared with the United States (see 'Open impact'). As a bloc, the EU now outperforms the United States. Both far exceed China in impact, although China's share of high-impact papers is growing rapidly[5]. Other countries that promote openness also perform well in

terms of impact: examples include Singapore and Australia.



EU Joint Research Centre Tools for Innovation Monitoring, based on Scopus data release August 2016

Some will argue that citation is not synonymous with quality or importance, but it does signal engagement and recognition. Studies dating as far back as 1992 show that international papers are, on average, more highly cited[6]. The countries that are engaging internationally are seeing a dividend in terms of attention to their research.

It may be that the exchange of ideas encourages greater creativity, or that a virtuous cycle of quality work attracts others to work with those in higher-impact countries. In fact, we had very similar results when we considered each component in our openness metric separately, although most of the

effect of the mobility variables is mediated by international collaboration. Analytically, it makes sense to combine these into a single variable. However, other factors — such as the ease of obtaining visas or support to study in a country — are not explicitly incorporated.

In Japan, especially, output and citation impacts have remained flat since 2000. Japan is also among the least internationalized of leading nations, and this could be dragging on its performance. Lack of professional mobility, as well as language barriers, may be hindering engagement.

Our analysis suggests that national funding programmes should, whenever possible, move away from policies that fund only national researchers. In the longer term, countries could benefit more by funding the best science, wherever it is, and ensuring that domestically based scientists are linked with it. Restricting the movement of researchers — by limiting exchange opportunities or imposing visa restrictions, for example — could be counterproductive.

Just as industries make 'build or buy' decisions, so governments must make 'link or sink' decisions about research investment. Our data add to a growing body of work about the changing science system, indicating that science policymakers who seek to enhance impact should prioritize international exchange.

Journal name:
Nature
Volume:
550,
Pages:
32–33
Date published:
(05 October 2017)
DOI:
doi:10.1038/550032a

Comments

Commenting is currently unavailable.

Collaborative software development made easy

Save time and protect critical code with 'continuous integration' services.

04 October 2017

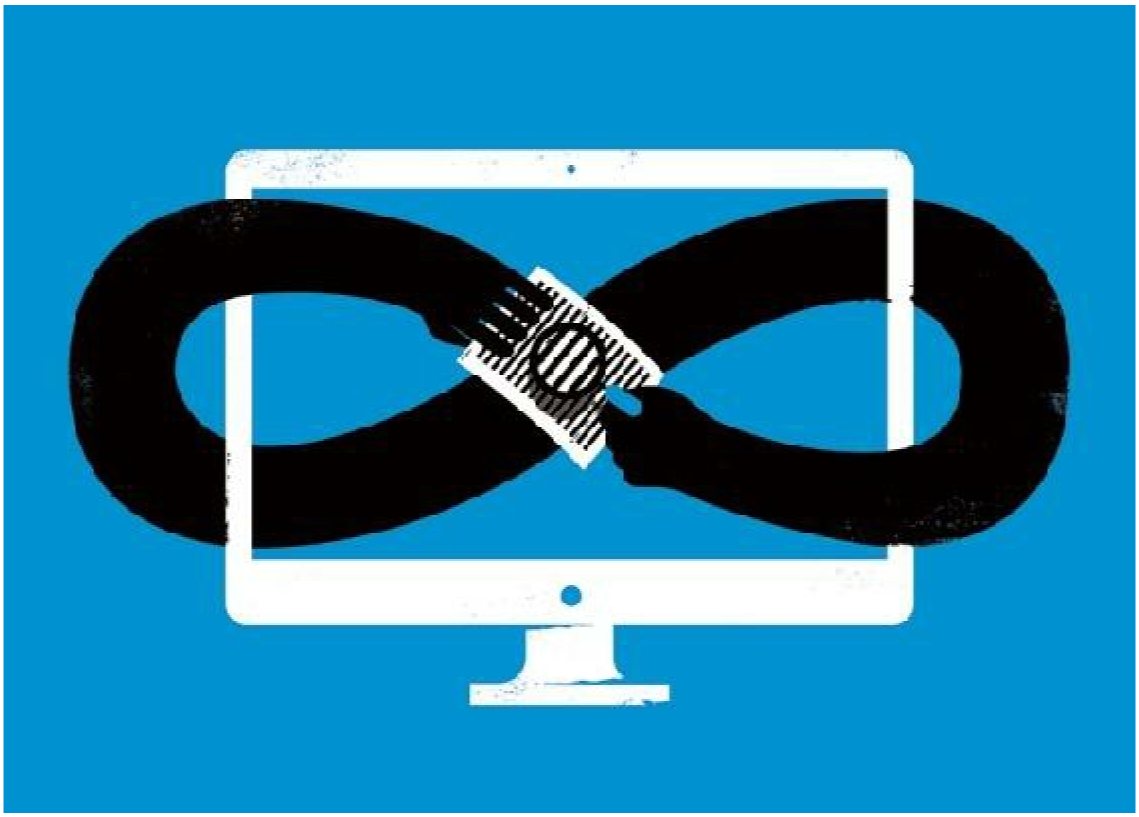


Illustration by the Project Twins

Sebastian Neubert, a particle physicist at Heidelberg University in Germany, leads a group studying subatomic particles called pentaquarks. The six team members all have access to the software code used to run their multi-step analyses, and the programmers update it daily with new features and bug fixes. With each code change, however, they run the risk of introducing

inadvertent errors that foul the underlying algorithms.

To prevent that, the team checks and rechecks the analyses, and uses error-checking algorithms, functions they can call whenever a change is proposed, to ensure that their software works as intended. One test, for example, verifies that a noise-cancelling algorithm gives the correct output when it is run on practice data.

In 2015, in an effort to save time and resources, the team took inspiration from the technology industry, automating their testing using a process called 'continuous integration'.

In continuous integration, changes to software code automatically trigger repetitive tasks, such as error-checking. Fundamentally, the process simplifies a task that diligent coders already perform. Programmers usually write lists of tests that they will run periodically to ensure that their code still works, just as Neubert's team do. But a busy team might forget or lack the time to run them, allowing errors to creep in. Continuous integration automates that process so those checks run whenever a change is proposed, saving team members the time they would spend hunting down an error. A team running genomic analyses could spend more time at the bench, while a group developing climate-prediction software could better refine its models. That said, the resulting peace of mind is only as good as the tests themselves: a poorly designed test can still allow mistakes to pass undetected.

The process is common in the commercial and open-source sectors. A study presented at the 2016 IEEE/ACM International Conference on Automated Software Engineering in Singapore found that about 40% of the 34,544 most-popular open-source projects hosted on the coding collaboration site GitHub used continuous integration in some form.

Only a few of those open-source projects might be considered scientific software, but an increasing number of scientists are looking to continuous integration to automate all sorts of time-consuming tasks, from testing code to updating documents with the latest data.

Researchers at institutions such as CERN, Europe's particle-accelerator laboratory near Geneva, Switzerland; the Pacific Northwest National

Laboratory in Richland, Washington; and the Ontario Institute for Cancer Research in Toronto, Canada, have embraced the practice, but adoption in the scientific sector remains relatively sparse.

For Neubert, continuous integration ensures that the pipeline's behaviour remains correct and consistent as his team refines its code, providing an “incredibly valuable” safeguard. “There is a real danger of just missing something or making a slight mistake,” he says.

Exceptions

A variety of continuous integration services exist. These include the open-source Drone, and commercial options such as CircleCI, Codeship, GitLab, Shippable and Travis CI, all of which offer pricing tiers based on the desired testing behaviour, number of users and whether the project is public or private. Travis CI, for instance, is free for open-source projects; private projects cost from US$69 per month. Shippable offers a free basic service for public projects, but charges $25–150 per month for support for private projects and greater computing power, among other features.

Researchers should consider what is a suitable and worthwhile investment, however. Not every project needs continuous integration and setting up and configuring a service can be challenging. Further difficulties can arise if the services need to interact with software or data with legal restrictions on its use, says Daniel Himmelstein, a data-science postdoc at the University of Pennsylvania in Philadelphia.

Also, code is often used only once, making the cost even less worthwhile. “For day-to-day research coding, the amount of code is not large enough to make continuous integration valuable,” says Andrea Zonca, a specialist in high-performance computing at the University of California, San Diego. He uses Travis CI when publishing code, but most that he writes is for his own one-time use and is not executed again.

Computing costs can also mount if code is being constantly updated and requires repeated testing, which is why Neubert's lab only tests its most

critical data analyses after code changes.

Despite these challenges, continuous integration services tend to improve code quality, says Björn Grüning, a bioinformatician at the University of Freiburg in Germany, especially on large projects such as Galaxy, a bioinformatics toolkit that Grüning, along with about 160 others, contributes to.

According to Grüning, continuous integration has shortened the turnaround time for approving contributions to the Galaxy project and given programmers more confidence when submitting new features and fixes. Before these services were available, it was often impractical for researchers in such projects to test every new feature collaborators proposed because they didn't have the time, he says.

Some researchers use continuous integration to automate non-programming tasks. In April, as part of a project studying how ecosystems change over time, Ethan White, an ecologist at the University of Florida in Gainesville, helped to configure Travis CI to update tables and plots automatically with new field or weather-station data, saving the research team up to 5 hours a month.

Continuous integration helps Himmelstein automate revisions to scientific papers, citations and web pages following text or code updates. Without continuous integration, he says, human maintainers would probably “get lazy and update the manuscript less frequently than every change”.

Initializing

Whether hosted externally by a third party or on a user's own machine, the continuous integration service is controlled with a custom set of instructions. This configuration file defines the tasks to be run and sets up the server with the correct environment — the operating system and software libraries — required to run them. The service then executes those instructions at set times or on receipt of a code or data update.

University of Pennsylvania bioinformatician Casey Greene, who uses

continuous integration to rerun his data analyses, has tested many of today's most popular services. “The good news about all of these services is that they're quite similar,” he says.

Subtle differences do exist, for instance in the number of concurrent jobs users can run, or the amount of computing power available to run them. “I'd encourage people to dig into the limits of each service to make sure they are compatible with their workflows,” advises Greene.

Although continuous integration adoption in science right now is small, it is growing, and more researchers should get on board, Greene says. Getting up to speed takes time, he acknowledges, but often, the effort is worth the reward. “Scientists analysing data should have it in their toolbox.”

Journal name:
Nature
Volume:
550,
Pages:
143–144
Date published:
(05 October 2017)
DOI:
doi:10.1038/550143a

Comments

Comments

There are currently no comments.

A taste of Toolbox

Nature's technology editor, Jeffrey Perkel, started blogging about workplace technology in science in 2016. Here are some highlights.

04 October 2017

From stadiums to genomes

Most bioinformaticians are either biologists skilled in programming or programmers with an interest in biology. Mike Goodstadt, the programmer behind the 3D genome-visualization tool TADkit, took a different approach. In the early-to-mid 1990s, Goodstadt was a student at the University of Bath, UK. His course of study? Architecture, with an emphasis on 3D modelling. After graduation, he helped to design and build a 61,500-seat stadium. But a faltering economy and newly acquired programming skills helped to steer him towards biology.

Lorena Barba, reproducibility champion

Lorena Barba, a mechanical and aerospace engineer at George Washington University in Washington DC, has long championed research reproducibility. “I've always believed that the open-source model is ideal for science, as it exposes the complete sequence of steps that produces a given result,” she says. In January, she travelled to Chile to run a week-long course on reproducible research computing. The month before, she had been awarded a 2016 Leamer-Rosenthal Prize, which celebrates those “working to forward the values of openness and transparency in research”. In this Q&A;, she talks flying snakes, 'repro-packs' and copyright.

The sound of DNA

With an alphabet comprising just four letters, a DNA sequence isn't much to look at. So when sequence-analysis tools want to highlight key elements, they typically do so using colour or font, or by overlaying other types of information. In the not-too-distant future, there may be another option. Molecular biologist and part-time drummer Mark Temple at Western Sydney University, Australia, describes DNA sonification, “an auditory display tool” for DNA: sequence in, audio out. “I'm not saying audio by itself is the bees' knees for interpreting DNA sequence,” Temple says, “but surely audio can contribute to your visual interpretation.”

Journal name:
Nature
Volume:
550,
Pages:
144
Date published:
(05 October 2017)
DOI:
doi:10.1038/550144a

Comments

Comments

There are currently no comments.

South Korea cracks down on dirty air

Despite huge clean-up effort, scientists say country’s pollution problem could get worse over next five years.

03 October 2017

Ed Jones/AFP/Getty

South Korea's capital, Seoul, ranks among the world's most polluted cities.

In a major attempt to clean its increasingly dirty air, South Korea’s government last week unveiled a five-year, 7.2 trillion won ($6.3 billion) plan to close down old coal plants, get diesel vehicles off the road and curb polluting emissions from industrial plants, construction sites and ships.

Although much of the spending had already been pledged, researchers say that the new strategy, announced on 26 September, is the country's most ambitious attempt yet to scrub its air. But because it omits controls on a class of chemicals called volatile organic compounds (VOCs), the initiative might make air quality worse before it improves.

The plan fulfils a key campaign pledge by President Moon Jae-in, who was elected in May by a Korean public increasingly concerned about their country's worsening air quality. At times this year, Seoul ranked among the world's top three most polluted cities. And the Organisation for Economic Co-operation and Development (OECD), based in Paris, reports that in 2015 South Korea's average exposure to fine-dust particles under 2.5 micrometres in size was the highest of all OECD member nations. This particulate matter, known as PM2.5, is small enough to enter the lungs and can cause respiratory illnesses.

The government hopes to cut domestic emissions of PM2.5 by 30% before 2022. Moon's administration has already focused on shutting down coal plants, temporarily closing eight of them in June and beginning the permanent shutdown of three in July. And the previous administration of Park Gyun-Hye had pledged 5 trillion won by 2020 to speed the adoption of electric cars to replace diesels.

NOx-ious crackdown

But the new strategy also aims to crack down on emissions of nitrogen oxides (NOx), which can react with other atmospheric compounds, including VOCs, sulfides and ammonia, to form ozone and fine-dust particles. Large industrial facilities such as steel plants and petroleum refineries will be fitted with monitoring equipment and held to a cap on their NOx emissions starting in 2019, the environment ministry's deputy director JaeHyun Kim says.

That approach has been informed in part by data released in July from a joint US–South Korean study called KORUS-AQ[1], says Kim. The most comprehensive examination of air quality in the region, it involved more than 580 researchers from the United States and South Korea, as well as several

research aircraft, including a NASA DC-8 jet that flew across the Korean peninsula and the Yellow Sea. Researchers found that South Korea was emitting more NOx and VOCs than its own ministry estimated, and recommended reductions in these chemicals. This highlighted the importance of addressing South Korea’s domestic pollution, says Kim, at a time when many in the country were more concerned about pollution blowing over from China.

The focus on NOx means the new plan is “a lot better than before”, says Kyung-Eun Min, an atmospheric chemist at the Gwangju Institute of Science and Technology. But she and other scientists point out that it says little about curbing VOCs. These are typically aromatic molecules produced for activities such as painting, printing and dry cleaning. A compound called toluene, used to manufacture solvents, is particularly instrumental in producing fine dust and ozone, the KORUS-AQ study found. The VOCs often leak during production, or while being stored or used by small businesses.

Ozone up?

Paradoxically, Min says, reducing NOx without reducing VOCs is likely to increase ozone across much of South Korea. That is because, according to the KORUS-AQ results and Min’s own work, relative levels of NOx are so high in Korea — especially in car-filled Seoul — that they restrict the efficiency of ozone production, much as an over-rich fuel mixture makes an engine sputter. The quickest way to cut ozone is to starve it of both NOx and VOCs, “but the VOC part is not really there,” Min says. However, regions downwind of Seoul may benefit more quickly from NOx reductions, says Rokjin Park, an air chemist at Seoul National University.

Tracking VOC emissions is particularly difficult, because there is no clear way to monitor or regulate small businesses such as painters and dry cleaners. A first step would be to collect data to nail down where South Korea’s VOCs are coming from, Min says. In the longer term, she suggests developing technology that can capture dirty air from such emissions sites so that it can be purified at treatment facilities — in a process analogous to sewage treatment.

Yong Pyo Kim, an environmental scientist at Ewha Womans University in Seoul and an author of the KORUS-AQ report, says he thinks that both ozone and fine dust could get worse for the next five years. “In my opinion, the environment ministry did not learn from the KORUS-AQ results seriously,” he says. The South Korean environment ministry has not responded to requests for comment from *Nature* about the criticisms.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22448

Comments

Comments

There are currently no comments.

Xenon view, butterfly wings and a strange squid

September’s sharpest science shots, selected by *Nature*’s photo team.

03 October 2017

CRISPR catches

Richard Wallbank/Smithsonian Institution and University of Cambridge

The beauty of butterfly wings owes much to just two genes, researchers revealed this month. They used the CRISPR gene-editing system to turn off the genes, called *WntA* and *optix*, to show how their absence dulls the colours

of these fleeting flyers. Left are the wings of an unmodified Sara longwing (*Heliconius sara sara*) from the study; right is a gene-edited version.

Inside Xenon

Image Slideshow

1. 

   Winner of a gold award in the 2017 International Images for Science competition, this picture by Enrico Sacchetti shows the interior of the Xenon1T experiment at Italy's Gran Sasso Laboratory, which hunts for dark matter.

   Enrico Sacchetti/Royal Photographic Society

2. 

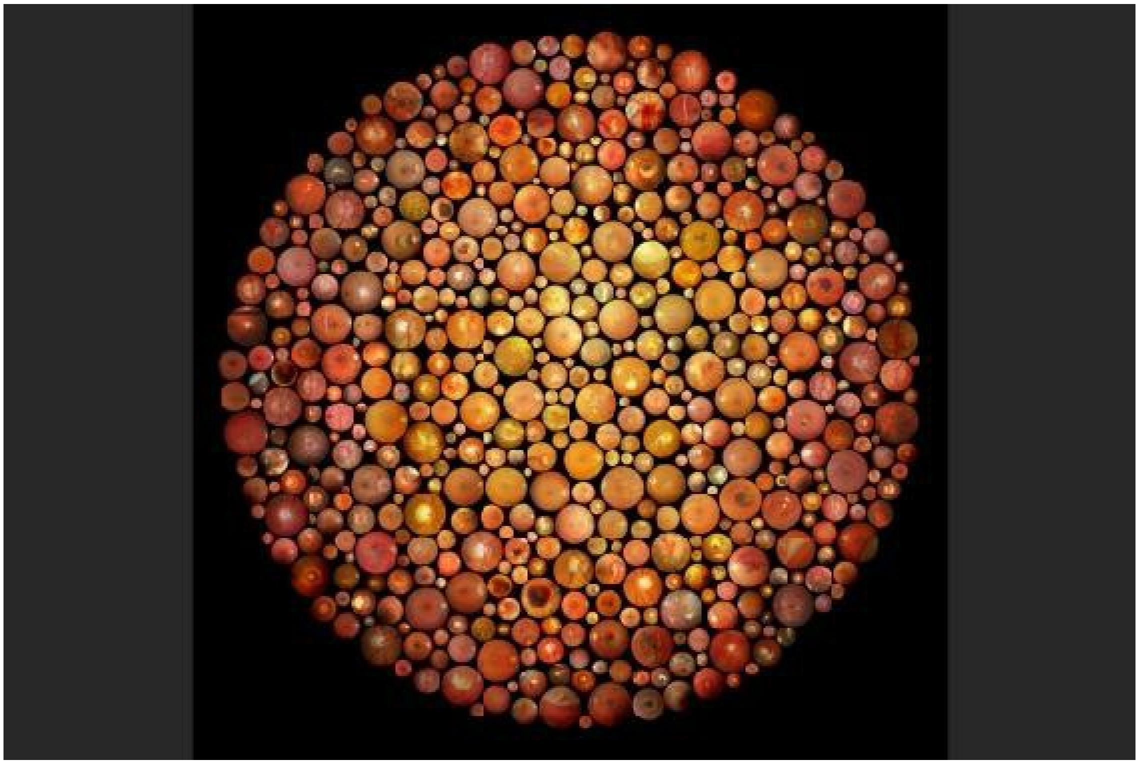
Another gold-award winner, this one taken by Teresa Zgoda. What looks like a frightening visage is actually a close-up of a pork tapeworm (*Taenia solium*), showing in detail the suckers that allow it to stick to the inside of humans and grow — and grow, and grow.

Teresa Zgoda /Royal Photographic Society

3. 

These legs belong to impalas (*Aepyceros melampus*); the black patches are glands used for scent marking. This image from Morgan Trimble won a bronze award in this year’s competition.

Morgan Trimble/Royal Photographic Society

4. 

This shot is a combination of hundreds of images of retinas shot by Jonathan Brett, and assembled to mimic a colour-vision test chart. The eyes took a silver award.

Jonathan Brett/Royal Photographic Society

Coming down…

Bill Ingalls/NASA

At the start of the month, this Soyuz capsule brought back three astronauts to Earth, landing near Zhezkazgan in Kazakhstan. Among them was Peggy Whitson, who spent 288 days in space aboard the International Space Station.

… and going up

Bill Ingalls/NASA

Ten days after Whitson and her colleagues returned to this planet, another three people left it when this Soyuz left for the space station from Baikonur Cosmodrome.

A complex cloud

Artem Mironov

This nebula — called the Rho Ophiuchi cloud complex — is 140 parsecs (460 light years) from Earth. Photographer Artem Mironov took three nights to capture this image of it, which went on to win this year’s Insight Astronomy Photographer of the Year award.

Seamount squid

NOAA Office of Ocean Exploration and Research

On 17 September, the crew of the US National Oceanic and Atmospheric Administration's ship *Okeanos Explorer* were exploring the Musicians Seamounts, a formation of undersea mountains in the Pacific Ocean, with remotely operated submersibles when they spotted this cranchiid squid. You can see more pictures of weird and wonderful deep-sea denizens on their diary site.

Bee bounty

Image Slideshow

1. 

The USGS Bee Inventory and Monitoring Lab in Laurel, Maryland has long been among our favourite purveyors of online insect images. Among the latest additions to its catalogue is this *Hoplitis fulgida*.

Anders Croft/USGS Bee Inventory and Monitoring Lab

2. 

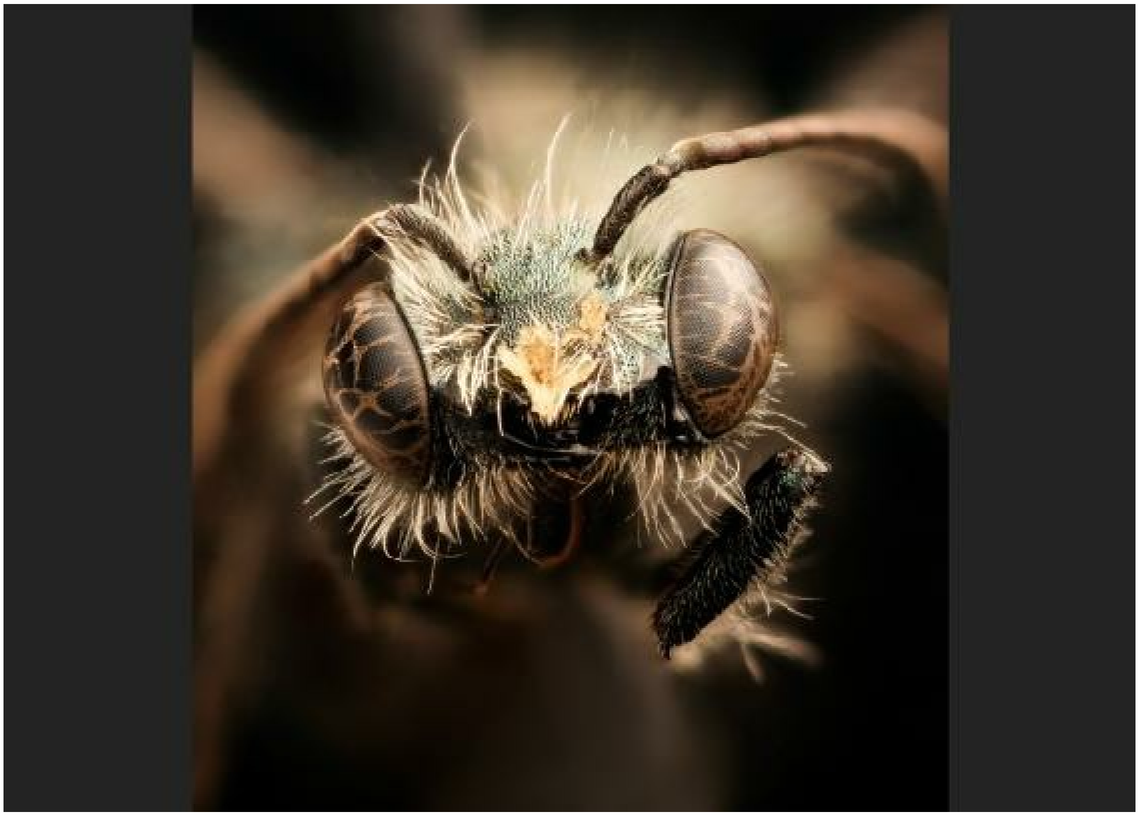
Another shot of *H. fulgida*, collected in Yosemite National Park, California.

USGS Bee Inventory and Monitoring Lab

3. 

Dianthidium singulare glues rocks together to make little houses for its eggs. The lab calls it a “boss looking bee”, and it’s hard to disagree.

USGS Bee Inventory and Monitoring Lab

4. 

The lab says this mason bee *Osmia subarctica* is a terrible specimen, but it has photographed beautifully.

USGS Bee Inventory and Monitoring Lab

Cassini comedown

NASA/Joel Kowsky

It is finally over. The Cassini mission this month dived into Saturn's atmosphere, destroying itself. In this photo, Cassini programme manager Earl Maize packs up his workspace at mission control in the Jet Propulsion Laboratory in Pasadena, California. on 15 September.

They grow up so fast

Online Tracking of Arabidopsis Root

Arabidopsis thaliana, or thale cress, is widely used as a model organism in labs. Daniel von Wangenheim of the Institute of Science and Technology Austria in Klosterneuburg won first place in the Nikon Small World in Motion Photomicrography Competition for this remarkable time-lapse video of the root tip of one *A. thaliana* plant growing.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22741

Comments

Comments

There are currently no comments.

Europe’s Joint Research Centre, although improving, must think bigger

External report criticizes lack of exploratory research.

03 October 2017

Sean Gallup/Getty

Europe’s Joint Research Centre first raised awkward questions about diesel car emissions.

The European Union’s Joint Research Centre (JRC) uses the label EU Science Hub now. Whether the rebranding will increase its profile is one

question. What science gets done inside this hub is another. In response to that query, there is some positive news. It is doing what it should be, and doing it well: collecting scientific and technical evidence in support of EU policies. That's according to the report of an external evaluation released this week. Furthermore, EU research commissioner Carlos Moedas praised the JRC at its annual public meeting on 26 September for contributing to the interminable struggle to counter false information and communicate science effectively to a sceptical public.

The JRC employs more than 2,000 scientists, who generate or collate a constant feed of information for authorities and politicians. In theory, this helps to support evidence-based policies — from the old chestnuts of genetically modified (GM) crops and nuclear safety to the ongoing refugee crisis, for which it holds a repository of relevant information and reliable statistics. Yet most of this work fails to reach public attention. For example, staff in the JRC transport section had worked out and published evidence that car makers were manipulating diesel-emission data years before the public scandal over Volkswagen finally broke in 2015.

The JRC celebrates its 60th anniversary this year. It has become a complex beast, operating at six sites in five EU countries, with a budget this year of €372 million (US$437 million). It was originally set up as a nuclear research organization, but widened its remit over the decades, adding institutes. Twenty years ago, it morphed into a centre with an explicit mission to provide support for a wide range of EU policies. But by that time it had lost its way, and tough reforms were introduced. A 2009 evaluation led by former UK government science adviser David King concluded that it was carrying out its new remit well, but criticized it for doing too little independent research of the type required to attract and keep the best scientists.

The new report, headed by the former Irish government science adviser Patrick Cunningham, echoes this call. It acknowledges how rapidly the centre has broken out of its much-criticized institute-based silos to restructure thematically into cross-site departments, such as energy and health, which more directly mirror policy areas. It also notes that the JRC has significantly increased its presence in the world's top-cited literature. But it says that the centre still does too little exploratory research — such research engages only

3.5% of JRC staff, well below the target of 10% that it set itself in 2015.

Why has it struggled? Although it has established partnerships with European universities and research institutes, and aided the exchange of scientists, many JRC researchers have different motivations from those of colleagues in universities. There is much satisfaction in contributing to policies that influence the lives of people in the EU. But officials and staff must look again at their priorities. As well as keeping the JRC relevant, a wider focus on the cutting edge would allow it to flag up hot topics to policymakers earlier.

But what policymakers do with the information they receive from their science service is another matter entirely. EU policy on GM crops is notoriously weak — scientific evidence for their safety has failed to convince some countries, whose citizens viscerally reject the technology. And sometimes the EU's intrinsic political weakness can block the implementation of its science-based policies. After all, the European Commission and EU member states ignored the findings on diesel emissions, and acted only after regulators in the United States cracked down.

Journal name:
Nature
Volume:
550,
Pages:
8
Date published:
(05 October 2017)
DOI:
doi:10.1038/550008a

Comments

Comments

There are currently no comments.

Bill & Melinda Gates Foundation

Make plans to eliminate cholera outbreaks

Governments must stop denying the occurrence of cholera and unite in long-term prevention strategies, says Anita Zaidi[1].

03 October 2017

As a medical student in Karachi in the 1980s, I saw cholera all the time. We had a dedicated diarrhoea ward in the hospital, and if there was an increase in diarrhoea cases in children aged over 3, we knew we had a cholera outbreak. Over the past decades, the world has become much better equipped to fight cholera, yet the disease continues to spread across sub-Saharan Africa, Asia and the Caribbean.

In Yemen, cholera has killed more than 2,000 people and infected nearly 700,000 in the past 5 months alone, eclipsing the post-earthquake outbreak in Haiti. Haiti still battles with the disease 7 years after its reintroduction. Meanwhile, Somalia is experiencing its worst outbreak in five years. South Sudan continues to fight its worst outbreak since it gained independence in

2011. If nothing changes, cholera will continue to claim some 100,000 lives a year and afflict around 3 million people, many of them children.

This week, the World Health Organization (WHO) launches a campaign to eliminate cholera outbreaks by 2030. The plan could move countries beyond ad hoc reactions, to sustainable prevention.

The disease is caused by the bacterium *Vibrio cholerae* and spreads mainly through contaminated water. Infection usually causes no or mild symptoms, but in approximately one-tenth of cases it swiftly leads to watery diarrhoea, vomiting and cramps. Rapid loss of fluid can result in dehydration and death within hours. An oral rehydration solution that costs cents can reduce fatality from a high of 50% to under 1%. Every year, it still fails to reach tens of thousands of victims in time.

Clean water, improved sanitation and better access to treatment have been game-changing for much of the world, but cholera is still thought to be endemic in 69 countries, including most of sub-Saharan Africa.

In the twenty-first century, no one should die from this disease. We have treatments and prevention strategies that work, including sufficient cholera-vaccine stocks. We know where outbreaks are most likely to start. To spread, cholera needs estuaries, rivers or coastal waters that are contaminated with faeces, and susceptible people living nearby; it has clear patterns of recurrence. What we need to do is get there first.

What’s stopping us? One barrier is stigma. Many national and regional governments don’t want to admit that their territory harbours cholera. Rather than controlling it, they hide it. The stigma goes back hundreds of years, to when ships with sick passengers were not allowed to dock and people feared being put in quarantine. Now the fears are public anger and loss of economic opportunities. Many countries with known endemic cholera in Asia and Africa report to the WHO that they have no cases, and in the face of an outbreak do not request cholera vaccines. In 2010, during the massive floods in Pakistan, my colleagues and I saw hundreds of cases of acute watery diarrhoea in Sindh that we confirmed to be cholera in our laboratory, but national health officials told us to keep it quiet.

Too many countries act only after a crisis has emerged: then they request vaccine campaigns, set up makeshift cholera clinics and urgently mobilize supplies.

These tactics can quell an outbreak and dampen transmission in the short term, but they don't stop outbreaks from happening again. For that, governments must intervene preemptively to control cholera in places where it recurs frequently. Since the WHO cholera-vaccine stockpile was established in 2013, almost 13 million doses have been delivered. Millions more doses should have been requested.

To truly stop cholera outbreaks, countries must do two things: deploy vaccines where cholera is endemic and strengthen the infrastructure that provides clean water and good sanitation.

Events in Malawi give reason for optimism. In April this year, the country adopted a national plan to control and prevent cholera that directs vaccines to affected communities identified by geo-spatial mapping. More than 2 million citizens have been vaccinated ad hoc since 2015. The new plan, made possible by strong political commitment at the Ministry of Health, collates two decades' worth of information to better estimate cholera burden, identify hotspots and support early intervention. At the same time, Malawi is planning to strengthen water and sanitation infrastructure. Experts are hopeful that this will reduce the country's cholera burden to its lowest level in years.

Similarly, the WHO Global Task Force on Cholera Control is launching a renewed strategy to eliminate cholera outbreaks worldwide. Unlike past efforts, this plan goes beyond responding to cholera flare-ups: it encourages countries to invest in protecting people from cholera over the short and long term.

The success of the WHO's plan ultimately depends on the commitment of governments worldwide. All governments, whether or not they are directly affected by cholera, must unite and increase their political and financial investment in cholera prevention and control.

The first cholera pandemic, in 1817, swept across South Asia, East Africa, the Middle East and Europe, claiming hundreds of thousands of lives. Back

then, we had no vaccine and a limited understanding of transmission. It is unacceptable that, now, in that pandemic’s 200th anniversary year, a disease we know how to fight remains out of control.

Journal name:
Nature
Volume:
550,
Pages:
9
Date published:
(05 October 2017)
DOI:
doi:10.1038/550009a

Comments

Comments

There are currently no comments.

Ethics of Internet research trigger scrutiny

Concern over the use of public data spurs guideline update.

03 October 2017

Matt Cardy/Getty

A Banksy artwork in Cheltenham, UK. Scientists tried to find the artist’s true identity using public data.

British graffiti artist Banksy is renowned for his anonymity. But that status was dented last year when researchers published a paper that cross-referenced the locations of Banksy’s street art with public information about people’s

addresses and likely movements (M. V. Hauge *et al. J. Spatial Sci.* **61,** 185–190; 2016). The team, led by academics at Queen Mary University of London, concluded that someone previously suspected to be Banksy probably was the secretive artist.

Because the study used public data, a university ethics committee said that the work was exempt from formal review — and informally advised academics that it would do no harm because a UK national newspaper had already identified the person in question as Banksy. But for some ethicists, the paper highlights growing concerns about the potential hazards of research that uses public data. “I think this study should never have been done,” says Jake Metcalf, a technology ethicist at the think tank Data & Society in New York City.

Metcalf is one of several academics calling for new guidelines to steer scientists through ethical quandaries in Internet research. The unprecedented availability of online data — together with tools to draw patterns from it, such as machine learning — is opening up research possibilities that outpace existing ethics frameworks around privacy, consent and harm, says Charles Ess, a research ethicist at the University of Oslo and a member of the Association of Internet Researchers. The association will discuss how to update its guidelines at its annual meeting on 19 October in Tartu, Estonia.

A flurry of similar initiatives is under way. Earlier this year, the SATORI project, funded by the European Commission, published recommendations on Internet research as part of an effort to standardize and update research-ethics guidelines. In September, the US National Science Foundation funded a US$3-million, 4-year study called PERVADE — of which Metcalf is a part — that aims to chart attitudes to data-research ethics, produce best-practice guidelines and create tools to assess the potential harms of such work. And some British universities are preparing their first guidelines on the ethics of Internet research, after the UK Research Integrity Office, a national advisory body, published non-binding recommendations about it last December.

Common themes among these efforts include rethinking what counts as ‘public’ data, the ethical use of social media and the need to consider a study’s potential harm to wider society, as well as to individuals. Many

countries have long-standing ethical checks for research that intervenes in human lives. But those principles, set up for medical and psychological studies, apply to research on human subjects, the definition of which often excludes Internet research, says Metcalf.

In the United States, for instance, studies using public data (which includes that purchased from a third party) generally do not count as human-subjects research because they don't access private, identifiable information about people. They don't need to be checked by an institutional review board (IRB) or require informed consent. Guidelines issued in 2013 add that researchers should sometimes consider seeking review — if a person incorrectly assumed that access to his or her public information was restricted, for example. But IRBs have no obligation to adopt these proposals, and different committees may come to different verdicts, says Metcalf.

Peter Hedges, head of the research-operations office at the University of Cambridge, UK, argues that even researchers who use information that is undeniably public, such as Twitter data, should review the ethics of their work. The SATORI guidelines advise that regulators and researchers should carefully consider whether publicly available information is actually private, and not fall back on simple classifications.

If someone's data are considered private and identifiable, that would usually mean obtaining their informed consent. But, in practice, such consent is often impossible to acquire for large-scale data studies, says Ess. And anonymizing data is difficult, because search engines can easily identify individuals from even small snippets of anonymized text or by cross-referencing them in multiple data sources. The SATORI guidelines recommend that researchers take precautions to ensure the anonymity of study participants, and Ess suggests that scientists can still, without too much effort, seek consent from anyone they explicitly quote in research papers.

When ethics committees do assess data studies, their viewpoint might be too narrow, says Ansgar Koene, an engineer and ethicist at the University of Nottingham, UK. They tend to consider the direct damage to an individual involved in research, rather than a project's potential to do widespread harm to society. That debate flared up in September when artificial-intelligence researchers at Stanford University in California posted a preprint of research

that predicted whether someone is gay from their photo; it used pictures sourced from an online dating site (see https://osf.io/zn79k). The study was approved by Stanford's IRB, but provoked condemnation from some advocacy groups for lesbian, gay, bisexual, transgender and queer (LGBTQ) people, which branded it dangerous. The study's lead author, Michal Kosinski, said the work aimed to protect people by exposing an existing threat from widely used technology. Kosinski and his colleague, Yilun Wang, discussed their results afterwards with representatives of the LGBTQ community, but Koene says that the discussion should have happened beforehand and the paper should have addressed their comments.

Computer science is a flashpoint for Internet-research ethics. Researchers in this field are not used to working with human study participants and often don't consider the ethical impact of their work, says Koene, who has surveyed approaches to ethics in different disciplines. A major concern, academics agree, is how companies use online data for research — much of which they have proprietary access to. In 2014, for example, Facebook altered users' newsfeeds without telling them, to study how this affected their emotions. A public backlash prompted Facebook to publish some details of its internal review process (M. Jackman and L. Kanerva *Wash. Lee Law Rev. Online* **72,** 442; 2016) — but there is little transparency overall about how this works, says Koene.

Researchers may not want to see their science slowed by formal ethical review, which can be time-consuming and opaque. Better ethics training is one solution, says Koene. But a failure to align data science with public perceptions of what is acceptable could generate a severe reaction, he warns. "The public will see us as no different from corporate or other special-interest groups pursuing a hidden agenda," he says.

Journal name:
Nature
Volume:
550,
Pages:
16–17
Date published:

(05 October 2017)
DOI:
doi:10.1038/550016a

Comments

Commenting is currently unavailable.

Gravitational wave detection wins physics Nobel

Rainer Weiss, Barry Barish and Kip Thorne share the 2017 prize for their work at LIGO to detect ripples in space-time.

03 October 2017

Left: Bryce Vickmark/MIT. Centre: Caltech. Right: Caltech Alumni Assoc.

Rainer Weiss (left), Barry Barish (centre), and Kip Thorne (right), who led work to detect gravitational waves.

Three physicists who had leading roles in the first direct detection of gravitational waves have won the 2017 Nobel Prize in Physics.

Rainer Weiss, at the Massachusetts Institute of Technology (MIT) in Cambridge and Barry Barish and Kip Thorne, both at the California Institute

of Technology in Pasadena, share the 9 million Swedish krona (US$1.1-million) award for their work at the US-based Laser Interferometer Gravitational-Wave Observatory (LIGO). In September 2015, LIGO picked up the deformations in space-time caused by the collision of two distant black holes.

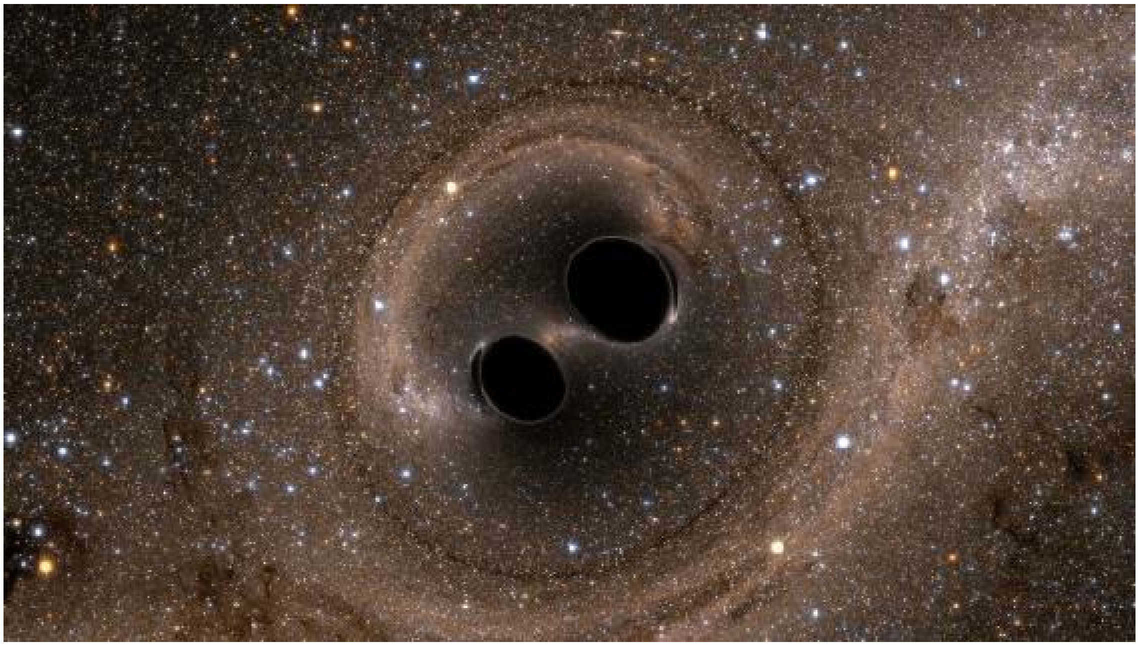
That discovery, which was announced in February 2016, opened up a new field of astronomy, in which scientists listen to the space-time vibrations emitted by some of the Universe’s most cataclysmic events. And it confirmed the existence of gravitational waves, which Albert Einstein had predicted a century before.

Weiss and Thorne are two of three physicists known as the Troika — the founders of LIGO’s giant twin detectors in Livingston, Louisiana, and in Hanford, Washington. The third troika member, Ronald Drever, died on 7 March this year. And Barish, who was LIGO director from 1997 to 2005, is widely credited with having transformed the collaboration from a chaotic endeavour to a well-oiled machine.

"I view this more as a thing that recognizes the work of about 1,000 people, a really dedicated effort that’s been going on for — I hate to tell you — as long as 40 years," said Weiss in an interview with the Nobel Committee just after winning the prize.

"We were all very happy for them to be recognized. They worked on this for decades," says Gabriela Gonzalez, a physicist at Louisiana State University in Baton Rouge, and a LIGO team member and former spokesperson for the collaboration. The Nobel prize can be awarded only to a maximum of three people, but the Nobel Committee noted the huge numbers of people who worked on LIGO in its press release.

Researchers had been widely expecting the committee to reward the team since last year's detection announcement. "I'm very happy that they got the right people," says Charles Misner, a general relativity theorist at the University of Maryland in College Park. Half of the Nobel prize has been awarded to Weiss, with the other half split between Barish and Thorne.



The SXS Project

A computer simulation of two black holes colliding, which generates gravitational waves.

Unimpeded motion

Few physicists doubted the existence of gravitational waves before the LIGO discovery. The distortions in space-time are an inevitable consequence of Einstein’s general theory of relativity, and propagate across the Universe almost unimpeded. In 1974, they were confirmed indirectly when researchers examined the radio flashes emitted by a pair of merging neutron stars; the shifts in the flashes' timing matched predictions of how gravitational waves would carry energy away from the event. That discovery was rewarded with the 1993 Nobel Prize in Physics.

But sensing the waves themselves was a monumental task. Even the most powerful deformations — those produced by collapsing stars or colliding black holes — would typically be tiny by the time they reached Earth. The waves detected in 2015 stretched and squeezed LIGO’s perpendicular 4-kilometre vacuum pipes by a fraction of a proton’s width, but that was

enough to noticeably shift out of sync the laser beams bouncing inside the pipes.

Physicists in the United States and the then-Soviet Union first proposed using laser interferometers to detect gravitational waves in the 1960s. Weiss made the first detailed calculations for how an interferometer would work in 1972. The idea seemed so far-fetched that even he was not sure it would work. “It might come to a junction in a year or so when we will decide it ain’t worth it,” he told science sociologist Harry Collins at the time[1].

Weiss, who was born in Germany in 1932, emigrated with his family to the United States in 1938 to escape from Nazism. He built his first prototype interferometer in the mid-1970s, soon followed by researchers in Europe — among them, Drever and his collaborators at the University of Glasgow, UK, and another group in Munich, Germany.

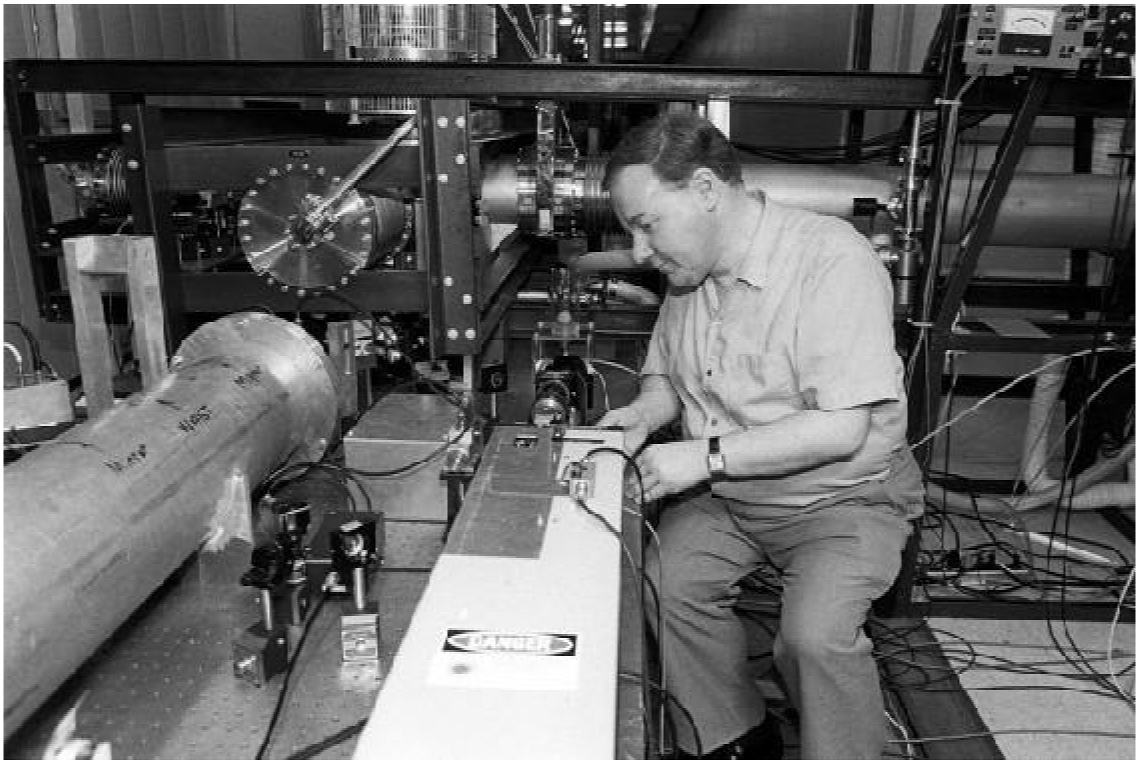
Thorne, born in Utah in 1940 to Mormon parents, specialized in general relativity and had also been developing ideas on the waves. At a conference in Washington DC in 1975, Thorne and Weiss shared a room in an over-booked hotel. During their conversations, Weiss convinced Thorne that interferometers were the right approach. Thorne, Weiss and Drever joined forces in the early 1980s, when it became clear that the US National Science Foundation would not fund two separate efforts, and the LIGO collaboration was born.

Dramatic turn-around

The troika did not always work smoothly and, at their own admission, did not possess the right skills for managing what was quickly becoming a vast operation. Things improved dramatically after Barish, who had been LIGO’s principal investigator since 1994, became director in 1997. Collins, who has closely studied the collaboration for decades, says that Barish turned LIGO into a ‘big science’ organization. “Without Barish turning things around, it would have collapsed,” he says.

LIGO initially struggled to get funded, but ended up being the largest and

most expensive experiment in the history of the US National Science Foundation. Its two nearly identical detectors first opened in 2002, with an admittedly scant chance of detecting anything during their first phase of data collection. The observatory shut down in 2010 for a major overhaul, and restarted in September 2015, three times more sensitive than before.



Bob Paz/Caltech Archives

Ronald Drever was one of the original co-founders of the LIGO project; he died in March 2017.

Researchers were cautiously optimistic of a discovery within a few years. But the Universe was kind to LIGO, providing a dramatic event for it to record on 14 September, while the interferometers were still being calibrated, days before their official science run was due to start. Since then, LIGO has detected at least three other gravitational-wave events — the most recent also spotted by Virgo, a similar interferometer near Pisa, Italy.

The LIGO team benefited from significant research efforts in other countries.

Germany and the United Kingdom have contributed funding and research, and GEO600, a smaller interferometer near Hannover, Germany, is the main test-bed for technologies that are implemented on its larger cousins in the United States.

The three winners have other strings to their bows: as well as working on LIGO, Weiss was a leading scientist in the Cosmic Background Explorer (COBE), a NASA probe that in the 1990s produced the first map of the cosmic microwave background, the ‘afterglow’ of the Big Bang. (Two other COBE researchers shared the physics Nobel in 2006.)

Thorne, who has spearheaded theoretical studies of gravitational waves, also helped to conceive the original idea for the plot of the 2014 film *Interstellar*, on which he was an executive producer. And before joining LIGO, Barish worked on neutrino experiments at the Fermi National Laboratory in Batavia, Illinois and elsewhere. He has also led the design of a proposed International Linear Collider.

Thorne and Weiss were generally considered shoo-ins for the Nobel. Before Drever’s passing last March, the troika raked up almost every prize there was for them to win, including the $3-million Special Breakthrough Prize in Fundamental Physics; the $500,000 Gruber Foundation Cosmology Prize; the $1.2-million Shaw Prize in Astronomy; and the $1-million Kavli Prize in Astrophysics.

Journal name:
Nature
Volume:
550,
Pages:
19
Date published:
(05 October 2017)
DOI:
doi:10.1038/nature.2017.22737

Comments

Commenting is currently unavailable.

Risk of human-triggered earthquakes laid out in biggest-ever database

Geologists track hundreds of quakes caused by people and the projects that set them off.

02 October 2017

Chris McGrath/Getty

A 7.8-magnitude earthquake that hit Nepal on April 30, 2015, has been linked by some to groundwater pumping.

From mining projects to oil and gas operations, human activity has set off

earthquakes around the world and in many geological settings. Research now highlights how big these quakes can get — and how little scientists agree on which ones are caused by people.

The Human-Induced Earthquake Database, or HiQuake, contains 728 examples of earthquakes (or sequences of earthquakes) that may have been set off by humans over the past 149 years. Most of them were small, between magnitudes 3 and 4. But the list also includes several large, destructive earthquakes, such as the magnitude-7.8 quake in Nepal in April 2015, which one paper linked to groundwater pumping[1].

Miles Wilson, a hydrogeologist at Durham University, UK, and his colleagues describe the database in a paper set to be published on October 4 in *Seismological Research Letters*[2]. The scientists say that HiQuake is the biggest, most up-to-date public listing of human-caused quakes ever made. By bringing the data together in this way, they hope to highlight how diverse induced quakes can be — and help society to understand and manage the future risk.

Earth-shaking activity

HiQuake began in 2016, when the Dutch Petroleum Society (NAM), an oil and gas company based in Assen, funded a team of researchers at Durham and at Newcastle University, UK, to collect examples of induced earthquakes. NAM drills in the Groningen gas field in the Netherlands, where it has set off many small earthquakes.

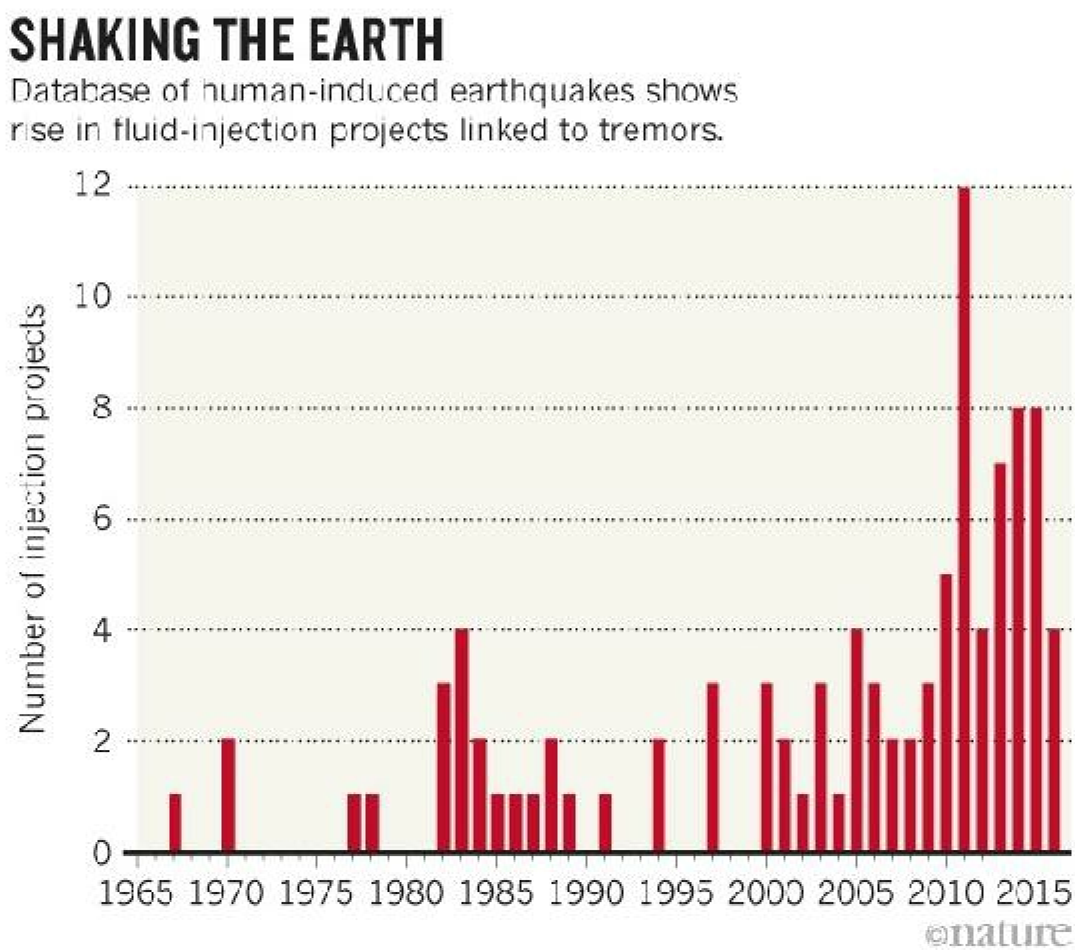
Wilson's team trawled through sources including scientific papers and media accounts to come up with its 728 events. When a single project, such as a wastewater-injection well, set off more than one quake, the researchers counted those as a single event. Further details appear in *Earth-Science Reviews*[3].

The result is a database in which the earliest entry dates to 1868, with a quake triggered by an Australian coal-mining operation. Of the 728 events, 271 (37%) are linked to mining — often from tunnel collapses. About 23% are

linked to water piling up behind a dam and 15% to conventional oil and gas development. Just 4% are linked to hydraulic fracturing, or fracking, for oil and gas. Some of the more unusual cases involve quakes triggered by the building of heavy skyscrapers or by an underground nuclear-bomb test.

Mass movement

In HiQuake, the fastest-growing quake-inducing activity in the database is the injection of wastewater back into the ground by oil and gas operations (see 'Shaking the earth'). The process that can increase stress on buried geological faults and cause them to generate small earthquakes. The number of these projects spiked in the early 2010s, at the height of wastewater-injection in Oklahoma and other parts of the central United States.



The largest event in the database is the magnitude-7.9 earthquake that struck in Sichuan, China, in 2008, which some have linked with the filling of a nearby reservoir[4]. Wilson says his team was initially startled to see quakes that large proposed as human-induced. But in retrospect, he says, “we probably shouldn’t be surprised by any anthropogenic cause”. All the projects linked to earthquakes — whether blasting a mining tunnel, injecting wastewater or pumping groundwater — involve moving mass around on Earth’s surface in ways that can nudge already-stressed faults.

The scientists found a relationship between the volume of material moved — such as the size of the reservoir filled before the Chinese quake — and the magnitude of the largest linked earthquake that followed. No such relationship was seen with factors such as dam height or reservoir area. The researchers suggest that limiting the amount of material moved in a construction project could help to minimize any quakes triggered.

Judgement calls

All possible instances of induced quakes were included “without regard to plausibility”, writes the team, because of the difficulty involved in deciding what constitutes absolute proof that an earthquake was caused by human activity. But that could mislead people about the real hazard from induced quakes, says Raphaël Grandin, a geophysicist at the Institute of Earth Physics in Paris. “When you put a dot in the database, and a scientific reference behind it, then you may lead the non-expert to think that the earthquake was caused by humans,” he says. Such a listing might hide scientific uncertainty, as with the Chinese quake: despite the paper linking it to reservoir filling, many seismologists do not believe it was triggered by human activity[5].

Susan Hough, a seismologist at the US Geological Survey in Pasadena, California, says she understands why the HiQuake team included all possible instances of induced quakes. “I suspect the authors were unwilling to pass judgement on published studies, which I consider a reasonable decision,” she says. “If you start down the road, where do you stop?”

Wilson agrees. “Any judgement calls we leave to users,” he says.

Over time, HiQuake should become more useful as researchers add examples and references to its entries, says Gail Atkinson, a seismologist at the University of Western Ontario in London, Canada, who leads a Canadian collaboration to study induced seismicity.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22693

Comments

Comments

There are currently no comments.

Discoveries have awkward first dates

Fuzzy timings over a plate-tectonics anniversary highlight the rolling nature of scientific discovery.

02 October 2017

Archive of Alfred Wegener Institute

Alfred Wegener first suggested the idea of continental drift which led to the theory of plate tectonics.

This week, the Geological Society in London will mark the 50th anniversary

of plate tectonics — the theory that describes the workings of Earth, how earthquakes strike, and why volcanoes happen. Or will it?

The timing of the anniversary is disputed. After all, this journal published its own 50th anniversary commemoration of plate tectonics 4 years ago (*Nature* **501,** 27–29; 2013). Columbia University's Lamont–Doherty Earth Observatory in New York celebrated last May. Confused? Blame the rolling nature of scientific discovery. Plate tectonics did not spring into existence fully formed, Athena-like, on a particular day in a particular year.

No doubt aware of this, the London conference, although billing itself as "Plate Tectonics at 50", pins next week more cautiously: as a commemoration of the "advent of the paradigm" — the arrival of the model of the theory.

Coming up with the modern theory of Earth involved sparks of insight from many different researchers, working in different laboratories on different continents. Most of the resulting papers were published in the 1960s, many of them in *Nature*.

In September 1963, Frederick Vine and Drummond Matthews described how stripes of changing magnetism on the sea floor represented the spreading of new oceanic crust away from the ridge where it was born (F. J. Vine and D. H. Matthews *Nature* **199,** 947–949; 1963). This was the crucial insight that nailed the concept of sea-floor spreading, which had been hinted at in the 1950s, when oceanic mapping by Marie Tharp and Bruce Heezen revealed a mountainous rift, and so this is the paper that *Nature* editors choose to commemorate in plate-tectonics anniversaries. Fast-forward four years, and Dan McKenzie and Robert Parker publish the first complete description of how crustal plates move around on the surface of the sphere (D. McKenzie and R. L. Parker *Nature* **216,** 1276–1280; 1967), the paper that the Geological Society is now celebrating.

Of course, Vine, Matthews, McKenzie and Parker were far from alone. In the 1960s, plate tectonics was such a fecund, fast-moving field that it involved several instances of simultaneous discovery. In early 1967, as McKenzie was developing his ideas of rigid-plate motions, he looked at a conference abstract by colleague Jason Morgan and decided not to attend the talk. As it

turns out, Morgan veered from the text of his abstract and instead described ideas of plate motions that were eerily like McKenzie's. Later that year, McKenzie sent off his manuscript to *Nature* — and, when he realized that Morgan was about to publish similar ideas, he asked the journal to delay his own paper in order to give Morgan the credit. *Nature*'s editor, John Maddox, sent a telegram back saying that the issue had already been typeset, so there would be no delay. Who has not skipped an event, only to have that affect their careers for years to come?

But back to the question of anniversaries. Popular interpretations of scientific history are biased towards the single great discovery by a single great person — and they are more easily commemorated in an anniversary. But most discoveries are much more nuanced and communal. Charles Darwin would not have published his ideas of evolution by natural selection when he did, had he not been prompted into it by the similar thoughts of Alfred Russel Wallace. Albert Einstein relied on the work of friends and colleagues to develop his general theory of relativity.

Similar broad revolutions are unfolding today. Despite all the bitterness and infighting over who invented the CRISPR–Cas9 gene-editing technique, the fact remains that a large number of very bright scientists made enormous advances quickly by playing off one another. Just as in the heyday of plate tectonics, one gene-editing breakthrough inspired the next, until biologists were brimming with publications. Historians may one day bicker about which CRISPR paper to celebrate on the 50th anniversary of the technique, but science as a whole is much better off than it was before.

And so, we could celebrate a 1963 publication on the magnetism of the sea floor, or a 1967 paper on the geometry of spherical rotations, or even the entirety of the dawning of plate tectonics. But when was that? Was it in 1912, when Alfred Wegener came up with the idea of continental drift? Or was it decades later, when his ideas were finally transformed into the concept we now know as tectonics? Much of that delay might trace to US researchers viciously opposing his ideas, as historian Naomi Oreskes described in *Plate Tectonics* (Westview Press, 2001). But after the slow start, Earth scientists in the 1960s were quick to embrace the data and theories that redrew almost every aspect of their field.

Such is the nature of discovery — incremental at times, fast-paced at others, occasionally derailing into pettiness. But it does nearly always move in the right direction. In these times of political uncertainty and global unrest, that is an accomplishment worth noting.

Journal name:
Nature
Volume:
550,
Pages:
7
Date published:
(05 October 2017)
DOI:
doi:10.1038/550007a

Comments

Commenting is currently unavailable.

Chinese scientists fix genetic disorder in cloned human embryos

A method for precisely editing genes in human embryos hints at a cure for a blood disease.

02 October 2017

Mauro Fermariello/SPL

Fixing the genetic mutation linked to β-thalassaemia would save affected individuals from having to get life-sustaining blood transfusions.

A team in China has taken a new approach to fixing disease genes in human embryos. The researchers created cloned embryos with a genetic mutation for a potentially fatal blood disorder, and then precisely corrected the DNA to

show how the condition might be prevented at the earliest stages of development.

The report, published on 23 September in *Protein & Cell*[1], is the latest in a series of experiments to edit genes in human embryos. And it employs an impressive series of innovations, scientists say. Rather than replacing entire sections of genes, the team, led by Junjiu Huang at Sun Yat-sen University in Guangzhou, China, tweaked individual DNA letters, or bases, using a precision gene-editing technology developed in the United States[2].

Huang's team is also the first to edit out the mutation responsible for a 'recessive' disease: one caused by having two faulty copies of a gene. Because it would be difficult for researchers to find dozens of embryos that all have this rare double mutation, the team worked around this roadblock by developing embryonic clones from their patient's skin cells.

"I thought, 'Why would they do cloning?' Then I read the paper, and thought, 'Wow, that's fascinating,'" says Shoukhrat Mitalipov, a reproductive-biology specialist at the Oregon Health and Science University in Portland who pioneered human cloning and also works on gene editing in embryos. "I would not have thought to do this."

Scientists around the world have now published eight studies reporting gene editing in human embryos, five in the past two months. None have permitted the embryos to grow beyond 14 days, and the research has had different purposes: some to test gene-editing technologies; others to edit various disease-related genes; and some to unravel the mechanisms behind early embryonic development. Huang's team led the first report, published in April 2015, in which they used the CRISPR–Cas9 enzyme complex to snip chromosomes at specific locations, excise DNA and replace it with other genetic material[3].

Precision editing

In the latest study[1], Huang's team used 'base editing', a modification of CRISPR–Cas9. It guides an enzyme to specific gene sequences, but does not

cut the DNA. Instead, the Cas9 enzyme is disabled and tethered to another enzyme that can swap out individual DNA base pairs. So far, this technique can convert guanine (‘G’) to adenine (‘A’), and cytosine (‘C’) to thymine (‘T’). Hundreds of genetic diseases are caused by single-base changes, or ‘point mutations’, and so editing of this sort at the embryonic stage could potentially stave off such conditions.

Huang’s team chose one mutation common in the Chinese population: a switch from an A to a G at a certain spot in the *HBB* gene, which can lead to β-thalassaemia, a recessive blood disorder associated with severe or fatal anaemia. Researchers generally source embryos from *in vitro* fertilization (IVF) clinics, but it’s rare for these facilities to have embryos with two copies of the same rare mutation. So Huang’s team found a person with the blood disorder, extracted their skin cells and used cloning techniques to develop embryos with the same genetic makeup.

The researchers reported that in 8 of 20 cloned embryos, they were able to convert the errant G back into an A in one or both copies of the gene. (Repairing only one copy might be enough to cure a recessive disease.) That rate is too low for the technique to be considered for clinical use, but the efficiency was high relative to that achieved in other gene-editing studies. “The repair rate is pretty good, and certainly promising,” says Gaetan Burgio, a geneticist at the Australian National University in Canberra. “Our study opens new avenues for therapy of β-thalassaemia and other inherited diseases,” says Huang.

But scientists caution that not all cells in the eight embryos were fixed. Such embryos are ‘mosaic’, meaning that they have a patchwork of cells with different genetic make-ups, which is potentially dangerous. “It looks like solid work, but highlights that the problem of mosaicism remains a challenge for any form of gene editing in the human embryo,” says Dieter Egli, a stem-cell biologist at Columbia University in New York City.

Unintended consequences

Some scientists also question whether Huang’s team looked thoroughly

enough for unintended genetic changes, called off-target effects, that might have been caused by the base-editing procedure, although the authors reported that none were found.

Huang says future experiments will be more comprehensive, but that this first study was a successful proof of principle that the base-editing technique can be used to correct a disease mutation in a human embryo. It may be that conventional CRISPR–Cas9 cannot fix embryos when both copies are faulty, although this isn't yet clear. In August, for instance, Mitalipov's team reported using CRISPR–Cas9 to repair a mutation in a gene that can cause a potentially deadly heart disorder, by using the other, healthy copy of the gene as a template[4].

In the future, Huang says, he plans to ask for oocytes and sperm from donors who have one mutated copy of the gene — and so are unaffected by the condition, but are carriers of the disease — and use these to produce embryos. Some of those embryos would have two mutated copies, and some one, but Huang wants to edit both types. That raises the contentious idea that gene editing might be used not only to prevent severe disease, but also to eliminate the chance of people becoming carriers of the disorder. "Base editing can repair the mutant site and block it from being passed on to the next generation," he says.

Journal name:
Nature
Volume:
550,
Pages:
15–16
Date published:
(05 October 2017)
DOI:
doi:10.1038/nature.2017.22694

Comments

Comments

There are currently no comments.

Medicine Nobel awarded for work on circadian clocks

Jeffrey Hall, Michael Rosbash and Michael Young unpicked molecular workings of cells' daily rhythms.

02 October 2017

Nora Tam/SCMP

Michael Rosbash (left), Jeffrey Hall (centre) and Michael Young (right) have been recognized for their work on circadian clocks.

Three scientists who studied the workings of organisms’ inner circadian clocks have won the 2017 Nobel Prize in Physiology or Medicine. Jeffrey Hall and Michael Rosbash, both at Brandeis University in Waltham, Massachusetts, will split the award of 9 million Swedish kronor (US$1.1

million) with Michael Young at Rockefeller University in New York City.

Beginning in the 1980s, the three researchers isolated and characterized a gene in fruit flies, *period*, that encodes a protein that builds up each night, only to be broken down the following day. In subsequent work, the trio, as well as other scientists, unpicked the molecular regulation of the *period* gene (and the protein that it encodes, called PER) and identified additional components of the circadian clock.

All multicellular organisms possess circadian clocks, and human versions of the genes that comprise their clocks have been implicated in sleeping disorders and other medical conditions.

Rosbash, Hall and Young have been collecting awards together for the past five years. In 2013, for example, they shared the Shaw Prize in life science and medicine, then worth US$1 million. That has set the expectation that a Nobel might be around the corner, says Herman Wijnen, who studies circadian clocks at the University of Southampton, UK and was a postdoc in Young's lab. "This has been one that people have been looking out for," he says. "It's been settled in the scientific community that this is the trio."

But Young says he was so stunned by the news that he could barely get his shoes on the morning he found out. "I'd go and I'd pick up the shoes, and then I'd realize I need the socks," he said during a press conference. "And then I realized I needed to put my pants on first." The award took Rosbash by surprise too, says Thomas Perlmann, secretary of the Nobel Assembly, which selects the prizewinners. "I first got hold of Michael Rosbash, and he was silent," says Perlmann. "And then he said, 'you are kidding me'."

The work has its roots in genetic screens performed by physicist and molecular biologist Seymour Benzer and geneticist Ronald Konopka, who together found fruit-fly mutants with abnormal hatching rhythms. (Benzer died in 2007; Konopka in 2015.) At the time, the idea that behaviour could have a genetic basis was controversial, says Wijnen. Years later, two teams — Young leading one, Hall and Rosbash working together to lead another — would clone the genes responsible. "That really changed the situation," says Wijnen. "Since then, it has become clear how conserved this system is and how conceptually it could work."

The competition between the two teams — each with ambitions to be first to identify the gene — was initially intense, says Charalambos Kyriacou, a behavioural geneticist at the University of Leicester, UK, who worked with Hall in the late 1970s. “As they got older they mellowed,” he says. “They’re all good buddies now.”

Subsequent work detailed how abundance of the PER protein peaks at night and then declines during the day. Researchers gradually pieced together a model in which the accumulation of PER serves as a signal that represses expression of the gene that encodes it. This type of negative feedback loop would become a prevailing theme in the study of circadian rhythms, as researchers identified additional loops and clock proteins over the years.

Joseph Takahashi at the University of Texas Southwestern Medical Center in Dallas and others extended the work from fruit flies to mammals, and showed that the system is remarkably conserved across species. Researchers have since tied the circadian clock to many aspects of mental and physical well-being. “We expose ourselves to inappropriate light, we travel across time zones, we do shift work,” says Wijnen. “And all of that is negatively impacting our health.”

The links between the circadian clock and human health are so pervasive that medical schools should increase their focus on chronobiology, says Martha Merrow, chair of medical psychology at Ludwig Maximilian University of Munich in Germany. This could be either as a speciality in its own right, or incorporated into medical training in other specialities such as endocrinology or rheumatology, she adds. A Nobel prize may give Merrow and her colleagues added force to make that case. Merrow learnt of the news before heading into an administrative meeting. “I was so breathless, I could hardly go into my meeting,” she says. “It’s just a fantastic choice. It will be great for our field.”

Journal name:
Nature
Volume:
550,
Pages:
18

Date published:
(05 October 2017)
DOI:
doi:10.1038/nature.2017.22736

Comments

Commenting is currently unavailable.

Nature News

周日, 22 10月 2017

Nature News

[周日, 22 10月 2017]

- **Nature News**

Nature News

Nature is a weekly international journal publishing the finest peer-reviewed research in all fields of science and technology on the basis of its originality, importance, interdisciplinary interest, timeliness, accessibility, elegance and surprising conclusions. Nature also provides rapid, authoritative, insightful and arresting news and interpretation of topical and coming trends affecting science, scientists and the wider public.

- ## The Human Cell Atlas: from vision to reality [周三, 18 10月 08:00]
  As an ambitious project to map all the cells in the human body gets officially under way, Aviv Regev, Sarah Teichmann and colleagues outline some key challenges.
- ## Top Chinese university to consider social-media posts in researcher evaluations [周三, 18 10月 08:00]
  Controversial policy means mainstream media are starting to rival rigorous academic publications in some universities in China.
- ## Mysterious particles spotted in Saturn’s atmosphere [周三, 18 10月 08:00]
  Source may be dust shed by planet’s iconic rings, according to data from NASA's doomed Cassini probe.
- ## Efforts to save leading Hungarian university hit hurdle [周三, 18 10月 08:00]
  US-registered Central European University faces another year of uncertainty over whether it can continue to operate in Hungary.
- ## Sleeping sickness can now be cured with pills [周三, 18 10月 08:00]
  Researchers seek approval from regulators for this quicker, easier treatment.
- ## Self-taught AI is best yet at strategy game Go [周三, 18 10月 08:00]
  Artificial-intelligence program AlphaGo Zero trained in just days, without any human input.
- ## Science must examine the future of work [周三, 18 10月 08:00]
  As automation changes employment, researchers should gather the evidence to help map the implications.
- ## Blue is in the eye of the bee-holder [周三, 18 10月 08:00]
  Flowers have evolved an ingenious way to attract pollinators.
- ## Epic star collision, asteroid fly-by and journal resignations [周三, 18 10月 08:00]
  The week in science: 13–19 October 2017.
- ## New definitions of scientific units are on the horizon [周三, 18 10月 08:00]
  Metrologists are poised to change how scientists measure the Universe.
- ## The future of work [周三, 18 10月 08:00]

Digital technologies are upending the workforce. The right research can tell us how.

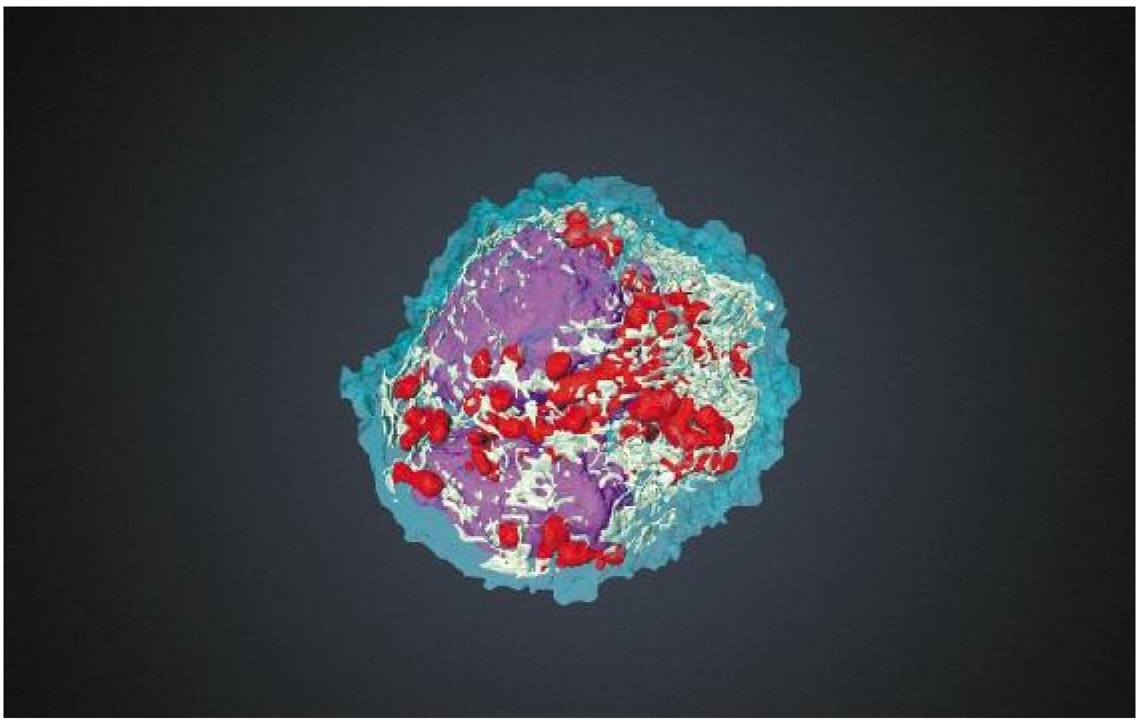
- **The shape of work to come** [周三, 18 10月 08:00]
  Three ways that the digital revolution is reshaping workforces around the world.
- **Lessons from history for the future of work** [周三, 18 10月 08:00]
  Global comparisons of previous social and economic upheavals suggest that what is to come depends on where you are now, argues Robert C. Allen.
- **The second Renaissance** [周三, 18 10月 08:00]
  Ian Goldin calls on scientists to help society to weather the disruptive transformations afoot.
- **Archaeology: The wonder of the pyramids** [周三, 18 10月 08:00]
  Andrew Robinson enjoys a volume rounding up research on the complex at Giza, Egypt.
- **Books in brief** [周三, 18 10月 08:00]
  Barbara Kiser reviews five of the week's best science picks.
- **History: Five millennia of Indian science** [周三, 18 10月 08:00]
  James Poskett applauds a show celebrating discovery on the subcontinent, from zero to the boson.
- **Federal funding: Stifled by budgets, not irrelevance** [周三, 18 10月 08:00]
- **Ornithology: Danish dairy farmer delivers data coup** [周三, 18 10月 08:00]
- **Open data: Spot data glitches before publication** [周三, 18 10月 08:00]
- **PhD students: living wage key to diversity** [周三, 18 10月 08:00]
- **PhD students: side jobs are no solution** [周三, 18 10月 08:00]
- **Breaking and entering** [周三, 18 10月 08:00]
  Escape is not an option.
- **Brazilian Amazon still plagued by illegal use of natural resources** [周二, 17 10月 08:00]
  Practices such as poaching and illegal logging are concentrated near inhabited areas and along rivers, study finds.
- **Give researchers a lifetime word limit** [周二, 17 10月 08:00]
  Brian C. Martinson imagines how rationing the number of publications a scientist could put out might improve the scientific literature.
- **Japanese research leaders warn about national science decline** [周二, 17 10月 08:00]
  Concern mounts over budget cuts and other changes that undermine basic science.
- **Reboot for the AI revolution** [周二, 17 10月 08:00]
  As artificial intelligence puts many out of work, we must forge new economic, social and educational systems, argues Yuval Noah Harari.

- **Eye in the sky offers clearest vision of Earth** [周一, 16 10月 08:00]
  The world’s latest carbon-monitoring satellite has advanced our understanding of how the planet functions. US politicians should take note.
- **Colliding stars spark rush to solve cosmic mysteries** [周一, 16 10月 08:00]
  Stellar collision confirms theoretical predictions about the periodic table.

The Human Cell Atlas: from vision to reality

18 October 2017

As an ambitious project to map all the cells in the human body gets officially under way, Aviv Regev, Sarah Teichmann and colleagues outline some key challenges.



Villani, A.-C. ET AL. SCIENCE 356, EAAH453 (2017); image Kathryn White; reconstruction James Fletcher

A new type of human dendritic cell recently discovered using single-cell RNA sequencing.

Our knowledge of the cells that make up the human body, and how they vary

from person to person, or throughout development and in health or disease, is still very limited. This week, a year after project planning began, more than 130 biologists, computational scientists, technologists and clinicians are reconvening in Rehovot, Israel, to kick the Human Cell Atlas initiative[1] into full gear. This international collaboration between hundreds of scientists from dozens of universities and institutes — including the UK Wellcome Trust Sanger Institute, RIKEN in Japan, the Karolinska Institute in Stockholm and the Broad Institute of MIT and Harvard in Cambridge, Massachusetts — aims to create comprehensive reference maps of all human cells as a basis for research, diagnosis, monitoring and treatment.

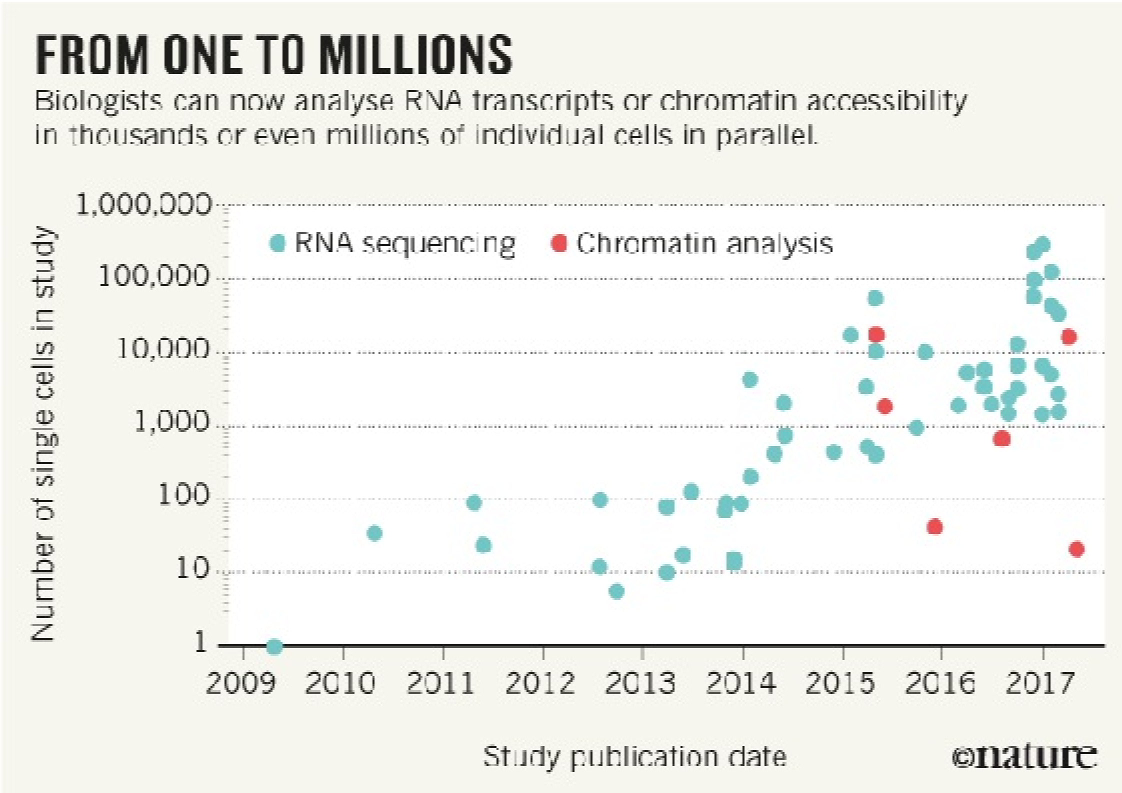
On behalf of the Human Cell Atlas organizing committee, we outline here some of the key challenges faced in building such an atlas — and our proposed strategies. For more details on how the atlas will be built as an open global resource, see the white paper[2] posted on the Human Cell Atlas website.

Cells have been characterized and classified with increasing precision since Robert Hooke first identified them under the microscope in the seventeenth century. But biologists have not yet determined all the molecular constituents of cells, nor have they established how all these constituents are associated with each other in tissues, systems and organs. As a result, there are many cell types we don't know about. We also don't know how all the cells in the body change from one state to another, which other cells they interact with or how they are altered during development.

Technology revolution

New technologies offer an opportunity to build a systematic atlas at unprecedented resolution. These tools range from single-cell RNA sequencing to techniques for assessing a cell's protein molecules and profiling the accessibility of the chromatin. For example, we can now determine the RNA profiles for millions of individual cells in parallel (see 'From one to millions'). Protein composition and chromatin features can be studied in hundreds or thousands of individual cells, and mutations or other markers tracked to reconstruct cell lineages. We can also profile multiple

variants of RNA and proteins *in situ* to map cells and their molecules to their locations in tissues.



Source: Svensson, V., Vento-Tormo, R. & Teichmann, S. A. Preprint at https://arxiv.org/abs/1704.01379 (2017)

We anticipate that the atlas will help researchers to answer key questions in diverse biological fields. In cellular taxonomy, it might enable the discovery and identification of cell types and molecular markers or signatures (a collection of genes, say, that characterize a specific cell type). In histology, it should enable researchers to relate tissue structure to the position of cells and molecules. Developmental biologists will be able to use it to track cell fate and lineage. Physiologists could characterize dynamic states, such as the cell cycle, and transient responses such as a T cell's reaction to a pathogen.

The atlas could also facilitate research on the molecular mechanisms of communication within and between cells. And it should allow biologists to compare cell types across species to better understand human evolution, and

to determine to what extent animal model systems and organoids reflect human biology.

Crucially, the atlas should help researchers to compare healthy reference cells to diseased ones in the relevant tissues — and so facilitate the development of better drugs and more accurate predictions of unintended toxicity. The atlas could also aid regenerative medicine — the process of replacing, engineering or regenerating human cells, tissues or organs to establish normal function. Key diagnostic tests, such as the complete blood count — a routine blood screen that provides crude counts of white blood cells, red blood cells and so on — would become vastly more informative if cell types and states could be identified with much finer granularity. Such information could, for example, help to diagnose blood cancer, autoimmunity or infection before clinical symptoms appear.

Early studies are already showing tremendous potential in all these areas. New cell types have been found in the brain[3–7], gut[8], retina[9] and immune system[10], and these discoveries have yielded new insight — into how the immune system[11] functions, for example, and into the dynamics of tumour ecosystems[12]. Yet, to take the next step — to build a human cell atlas that is truly useful — requires taking the long view and addressing various systemic and organizational challenges, as well as technical and scientific ones.

The challenges

Agree on scope. In light of the enormous complexity of the human body, and the rapid evolution of technologies for probing cells and tissues, and for analysing the data, we plan to build this resource in phases and generate reference maps at increasing resolution as the project progresses.

The first draft of the atlas will profile cells' molecular and spatial characteristics, capturing only those cell types that occur above a pre-specified rarity — ones that make up more than 1% of a sample, say. These cells will be obtained from major tissues from healthy donors, taking into account the genetic diversity, geographical location and person's age. Although disease will not be a focus of the first draft of the atlas, we plan to

look at some disease samples to compare them with healthy cell types.

The first draft will focus on tissues, not whole organs. Extremely rare cells may be missed, and sample sizes may be too small to fully reveal the links between cellular characteristics and human diversity. In later phases, the atlas could take on entire organs, include small cohorts of people (say, 50–60) with diseases of interest, gather bigger sample sizes and provide greater power to associate molecular variation with the underlying genetic diversity. A similar step-wise strategy was deployed in the Human Genome Project; even a partially assembled genome proved immediately useful to researchers, and human genetic variation in health and disease was tackled over several years after the full genome was sequenced.

The atlas will provide an important starting point for functional studies — for instance, those aimed at establishing the mechanistic links between cell states and disease. But such studies are themselves beyond its scope. Again, this parallels what happened with the Human Genome Project: studies of functional elements in the genome, which are ongoing, have relied on the reference sequence obtained through the project.

The atlas will aim to provide a detailed representation of molecules, cells, tissues, organs and systems, allowing researchers to zoom in and out to identify patterns and interactions at various levels of resolution. To this end, those compiling the atlas must establish how many cells to sample, which types of molecular features to analyse, how to assign cells to different categories and how to subdivide those categories. At the spatial level, they must decide how to sample complex anatomies and histologies. Lastly, they need to establish ways of connecting the various layers of cellular and spatial information from different samples to a single anatomical reference by developing what is termed a common coordinate framework.

To ensure the best use of resources, those involved in the initiative must agree on the desired resolution for each phase of the atlas. Researchers could, of course, try to pursue ever-rarer cell types, but potentially at ever-greater expense. In this respect, the Human Cell Atlas will pursue similar approaches to those used in human genetic studies that focus on variants present at a certain frequency. Here, geneticists have begun to tackle increasingly rare variants as technologies have advanced.

Be open and fair. To have maximum impact, the Human Cell Atlas must be an open resource, on many levels.

The project is already open to all interested participants who are committed to its values. Discussions about particular organs, tissues, technologies or computational approaches are running on more than a dozen Slack channels that anyone can join.

Wherever consent agreements allow, atlas data will be made publicly available in an open-source data-coordination platform as soon as possible, after they have been collected and have passed quality-control checks. All standards established to ensure the production of high-quality data, and any updates to those standards, will also be shared. The same goes for new technologies and computational methods resulting from the project.

Atlas data and analysis products will exist in multiple public clouds (currently, those hosted by Google, Amazon and Microsoft) to ensure that people with different preferred cloud environments can access them. Because computation will happen in the cloud, individual researchers will not need to download and store all the data or have access to their own high-performance computing power. Finally, in addition to the continual release of data and periodic formal data releases, publications interpreting the data will help to establish standardized approaches and disseminate the insights and value that can be gained from them.

As much as possible, the atlas must reflect the diversity of humans and human experience. The broad distribution of participating researchers, institutions and countries involved in the initiative will, in itself, help to ensure tissue diversity. The initiative currently includes members from 5 continents and more than 18 countries, including Japan, Israel, South Africa, China, India, Singapore, Canada and Australia.

Getting appropriate consent agreements and fostering public trust from the outset will also help efforts to obtain sufficient geographical, gender, age and genetic diversity in sampling. As part of the global initiative, an ethics working group will establish how best to obtain informed consent from sample donors, how the terms of that consent can be adhered to and how to protect the privacy of participants and donors appropriately. Various existing

projects involving human samples, such as the public-research project ENCODE (the Encyclopedia of DNA Elements), which aims to identify all the functional elements of the human genome, can provide guidance on this.

Procure samples appropriately. Obtaining tissue samples using standardized procedures, with appropriate consent and in a way that enables other researchers to know exactly where the sample came from is a complex endeavour. To access the diversity of human tissues needed, researchers will work with both fresh tissue from live donors and specimens obtained postmortem or from transplant organ donors.

We plan to learn from, and build on, pre-existing reliable procurement processes. Examples include those used in the Genotype-Tissue Expression Project (GTEx, a database and tissue bank designed to help researchers to gain insight into the mechanisms of gene regulation in humans) and the Cambridge Biorepository for Translational Medicine, a resource for multidisciplinary research projects for which fresh tissue is required.

Organize effectively. The Human Cell Atlas consortium is built on four distinct and interconnected pillars. Collaborative biological networks involve experts in biological systems or organs as well as in genomics, computation and engineering, working together to build maps of each tissue, system or organ. Several biological-network pilot projects have been formulated through grass-roots efforts in the Human Cell Atlas community. As well as revealing new biology and helping to build a collaborative international network, these activities are informing the community about how to structure sampling and conduct analyses for a full-scale cell atlas.

A technical forum involving genomics experts, imaging specialists and biotechnologists, is developing new technologies, and testing, comparing and disseminating existing ones. A data-coordination platform is being designed to bring researchers to the data by developing the software to upload, store, process and serve data. The platform also provides an open environment in which computational methods and algorithms developed by any interested group can be shared. Finally, an analysis garden involves computational biologists working together to develop sophisticated techniques for data mining and interpretation.

Activities across all areas are currently governed by a scientific steering group, the Human Cell Atlas organizing committee. Co-chaired by two of us (A. R. and S. A. T.), this includes 27 scientists from 10 countries and diverse areas of expertise. The committee establishes working groups (about 5 so far, consisting of about 5 to 15 members each) that tackle specific key areas. For instance, an analysis working group is crafting best practices for computational analysis through a community-wide process, including workshops and jamborees. The committee governs the data-coordination platform, including making all policy decisions and approving its overall plan.

Join the effort

Having a catalogue of genes at our fingertips has transformed research in human biology and disease. Similarly, we believe that the Human Cell Atlas will catalyse progress in biology and medicine. Descriptors such as ‘cell type’ and ‘cell state’ can be difficult to define at the moment. An integrative, systematic effort by many teams of scientists working together and bringing different expertise to the problem could dramatically sharpen our terminology, and revolutionize the way we see our cells, tissues and organs. We invite you to join the effort.

Journal name:
Nature
DOI:
doi:10.1038/550451a

Supplementary information

PDF files

1. HCA organizing committee (61K)

Comments

Comments

There are currently no comments.

Top Chinese university to consider social-media posts in researcher evaluations

Controversial policy means mainstream media are starting to rival rigorous academic publications in some universities in China.

18 October 2017

Wang Zhao/AFP/Getty

News articles written by researchers at some Chinese universities will now be considered in evaluations.

One of China's most prestigious universities plans to give some articles in

newspapers and posts on major social-media outlets the same weight as peer-reviewed publications when it evaluates researchers.

The policy has sparked a vigorous debate among Chinese academics. Proponents say it will encourage researchers to engage with the public, but many are concerned that it will promote those who toe the party line established by China’s strictly censored media and social media, at the expense of more highly qualified researchers. Critics also say the system could be manipulated to inflate a researcher’s impact, for example by artificially boosting page views.

Zhejiang University in Hangzhou announced the policy on its WeChat page on 15 September, saying that it would mainly apply to the humanities and social sciences. But Chinese researchers say the move could influence science as well, by giving a hiring and promotion advantage to politically minded scientists.

“You do not need to be good scientist, you do not need to publish good science papers,” says one biologist at a prominent Beijing-based university who requested anonymity. He is concerned that the policy could alter evaluations at China’s main grant agency, the National Natural Science Foundation of China (NSFC). “If they open the Pandora’s box, the NSFC might change its policy as well,” he says. The agency's head, Yang Wei, says it will do no such thing. NSFC grants are given solely “according to the judgement of peer reviewers”, he says.

Viewing figures

The Zhejiang policy sets specific criteria: articles have to be original, written by the researcher and at least 1,000 words long; they need to be picked up by major news outlets and widely disseminated through social media; and they need to have been seen by a large number of people. The policy requires an article to be viewed more than 100,000 times on WeChat, China’s most popular instant-messaging service, or 400,000 times on news aggregators such as Toutiao. Articles that meet the criteria will be considered publications, alongside papers in peer-reviewed journals.

The university has also established a publication hierarchy, with official media outlets such as the *People's Daily* considered most important, regional newspapers and magazines occupying a second tier, and online news sites such as Sina, NetEase or Sohu ranking third.

Ping Fu, who researches library science at Central Washington University in Ellensburg, is concerned that the policy will blur the distinction between peer-reviewed academic publications and popular writing. This could affect the top levels of scholarship in China, he says. Liu Jin-ping, a biologist at Hainan University in Haikou, also worries that the policy will give prominence to stories that "flatter the government". Some academics will aim to "become Internet stars" so they can be promoted, he wrote on his blog.

Full credit

Lin Boqiang, an energy-policy and climate-change researcher at Xiamen University who has published some 800 media commentaries, thinks researchers should get credit for this work. He "criticizes government policy all the time" and would never write something incorrect to please political powers, he says: "Our reputation is on the line."

But both Liu and Lin are concerned the system could be gamed, either for self-interest or with political motivation. Lin says these articles should not be considered equal to academic publications. "Other universities will do this," he says. "I hope they do it in a more sophisticated way."

Zhejiang University refused to answer *Nature*'s questions about the policy, but it posted a statement on its homepage in response to the controversy, saying that the commentaries in the mainstream media will supplement and not replace peer-reviewed journals: "This policy is to explore more forms of exposure of research, especially for humanities and social sciences, and the assessment will be made by a strict panel review, which will not lower the academic standard."

Grant committees in other countries encourage researchers to do public outreach, but the Zhejiang policy is rare in how it ranks such efforts for

researcher evaluation. Jilin University in Changchun announced a similar policy in August.

Balancing act

Glen Peters, a climate-policy researcher at the Center for International Climate Research in Oslo, agrees that researchers should be acknowledged for important contributions to public understanding, but he says the challenge in giving scientists credit for public outreach is how to measure its quality and impact against those of conventional journal publications. “If you don’t get the weighting right, then incentives could be perverted and lead to bad outcomes, such as poor quality and political bias,” he says. “The potential is high, but so are the risks.”

One journalist at China’s *Legal Daily* has questioned whether such a policy is legal. It was drafted by the university’s propaganda department, part of the Communist Party of China. According to the laws that govern universities, evaluation decisions are supposed to be made by university administrative departments or faculty committees, writes the journalist.

Some scientists contacted by *Nature* are confident that this initiative will not affect science. But others see it as part of the government’s attempts to control information. There is already concern about Chinese President Xi Jinping’s efforts to align education with communist values and to control what is written by journalists or on social media. Scientists say that bans on Google, Google Scholar and other Internet-based technologies hamper their ability to stay in touch with international peers. “There are certainly many layers of concern,” says one environmental scientist who did not want to be named for fear of damaging relationships with Chinese colleagues.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22822

Comments

Commenting is currently unavailable.

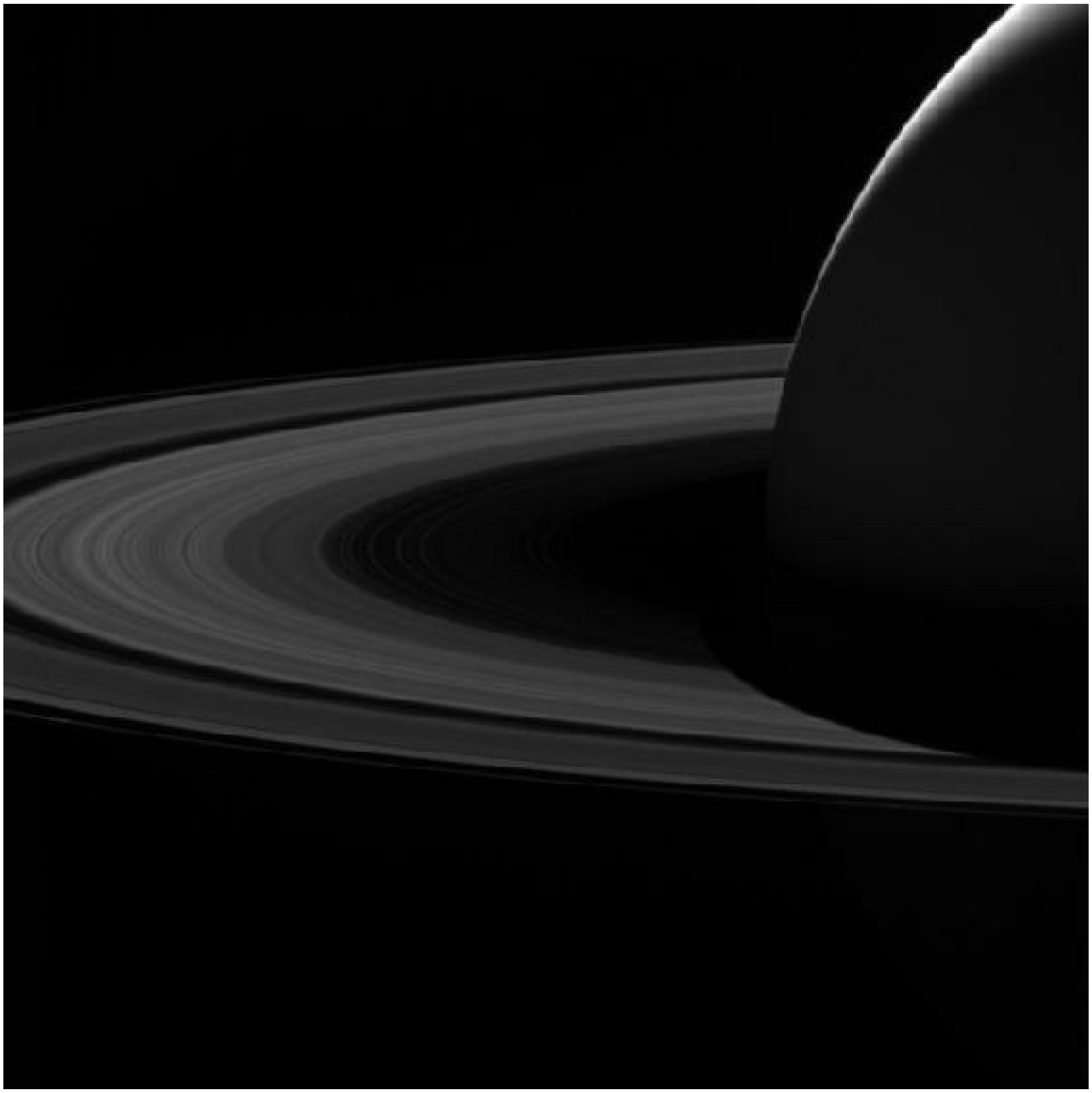
| 章节菜单 | 主菜单 |

Mysterious particles spotted in Saturn’s atmosphere

Source may be dust shed by planet’s iconic rings, according to data from NASA's doomed Cassini probe.

18 October 2017

Provo, Utah



NASA/JPL-Caltech/SSI

Saturn's rings are made of whirling bands of ice and dust.

NASA's Cassini spacecraft continues to yield surprising discoveries, more than a month after it burned up on its mission-ending dive into Saturn. New data from the probe suggest that Saturn's majestic rings are showering tiny dust particles into the planet's upper atmosphere, where they form a complicated and unexpected chemical mix.

A mass spectrometer aboard Cassini detected the strange chemistry as the

probe spent its final five months looping between Saturn and its rings.

“We really hit the jackpot,” said Mark Perry, a planetary scientist at the Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland. He reported the findings on 17 October at a meeting of the American Astronomical Society’s Division for Planetary Sciences in Provo, Utah.

Mission scientists had expected Cassini's mass spectrometer to spot the signature of water molecules as the spacecraft slipped between the planet and its rings. In the 1970s and 1980s, NASA's Pioneer and Voyager missions found fewer charged particles than expected in Saturn’s uppermost atmosphere. On the basis of those data, researchers proposed in 1984 that water molecules coming off the rings — mostly in the form of ice — act as catalysts to strip charged particles from the atmosphere[1]. Cassini's final months gave scientists their first opportunity to test this idea directly.

Chemical surprise

But it wasn't evidence of water that jumped out at Cassini's science team. Data from the mass spectrometer revealed a witch’s brew of chemicals, including methane, a molecule that could be carbon monoxide and more-complex molecules. The concentrations of these chemicals are greatest around Saturn’s equator and at high altitudes, which suggests that the material is shedding off the planet’s rings.

The deeper the probe went into the atmosphere, the stranger the measurements became. Cassini’s closest swings past Saturn's surface revealed a panopoly of heavy molecules, Perry told conference attendees. The scientists have not yet pinpointed each type of molecule, but clearly, there is much more than just water around.

By analysing the types of material that could be coming off the rings, Perry’s team concluded that the debris must be fragments of tiny dust particles, which measure just 1 to 10 nanometres across but are relatively heavy. When these particles spiralled off the rings and slammed into Cassini’s mass spectrometer, they shattered into smaller pieces.

Exactly how those particles make the journey from the rings to the atmosphere remains to be seen. “We have a lot of work to do to understand how they are getting in there,” Perry said. “None of the models predict this.”

On these final plunges, pulled along by Saturn’s gravity, Cassini was zooming along at more than 30 kilometres per second — a speed more than four times greater than the mass spectrometer was designed to withstand. “These are higher speeds than anything it has ever seen,” noted Linda Spilker, a planetary scientist at the Jet Propulsion Laboratory in Pasadena, California, and Cassini’s project scientist.

At such enormous speeds, anything that Cassini rammed into would have splintered into bits.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22838

Comments

Comments

There are currently no comments.

Efforts to save leading Hungarian university hit hurdle

US-registered Central European University faces another year of uncertainty over whether it can continue to operate in Hungary.

18 October 2017

Ferenc Isza/AFP/Getty Images

A sudden change to Hungarian higher-education law in April led to widespread protests.

The threatened Central European University (CEU) in Budapest has been dealt a blow in its efforts to avert possible closure in Hungary.

The country’s parliament voted on 17 October to postpone for a year a

decision that would allow the university to keep operating there. At a press conference held by the university shortly after the vote, CEU rector Michael Ignatieff called the delay “unacceptable” and “unnecessary”.

In April, the Hungarian government unexpectedly amended its higher-education law to require that all foreign-accredited universities there had to operate as higher-education institutes in their countries of origin by 1 January 2018.

The change drew protests and was widely believed to be politically motivated. Critics saw it as an attack on billionaire philanthropist George Soros, who founded the university in 1991 and has openly criticized Hungary’s strict refugee policies.

The CEU took steps to comply with the new requirements and on 3 October sealed an agreement with Bard College in Annandale-on-Hudson, New York, to provide educational activities there. Accredited courses run jointly by the universities would be launched next year, the CEU said. The agreement still needs to be signed by the Hungarian government and ratified by the country’s parliament.

But on 16 October the government proposed delaying the implementation of the amendment until 1 January 2019, and the parliament approved the delay the next day.

A government spokesperson told *Nature* that the purpose of the delay was to give other foreign higher-education institutions time to comply with the new requirements, adding that three institutions, including the CEU, are still in negotiation.

Zoltan Balogh, Hungary’s minister for human capacity, suggested on 16 October that government sign-off of the CEU’s agreement might have to wait for the new deadline.

“We are being deliberately kept in legal limbo,” said Ignatieff, who fears the uncertainty will make it hard to retain faculty and recruit students. “We are being slowly strangled in this battle for academic freedom.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22855

Comments

Comments

There are currently no comments.

Sleeping sickness can now be cured with pills

Researchers seek approval from regulators for this quicker, easier treatment.

18 October 2017

Neil Brandvold

Health workers screen people in a remote village in the Democratic Repulic of the Congo for sleeping sickness.

For the first time, researchers have cured the deadly neurological disease sleeping sickness using pills instead of a combination of intravenous infusions and pills. The investigators presented the results from final clinical trials on 17 October at the European Congress on Tropical Medicine and

International Health in Antwerp, Belgium, providing hope that the treatment will help to eliminate the malady within a decade.

The oral therapy — called fexinidazole — cured 91% of people with severe sleeping sickness, compared with 98% who were treated with the combination therapy. It also cured 99% of people in an early stage of the disease who would typically undergo a spinal tap to determine whether they needed infusions. The relative ease of the treatment with fexinidazole means that if approved, it might save more lives than the current option, say the investigators leading the phase 3 trial, the final phase of testing before the drug goes to regulators for approval.

Sleeping sickness is endemic to Africa and generally infects extremely poor people who live in remote regions. The sick often suffer from the disease for years before seeking treatment, causing them and those caring for them to miss work and spend their savings on traditional medicines. Trekking to a hospital and remaining there for intravenous infusions is costly as well.

"It's not just the person with sleeping sickness, it's the family that takes care of them during years of this neurological, very serious disease," says Philippe Büscher, a sleeping-sickness specialist at the Institute of Tropical Medicine in Antwerp, Belgium, who was not involved in the study. "Whatever money they have, they'll spend on this instead of anything else."

Büscher commends the team for conducting a quality clinical trial under extraordinary circumstances in countries hit hardest by the disease, the Democratic Republic of the Congo and the Central African Republic. Investigators had to carry equipment to remote clinics over rugged terrain; one study site was repeatedly robbed; and early on in the trial, some participants fled armed conflict. "I need to congratulate them for beautiful work," Büscher says.

Neil Brandvold

The hospital where Pablo Loela was being treated for sleeping sickness canno afford to provide food for their patients: families must provide meals for their loved ones.

A better way

Sleeping sickness — also known as human African trypanosomiasis — is spread through the bite of tsetse flies carrying parasites, most commonly *Trypanosoma brucei gambiense*. The organism infects the central nervous system, and patients can experience confusion, daytime sleepiness, night-time insomnia and various psychiatric symptoms, including manic episodes and aggression. If left untreated, they enter a coma and die. For decades, the only treatment was a toxic arsenic-based drug that killed one in 20 patients.

In 2009, researchers introduced a safer option: nifurtimox–eflornithine combination therapy, or NECT, which consists of pills and 14 intravenous

infusions. For the first time in 50 years, the incidence of sleeping sickness slipped below 10,000 new cases per year; it's currently around 2,200, according to the World Health Organization. But the need for infusions, along with the spinal tap required to qualify a patient for the treatment, still present obstacles in regions where sterile equipment, electricity and doctors are in short supply.

The group that developed NECT — a non-profit research organization based in Geneva, Switzerland, called the Drugs for Neglected Diseases initiative (DNDi) — continued searching for a better therapy. In 2007, it discovered fexinidazole, a compound that had been shelved by Paris-based pharmaceutical company Sanofi. With the firm's agreement, the DNDi took the drug through clinical trials. It estimates that developing the therapy through to approval will cost a total of around US$50 million — a fraction of what pharmaceutical companies often spend on new drugs.

Just the beginning

Sanofi will soon submit an application for drug approval through the European Medicines Agency, whose sign-off could pave the way for regulators in the Democratic Republic of the Congo. The drug might get a green light by the end of next year, says Nathalie Strub Wourgraft, the DNDi's medical director. Because it is a simple oral treatment, she suggests that patients might even be treated at home, which would save them and their families the expense of hospital stays.

However, Büscher argues that home treatments could be dangerous because people who don't respond to fexinidazole could die of the disease if not seen immediately by medical staff. It's imperative that patients follow up with health workers, he says, and he suggests offering people incentives to return to the clinic, such as money or staples including salt or sorghum. "This is a success," he says, "but it is not the end."

DNDi researchers and their colleagues are currently working on what they hope will be an even better oral treatment to cure the disease in a single dose, and more reliably than fexinidazole.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22856

Comments

Commenting is currently unavailable.

Self-taught AI is best yet at strategy game Go

Artificial-intelligence program AlphaGo Zero trained in just days, without any human input.

18 October 2017

Xavierarnau/Getty

AlphaGo Zero came up with Go strategies that human players haven't invented in thousands of years.

An artificial intelligence (AI) program from Google-owned company DeepMind has reached superhuman level at the strategy game Go — without learning from any human moves.

This ability to self-train without human input is a crucial step towards the dream of creating a general AI that can tackle any task. In the nearer-term, though, it could enable programs to take on scientific challenges such as protein folding or materials research, said DeepMind chief executive Demis Hassabis at a press briefing. “We’re quite excited because we think this is now good enough to make some real progress on some real problems.”

Previous Go-playing computers developed by DeepMind, which is based in London, began by training on more than 100,000 human games played by experts. The latest program, known as AlphaGo Zero, instead starts from scratch using random moves, and learns by playing against itself. After 40 days of training and 30 million games, the AI was able to beat the world's previous best 'player' — another DeepMind AI known as AlphaGo Master. The results are published today in *Nature*[1], with an accompanying commentary[2].

Getting this technique, known as reinforcement learning, to work well is difficult and resource-intensive, says Oren Etzioni, chief executive of the Allen Institute for Artificial Intelligence in Seattle, Washington. That the team could build such an algorithm that surpassed previous versions using less training time and computer power “is nothing short of amazing”, he adds.

Strategy supremo

The ancient Chinese game of Go involves placing black and white stones on a board to control territory. Like its predecessors, AlphaGo Zero uses a deep neural network — a type of AI inspired by the structure of the brain — to learn abstract concepts from the boards. Told only the rules of the game, it learns by trial and error, feeding back information on what worked to improve itself after each game.

At first, AlphaGo Zero’s learning mirrored that of human players. It started off trying greedily to capture stones, as beginners often do, but after three days it had mastered complex tactics used by human experts. “You see it rediscovering the thousands of years of human knowledge,” said Hassabis.

After 40 days, the program had found plays unknown to humans (see 'Discovering new knowledge').

Discovering New Knowledge

Deepmind

Approaches using purely reinforcement learning have struggled in AI because ability does not always progress consistently, said David Silver, a scientist at DeepMind who has been leading the development of AlphaGo, at the briefing. Bots often beat their predecessor, but forget how to beat earlier versions of themselves. This is the project's first "really stable, solid version of reinforcement learning, that’s able to learn completely from scratch," he said.

AlphaGo Zero’s predecessors used two separate neural networks: one to predict the probable best moves, and one to evaluate, out of those moves, which was most likely to win. To do the latter, they used ‘roll outs’ — playing multiple fast and randomized games to test possible outcomes. AlphaGo Zero, however, uses a single neural network. Instead of exploring possible outcomes from each position, it simply asks the network to predict a winner. This is like asking an expert to make a prediction, rather than relying on the games of 100 weak players, said Silver. “We’d much rather trust the predictions of that one strong expert.”

Merging these functions into a single neural network made the algorithm both stronger and much more efficient, said Silver. It still required a huge amount of computing power — four of the specialized chips called tensor processing units, which Hassabis estimated to be US$25 million of hardware. But its predecessors used ten times that number. It also trained itself in days, rather than months. The implication is that “algorithms matter much more than either computing or data available”, said Silver.

Think outside the board

Several DeepMind researchers have already moved from working on AlphaGo to applying similar techniques to practical applications, said Hassabis. One promising area, he suggested, is understanding how proteins fold, an essential tool for drug discovery.

Generating examples of protein folding can involve years of painstaking crystallography, so there are few data to learn from, and there are too many possible solutions to predict structures from amino-acid sequences using a brute-force search. The puzzle shares some key features with Go, however. Both involve well-known rules and have a well-described goal. In the longer term, such algorithms might be applied to similar tasks in quantum chemistry, materials design and robotics.

Silver acknowledged that to apply its approach to real-world tasks more generally, the AI will need the ability to learn from smaller amounts of data and experience. Another essential step will be learning the rules of a game for itself, as another DeepMind bot did in 2015 for arcade games. Hassabis reckons this is something AlphaGo Zero could eventually do: “We’re pretty sure it would work, it would just extend the learning time a lot,” he said.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22858

Comments

Comments

There are currently no comments.

Science must examine the future of work

As automation changes employment, researchers should gather the evidence to help map the implications.

18 October 2017

VCG/Getty

Automation will take away jobs, but a bigger question is how many it will generate.

In 2014, the *Los Angeles Times* began beating its rivals to report earthquakes, using an algorithm to convert announcements from the US Geological Survey

(USGS) to breaking news within a few minutes. This June, it announced that a magnitude-6.8 quake had shaken Santa Barbara, California. That was certainly news to the distinctly unshaken residents of Santa Barbara; the earthquake the newspaper was reporting on had actually happened in 1925. The paper's Quakebot had misinterpreted an update to the USGS seismic database and published its story online without anyone checking. The story was deleted and Santa Barbarans (and human journalists everywhere) could breathe a sigh of relief.

The tale encapsulates many of the issues that surround the intensifying debate about the roles of computers and humans in the workplace of the future — both the very near and the very far. Much of that debate places people and algorithms in direct competition. From lorry drivers threatened by self-driving vehicles to doctors who could be replaced by know-it-all diagnostic devices, many jobs as we know them could be done by artificial intelligence (AI) systems.

In an Editorial last year on the likely role and risks of AI in future society, *Nature* noted that even academic debate on the topic is polarized between sceptics and fanciful futurists (see *Nature* **532,** 413; 2016). In a special issue this week, we try to find and explore some middle ground, by bringing together and assessing the evidence on how automation will affect the future of work.

In a sense, this debate is nothing new. Technology and automation have been putting people out of jobs for hundreds of years, as historian Robert Allen discusses in a Comment. So have other factors — chiefly economic trends and globalization. But the spread of technology has also created new roles. In broad terms, as manufacturing jobs in the West have been transferred to low-wage economies elsewhere, politicians and economists have looked to tech to help fill the gap. These new industries, they argue, both need direct labour to develop them and create employment indirectly through the need for service and support. But will this trend continue? The true debate over the future of work is not whether computers will replace people in many jobs — they surely will — but whether they are team players. For how long will Quakebot and its descendants need a human supervisor?

Both sceptics and fanciful futurists will find something to agree and disagree

with in the articles that follow. In a Comment, Yuval Noah Harari, historian and best-selling author of *Sapiens* (Harper, 2014) and *Homo Deus* (Harvill Secker, 2015), argues: “The challenges posed in the twenty-first century by the merger of infotech and biotech are arguably bigger than those thrown up by steam engines, railways, electricity and fossil fuels.” He also offers reassurance about job prospects for some people, from a perhaps unlikely source. Each US military drone flying over Syria keeps 110 people in a job, he writes — 30 operators and 80 analysts to process the information it sends back. This is not an argument for more drones, the use of which is controversial. But, as Harari writes: “A careful study of the military job market might tell us a lot about potential future developments in the civilian economy.”

Careful study, *Nature* naturally argues, is something that (human) scientists and other academics excel at. As the 2016 editorial put it, “it is crucial that progress in technology is matched by solid, well-funded research to anticipate the scenarios it could bring about”, such as impacts on mental health and management, and how humans interact with robots. It’s important, too, to study possible political and economic reforms that will allow those usurped by machinery to contribute to society.

The Oxford Martin Programme on Technology and Employment at the University of Oxford, UK, is doing just this (see go.nature.com/2xxauvm). Oxford economist Ian Goldin offers his own thoughts.

Among the topics worthy of examination is the future fate of science and scientists. So far, the application of technology and automation to research has fuelled, and not felled, the need for human support. Indeed, fields such as bioinformatics exist only because of the work that computers generate for scientists. But as explored in a Careers Feature, science is not immune from the gig economy — short-term employment on specialist tasks such as writing a literature review or managing a database. The trend towards parcelling off and even publishing science as a series of steps rather than full papers could see demand for freelance services rise. (The breakdown of complex tasks into a series of simpler steps is, of course, also a proven path to automation.)

Still, browse ‘help needed’ adverts for scientific gigs and the future looks less

rosy. As little as US$80 to perform a detailed meta-analysis of published studies? It’s hardly worth even plugging in for that.

Journal name:
Nature
Volume:
550,
Pages:
301–302
Date published:
(19 October 2017)
DOI:
doi:10.1038/550301b

Comments

Comments

There are currently no comments.

Blue is in the eye of the bee-holder

Flowers have evolved an ingenious way to attract pollinators.

18 October 2017

Ron Reznick/VW Pics/UIG via Getty Images

Nanostructures on flowers generate a blue halo that attracts bees.

The car maker Lexus announced a new paint job for its LC coupé this month, which it says will appeal to drivers who value the interaction of science and craftsmanship. The car is blue and the science it leans on is the optics of iridescence. Lexus says that it uses several layers of pigment to increase the amount of incoming light that reflects as blue. The finish, it claims, is “more blue” than anything seen before — and more time-consuming to apply. People who buy the model are unlikely to suffer that common psychological

bias experienced by owners of a new car who suddenly notice other vehicles everywhere the same colour as theirs: at present, the company can make just two a day.

Lexus says that its new blue is based on the famous wings of the morpho butterfly. These contain no pigment, but look blue because of how the wing structure physically separates the various components of white light and reflects only certain wavelengths. The company could also have borrowed the idea from the (less PR friendly) tarantula spider, many species of which use the hairs on their legs and body to show off the same blue effect. In fact, such iridescence is fairly common in plants and animals — sometimes deliberate (the shimmer of the peacock tail) and sometimes less so (the same effect from a fresh cut of meat). It's why a blue-cooked steak really does look blue. blue pigments are rare), and this week a paper online in *Nature* explores its role in flowering plants (E. Moyroud *et al. Nature* http://dx.doi.org/10.1038/nature24285; 2017).

Fewer than 10% of the 280,000 species of flowering plant naturally produce blue petals. This presents a problem, because the bees on which many flowers rely for pollination struggle to see any colour other than blue. So how do these flowers attract the insects they need?

The new study shows that they use structural-colour techniques to generate an iridescent blue halo. From the tulip to the golden perennial sweet pea, a dozen different flowering plants of varying colours were found to have surface nanostructures that produced the optical effect. It's visible to the human eye, too, and best seen against dark-coloured petals.

In a series of tests with bumblebees (*Bombus terrestris*), the researchers demonstrate that the insects avoid artificial flowers made to have smooth surfaces that don't produce the blue ring. And they show how the insects see the halo more easily than we do, because bee vision can better distinguish the ultraviolet frequencies into which the structural-colour effect spreads. The findings are discussed in an accompanying News & Views article (D. D. Deheyn *Nature* http://dx.doi.org/10.1038/nature24155; 2017).

Lexus boasts that it took more than a decade to develop its new blue paint. It took the flowers a lot longer: their ability to generate the halo effect has

evolved over millions of years, and perhaps emerged in each species independently. In both cases, the colour is best appreciated at first hand. Photographs do not do it justice. Take a stroll in the garden. And keep one eye on the road.

Journal name:
Nature
Volume:
550,
Pages:
302
Date published:
(19 October 2017)
DOI:
doi:10.1038/550302a

Comments

Comments

There are currently no comments.

Epic star collision, asteroid fly-by and journal resignations

The week in science: 13–19 October 2017.

18 October 2017

Events | People | Research | Facilities | Policy | Awards | Funding | Trend watch

EVENTS

Flames devastate northern California Wildfires have scorched about 890 square kilometres in Northern California, leaving at least 41 people dead as of 17 October, making them the deadliest fires in the state’s history. Nearly 100,000 residents of Napa and Sonoma Counties had been evacuated from their homes, although this week officials have started to let people return. At least 88 of the many hundreds of people who were reported missing are still unaccounted for. The exact cause of the flames is unknown, but the area was primed for a conflagration. Vegetation flourished in the region after record rainfall last winter, and heatwaves this summer dried everything out, turning it into kindling. Winds gusting at more than 100 kilometres per hour hindered the efforts of firefighters to bring the blazes under control.

Justin Sullivan/Getty

Journal editors quit Five German scientists said on 12 October that they have resigned their editorial positions at journals published by Elsevier, after negotiations over a national licensing agreement for German institutes ground to a halt. For more than a year, a consortium of German science organizations called Projekt DEAL has been pushing for a new type of nationwide licence with Elsevier that would include open-access options and replace the need for individual institutional subscriptions. About 200 German universities and research institutes have cancelled their individual contracts with the Dutch publisher.

Asteroid buzz A house-sized asteroid whizzed by Earth on 12 October, passing within 44,000 kilometres of the planet — just above the orbits of geostationary satellites — and providing a test of international planetary defences. Telescopes around the globe swivelled to track the body, which is estimated to be 15–30 metres wide and is known as 2012 TC4. NASA, the European Space Agency and other asteroid-hunting groups gathered data to fine-tune orbital calculations and establish its future path. The asteroid's next

close pass will be in 2050, when it will safely fly by Earth. Future Earth impacts after that date have not been ruled out.

PEOPLE

Trump nominations Barry Myers, the chief executive of weather-forecasting firm AccuWeather, is US President Donald Trump's pick to lead the National Oceanic and Atmospheric Administration (NOAA), the White House said on 11 October. Myers, an attorney by training, has led AccuWeather — based in State College, Pennsylvania — since 2007. Some scientists worry that his ties to the company could lead to conflicts of interest, and note that he has no direct experience with NOAA's broader research portfolio, which includes the climate, oceans and fisheries. Two days later, the White House announced that Trump had nominated Kathleen Hartnett White, a former Texas environmental regulator and prominent climate sceptic, for its top environmental post. If confirmed as chair of the Council on Environmental Quality, White would advise the president and coordinate federal policies on energy and the environment. White is a fellow at the Texas Public Policy Foundation, a conservative think tank based in Austin. She has called efforts to shift away from fossil fuels "environmental lunacy".

New Pasteur chief Stewart Cole was appointed on 13 October as the next president of the Pasteur Institute in Paris, replacing Christian Bréchot, who had reached the institute's mandated retirement age. Many of the Pasteur's researchers had wanted Bréchot to stay on, but a campaign to change the age-limit rule was unsuccessful. Cole, a microbial-pathogenesis specialist, has held several posts at the biomedical research institute and will begin his four-year term in January. Last month, Bréchot was appointed president of the Global Virus Network, an international coalition of virologists based in Baltimore, Maryland.

RESEARCH

Epic stellar clash Researchers announced on 16 October that they had for the first time witnessed the collision of two neutron stars — and perhaps the

subsequent formation of a black hole. The event was first spotted on 17 August by gravitational-wave detectors in the United States and Italy and by a NASA γ-ray probe. More than 70 observatories rushed to observe the collision's aftermath; their discoveries are detailed in dozens of papers and solve several cosmic mysteries.

FACILITIES

FAST's first pulsars The world's largest single-dish telescope has observed its first two pulsars. The Five-hundred-meter Aperture Spherical Telescope (FAST) in southern China's Guizhou province detected the neutron stars in August. Researchers at the National Astronomical Observatories of China reported the results on 10 October after they were confirmed by an Australian telescope. The observations suggest FAST is working well, despite its radical design: the dish consists of thousands of panels that move to track radio signals, requiring elaborate coordination. Signals from the two pulsars were captured a year into an estimated three-year debugging phase. FAST, which is expected to find hundreds, possibly thousands, of pulsars, is looking for clues to how the Universe formed, as well as for signs of extraterrestrial life.

China Daily/Reuters

POLICY

Climate-rule repeal On 10 October, the US Environmental Protection Agency moved to repeal former president Barack Obama's landmark regulations to reduce greenhouse-gas emissions from power plants. Agency administrator Scott Pruitt signed a measure to begin the process of rescinding the Obama policy, a move that is expected to spark lawsuits by environmental groups and some states. The power-plant rule would reduce greenhouse-gas emissions to 32% below 2005 levels by 2030. In 2016, the Supreme Court blocked the policy from taking effect; legal challenges from 27 state governments are still pending, although a federal appeals court has put the case on hold while the administration of President Donald Trump reviews the rule.

Measuring impact UK science minister Jo Johnson has announced plans to

assess universities on their economic impact and engagement with wider society. Higher-education bodies will consult on creating a Knowledge Exchange Framework, an evaluation system designed to incentivize activities such as transferring technology into industry, spinning off companies and conducting contract research, training and consultancy, Johnson said on 12 October. If implemented, the framework would become a third strand of UK university assessment, alongside the Teaching Excellence Framework and Research Excellence Framework.

AWARDS

MacArthur grants The philanthropic MacArthur Foundation in Chicago, Illinois, announced its 2017 award recipients on 11 October. Six of the 24 winners — often referred to as MacArthur geniuses — are scientists. They include anthropologist Jason De León of the University of Michigan in Ann Arbor, who uses methods including archaeology and forensic science to study undocumented migrants on the US–Mexican border; computational linguist Regina Barzilay of the Massachusetts Institute of Technology in Cambridge, who deciphers ancient languages using machine learning; and immunologist Gabriel Victora of the Rockefeller University in New York City, who observes how antibodies evolve in the immune system in real time. Each winner gets US$625,000 over 5 years, with no restrictions on how they can spend the money.

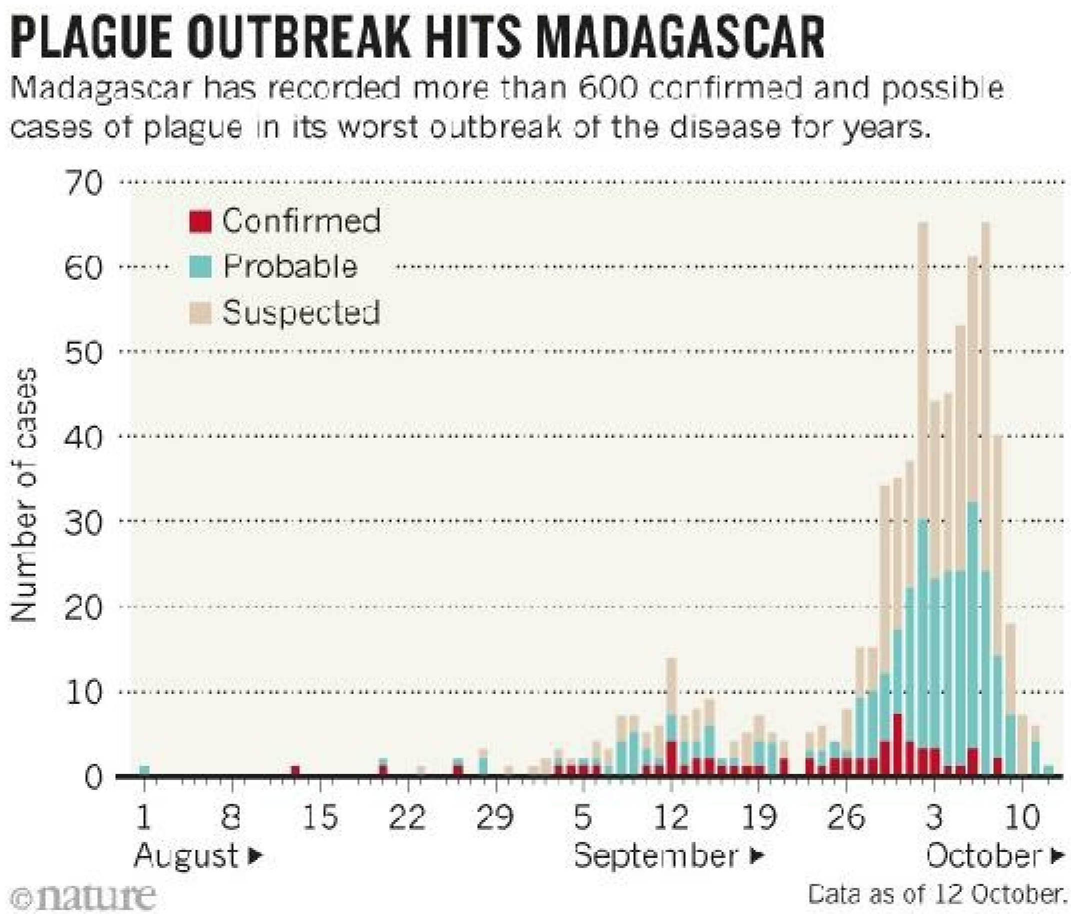
FUNDING

Research boost Online shopping giant Alibaba will set up seven international research laboratories as part of its plan to spend US$15 billion on research and development over the next three years. The company, based in Hangzhou, China, announced the Alibaba DAMO Academy on 11 October. The seven labs will be established in China, the United States, Russia, Israel and Singapore. Research topics will include data intelligence, the ‘Internet of things’, quantum computing and human–machine interfaces. Recruitment of the first 100 researchers is under way. The advisory board of the academy includes prominent scientists from outside China, including

geneticist George Church of Harvard University in Cambridge, Massachusetts.

TREND WATCH

Madagascar is battling an outbreak of plague, with more than 600 cases and at least 57 deaths since 1 August. Plague is endemic to the island and surfaces almost annually. But the current outbreak is unusually large, and cases are mostly of pneumonic plague, which is deadlier and more transmissible than the more usual bubonic form. Untreated, pneumonic plague can kill within 24 hours. On 10 October, the World Health Organization reported a linked case of plague in the Seychelles.



Source: WHO

Journal name:
Nature
Volume:
550,
Pages:
306–307
Date published:
(19 October 2017)
DOI:
doi:10.1038/550306a

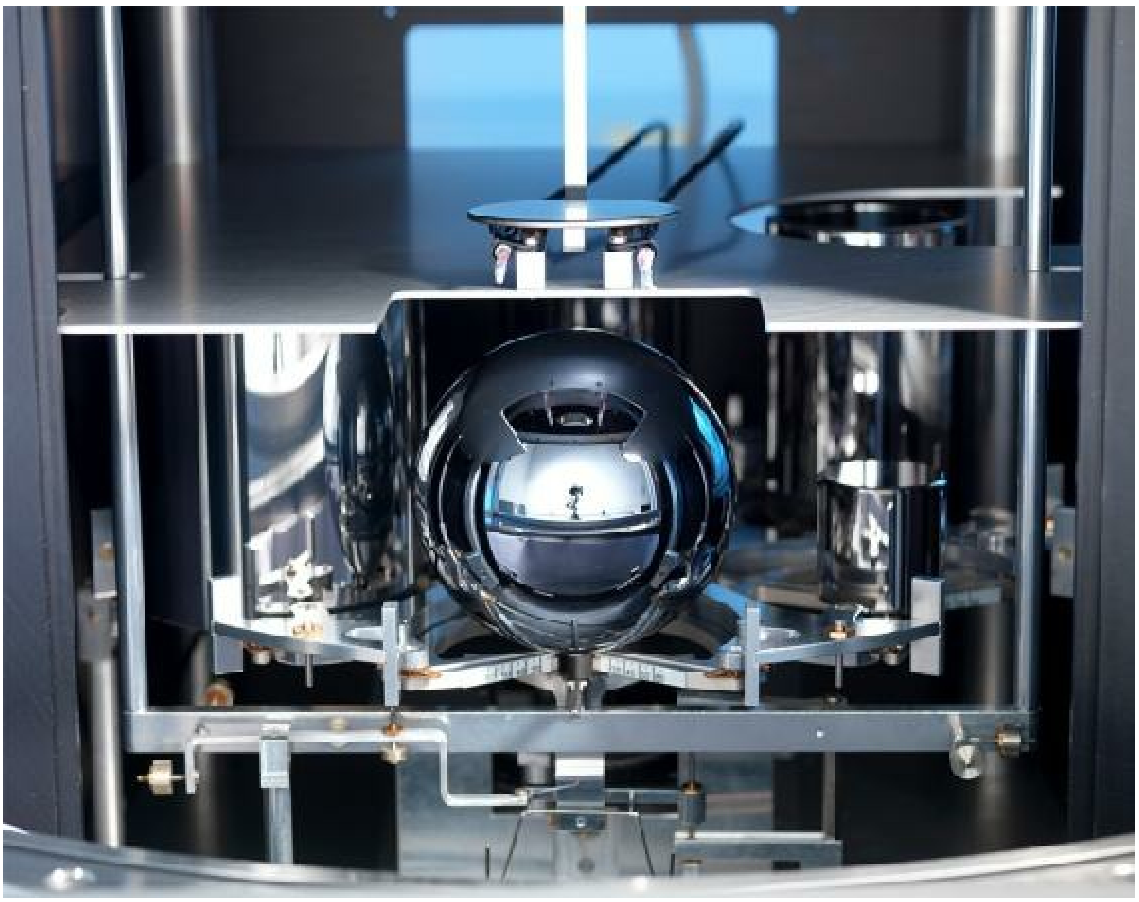
Comments

Commenting is currently unavailable.

New definitions of scientific units are on the horizon

Metrologists are poised to change how scientists measure the Universe.

18 October 2017



Natl. Phys. Lab., UK

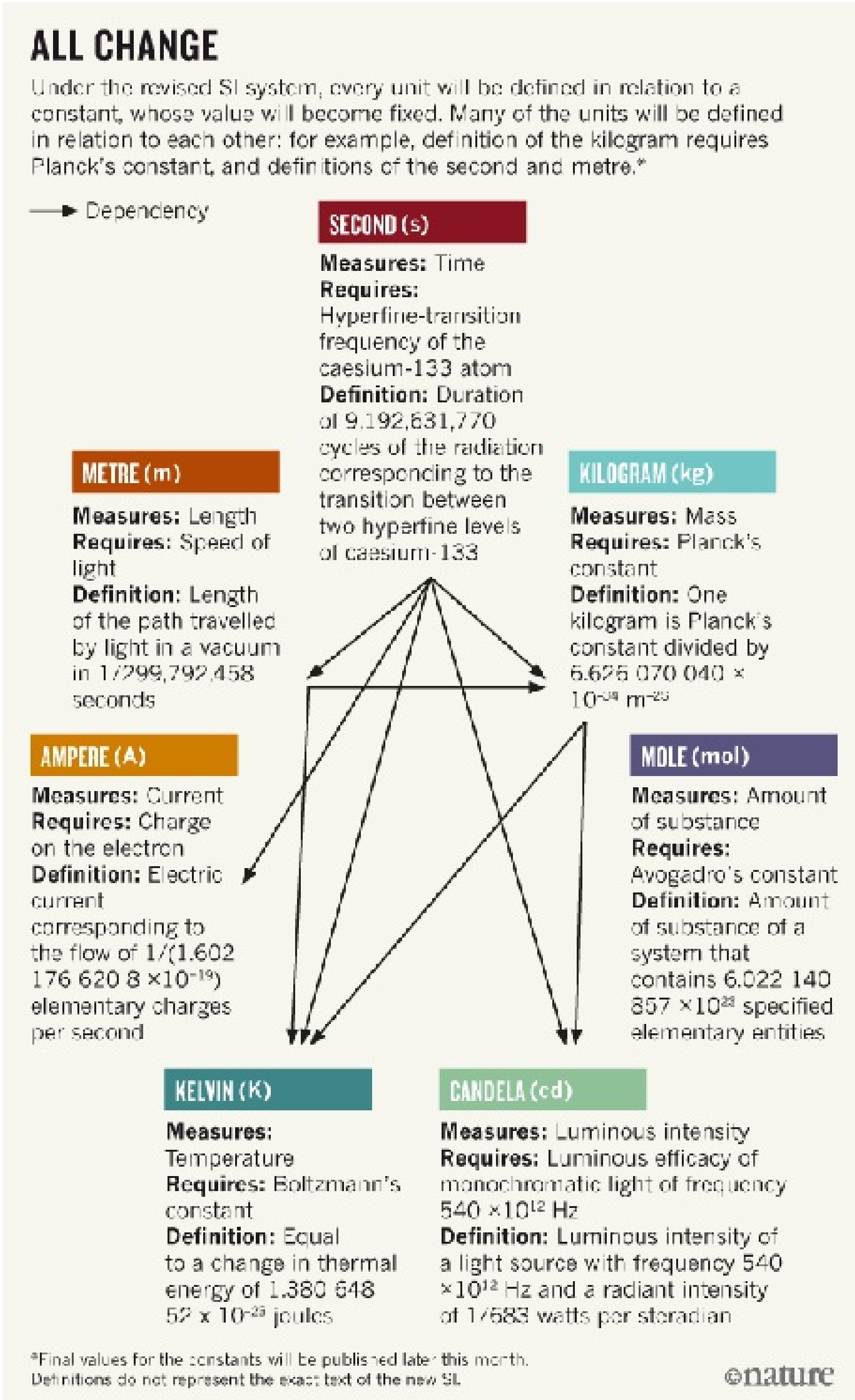
A sphere of pure silicon can be used to define a unit of measurement known as a mole.

Revamped definitions of scientific units are on their way. In the biggest

overhaul of the international system of units (SI) since its inception in 1960, a committee is set to redefine four basic units — the ampere, the kilogram, the kelvin and the mole — using relationships to fundamental constants, rather than abstract or arbitrary definitions. The International Bureau of Weights and Measures is reviewing the plans at a meeting near Paris from 16 to 20 October. Its recommendations will then go before the General Conference on Weights and Measures, which oversees the SI system, in November 2018. The changes would take effect in May 2019.

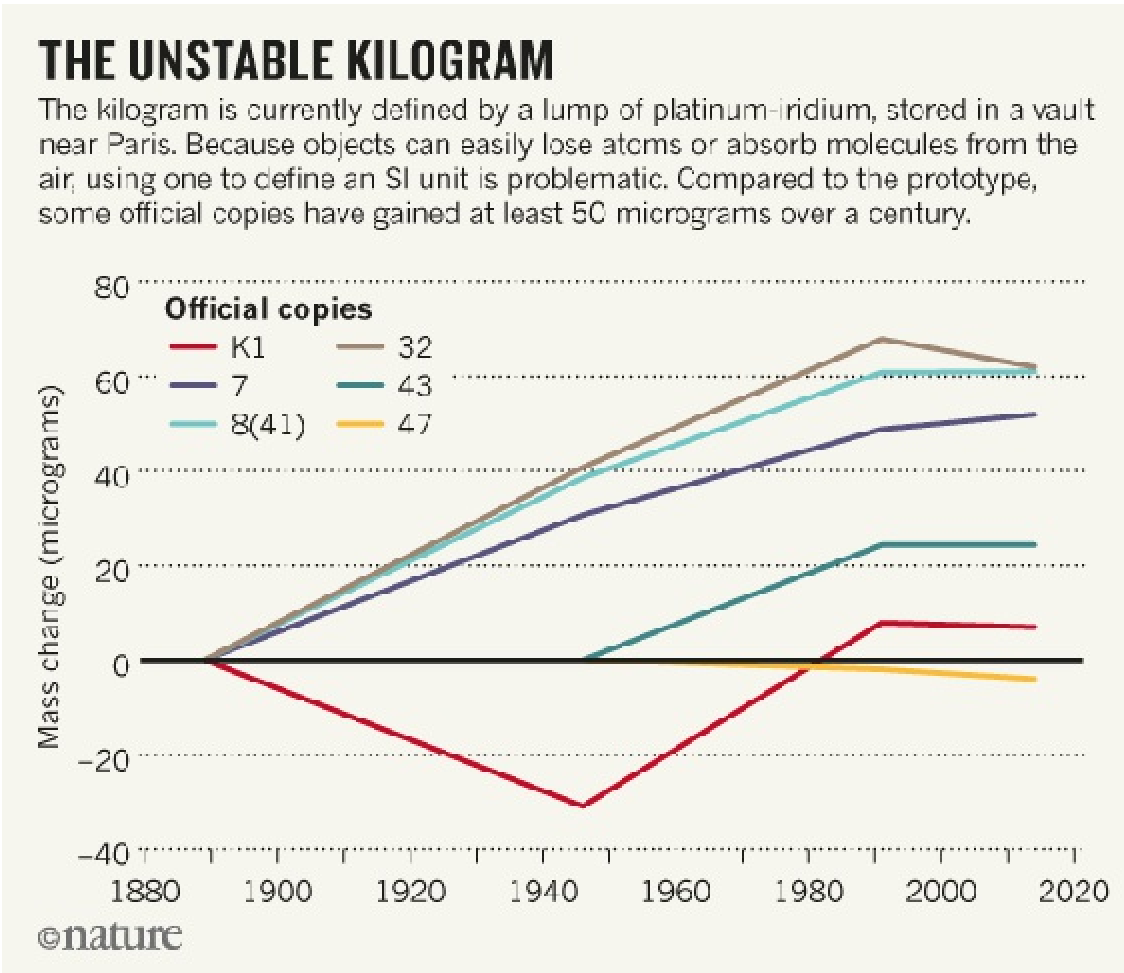
The kilogram is currently defined as the mass of a chunk of metal in a vault in Paris. And an imaginary experiment involving the force between two infinite wires defines the ampere, the unit of electrical current. The mole, meanwhile, is the amount of substance in a system with as many elementary entities as there are atoms in 0.012 kilograms of carbon-12, while the kelvin relates to the temperature and pressure at which water, ice and water vapour co-exist in equilibrium, known as the triple point of water. In the future, these units will be calculated in relation to constants — for example, the ampere will be based on the charge of an electron.

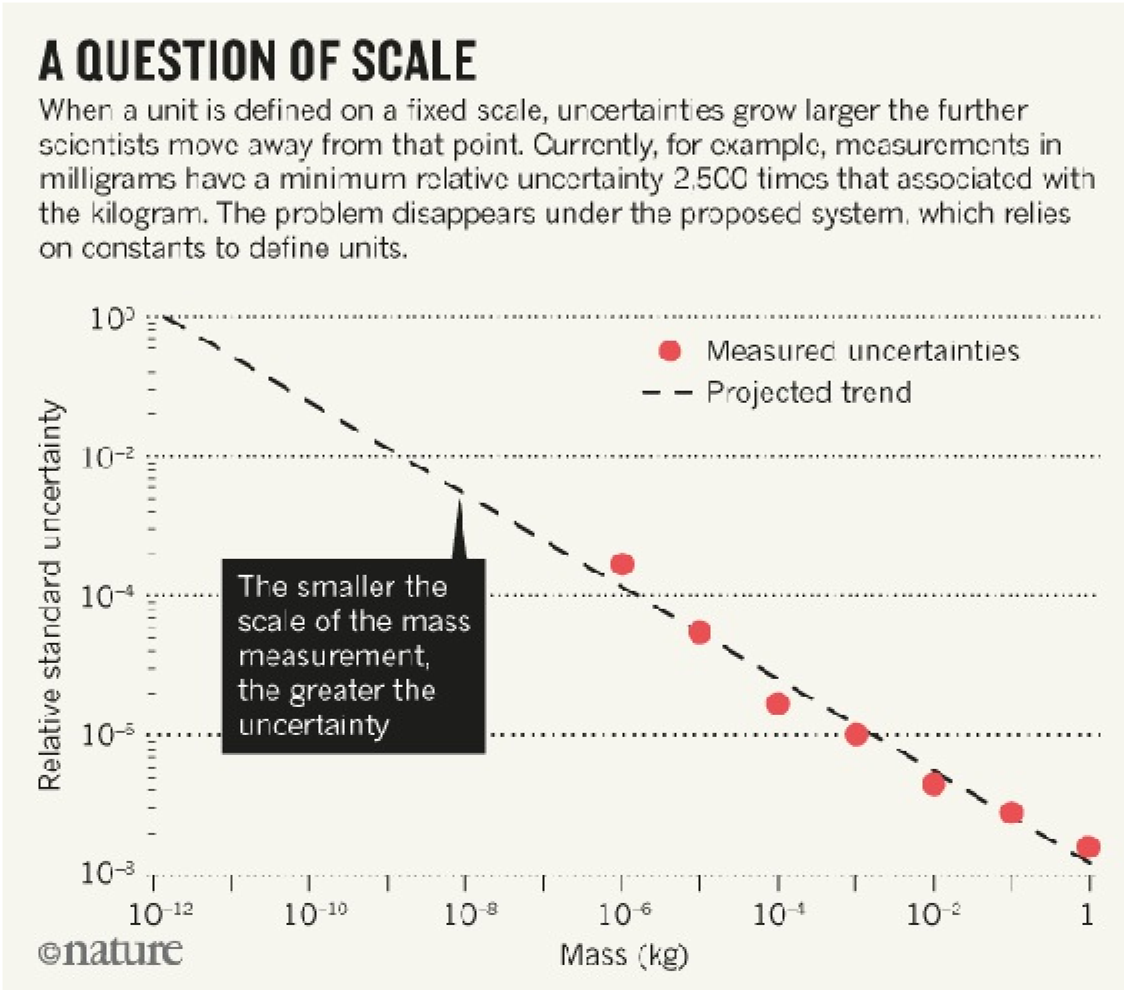
Redefinition might not affect everyday measurements, but it will enable scientists working at the highest level of precision to do so in multiple ways, at any place or time and on any scale, without losing accuracy.


ALL CHANGE
Under the revised SI system, every unit will be defined in relation to a constant, whose value will become fixed. Many of the units will be defined in relation to each other: for example, definition of the kilogram requires Planck's constant, and definitions of the second and metre.*
Dependency
SECOND (s)
Measures: Time
Requires: Hyperfine-transition frequency of the caesium-133 atom
Definition: Duration of 9,192,631,770 cycles of the radiation corresponding to the transition between two hyperfine levels of caesium-133
METRE (m)
Measures: Length
Requires: Speed of light
Definition: Length of the path travelled by light in a vacuum in 1/299,792,458 seconds
KILOGRAM (kg)
Measures: Mass
Requires: Planck's constant
Definition: One kilogram is Planck's constant divided by 6.626 070 040 × 10⁻³⁴ m⁻²s
AMPERE (A)
Measures: Current
Requires: Charge on the electron
Definition: Electric current corresponding to the flow of 1/(1.602 176 620 8 ×10⁻¹⁹) elementary charges per second
MOLE (mol)
Measures: Amount of substance
Requires: Avogadro's constant
Definition: Amount of substance of a system that contains 6.022 140 857 ×10²³ specified elementary entities
KELVIN (K)
Measures: Temperature
Requires: Boltzmann's constant
Definition: Equal to a change in thermal energy of 1.380 648 52 x 10⁻²³ joules
CANDELA (cd)
Measures: Luminous intensity
Requires: Luminous efficacy of monochromatic light of frequency 540 ×10¹² Hz
Definition: Luminous intensity of a light source with frequency 540 ×10¹² Hz and a radiant intensity of 1/683 watts per steradian
*Final values for the constants will be published later this month. Definitions do not represent the exact text of the new SI.
©nature

The problem

For measurements on conventional scales, existing definitions of SI units suffice. But they are poor tools for modern science at the extremes. And basing units on specific points or materials can be troublesome and inelegant, say metrologists.





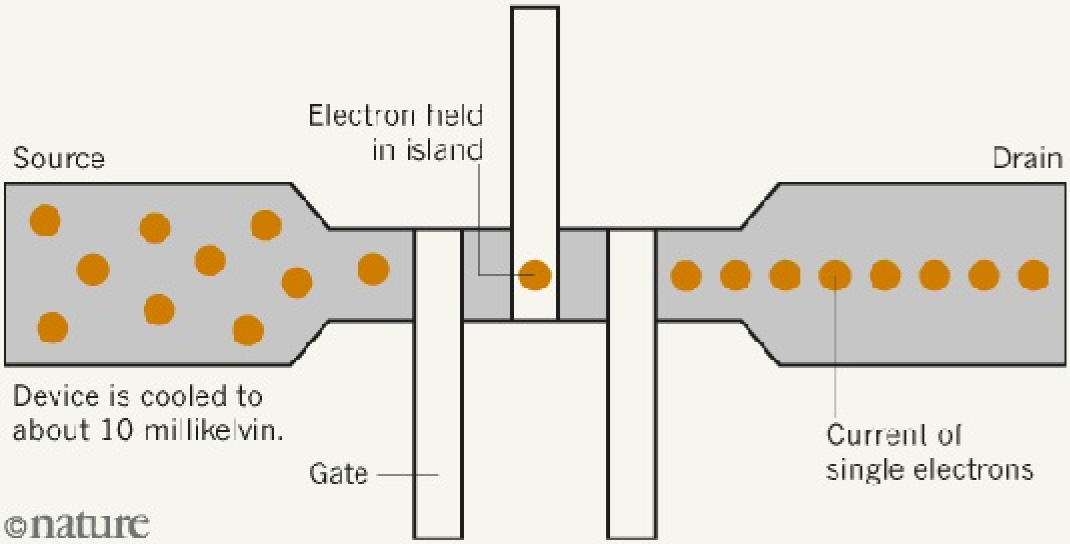
Source: Shaw, G. et al. Metrologia 53, A86–A94 (2016).

The techniques

Under the revamped SI system, researchers will be able to use various experiments to relate constants to each of the units measured.

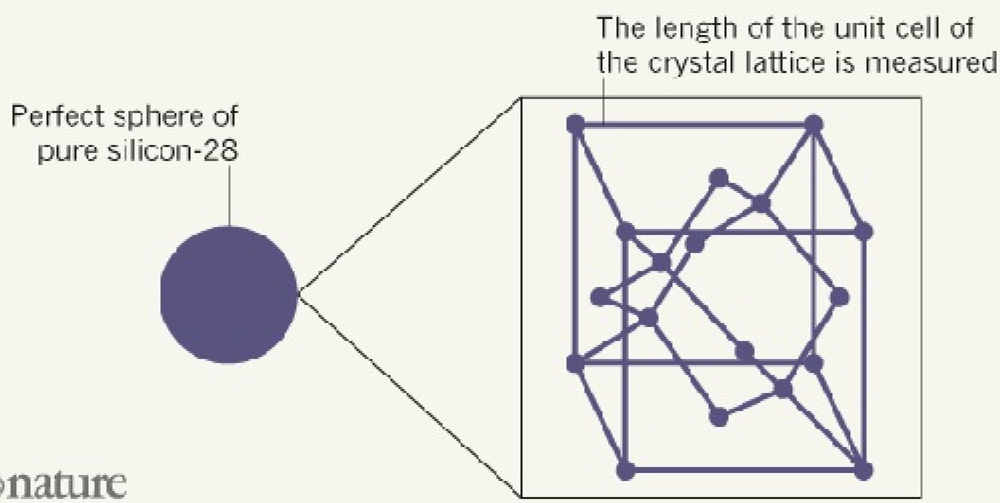
AMPERE: THE SINGLE-ELECTRON PUMP

Used to measure the charge of an electron, an electron pump could become one tool for determining the ampere. By trapping individual electrons as they travel rapidly across a conductor, the pump can generate a measureable current by counting single electrons.



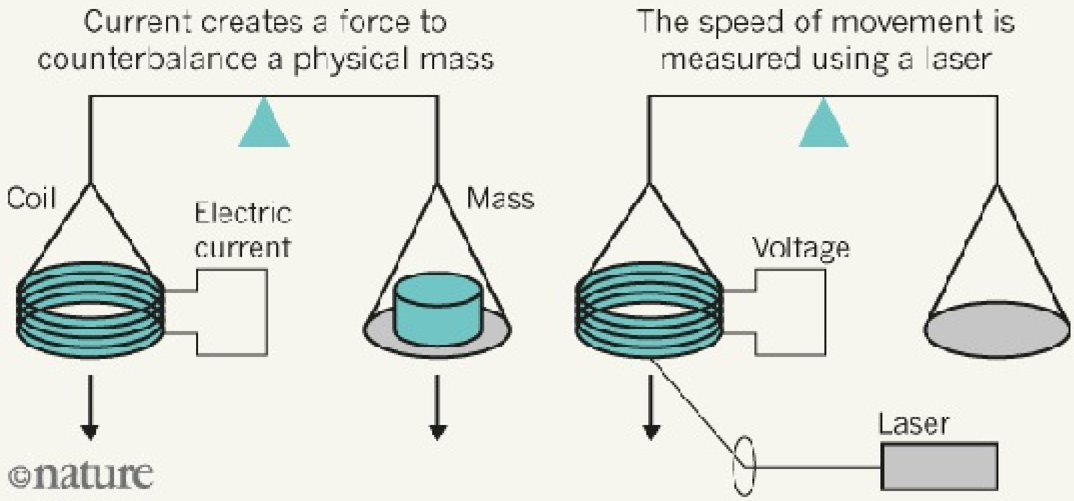
MOLE: THE SILICON SPHERE

As the device that gives scientists Avogadro's constant, this silicon sphere offers a state-of-the-art way to measure a mole. It would determine the precise number of atoms in a perfect sphere of pure silicon-28. Researchers do this by using lasers to measure the length of a unit of the sphere's crystal lattice, and its mean diameter.



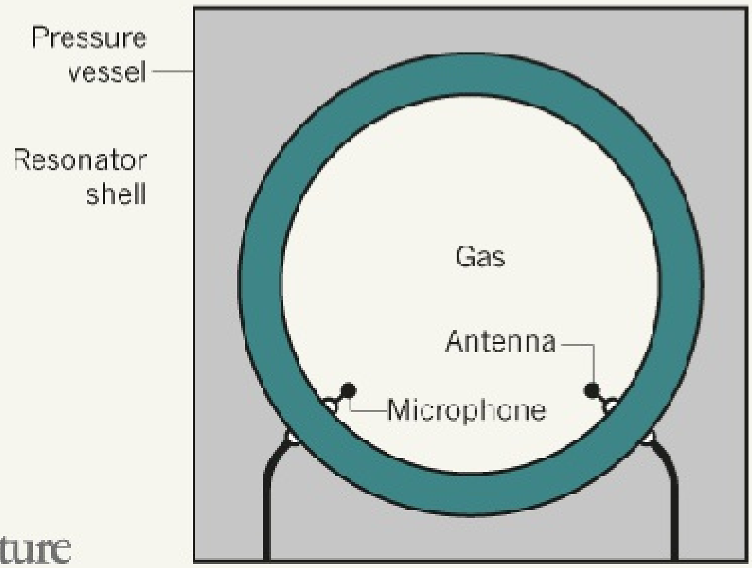
KILOGRAM: THE WATT BALANCE

The Watt balance compares mechanical power with electromagnetic power using two separate experiments. First, a current is run through a coil in a magnetic field to create a force that counterbalances a known physical mass. Then, the coil is moved through the field to create a voltage. By measuring the speed as well as experimental values that relate the voltage and current to Planck's constant, scientists can precisely determine the weight of a mass in kilograms.



KELVIN: ACOUSTIC THERMOMETRY

This technique could be used to derive precise temperature measurements. The speed of sound in a gas-filled sphere (which is proportional to the average speed of the atoms in it) can be determined at a fixed temperature, by analysing the frequency of sound waves that resonate within in it and measuring the sphere's volume.



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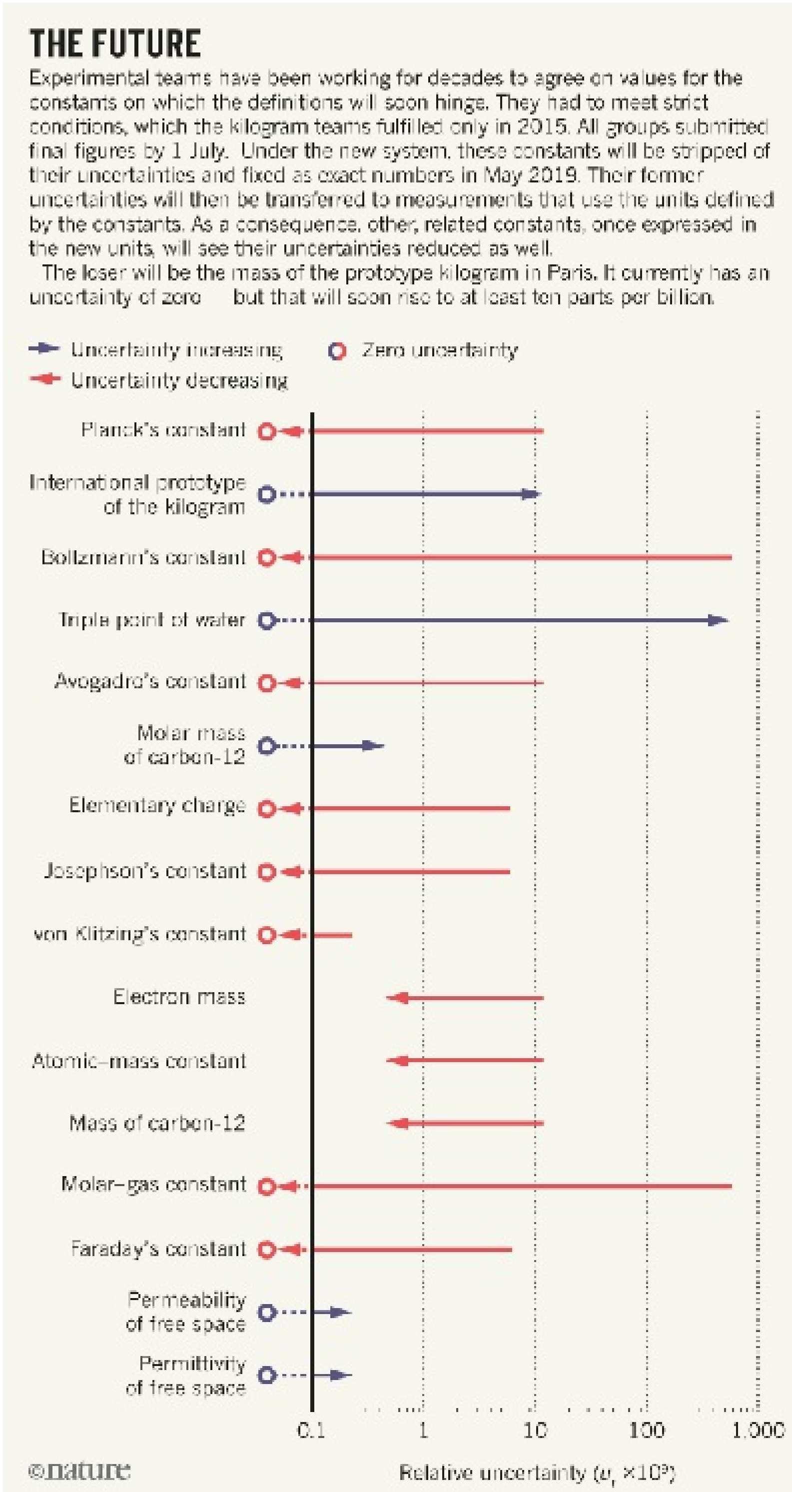


Journal name:

Nature

Volume:

550,
Pages:
312–313
Date published:
(19 October 2017)
DOI:
doi:10.1038/550312a

Comments

Comments

There are currently no comments.

The future of work

Digital technologies are upending the workforce. The right research can tell us how.

18 October 2017

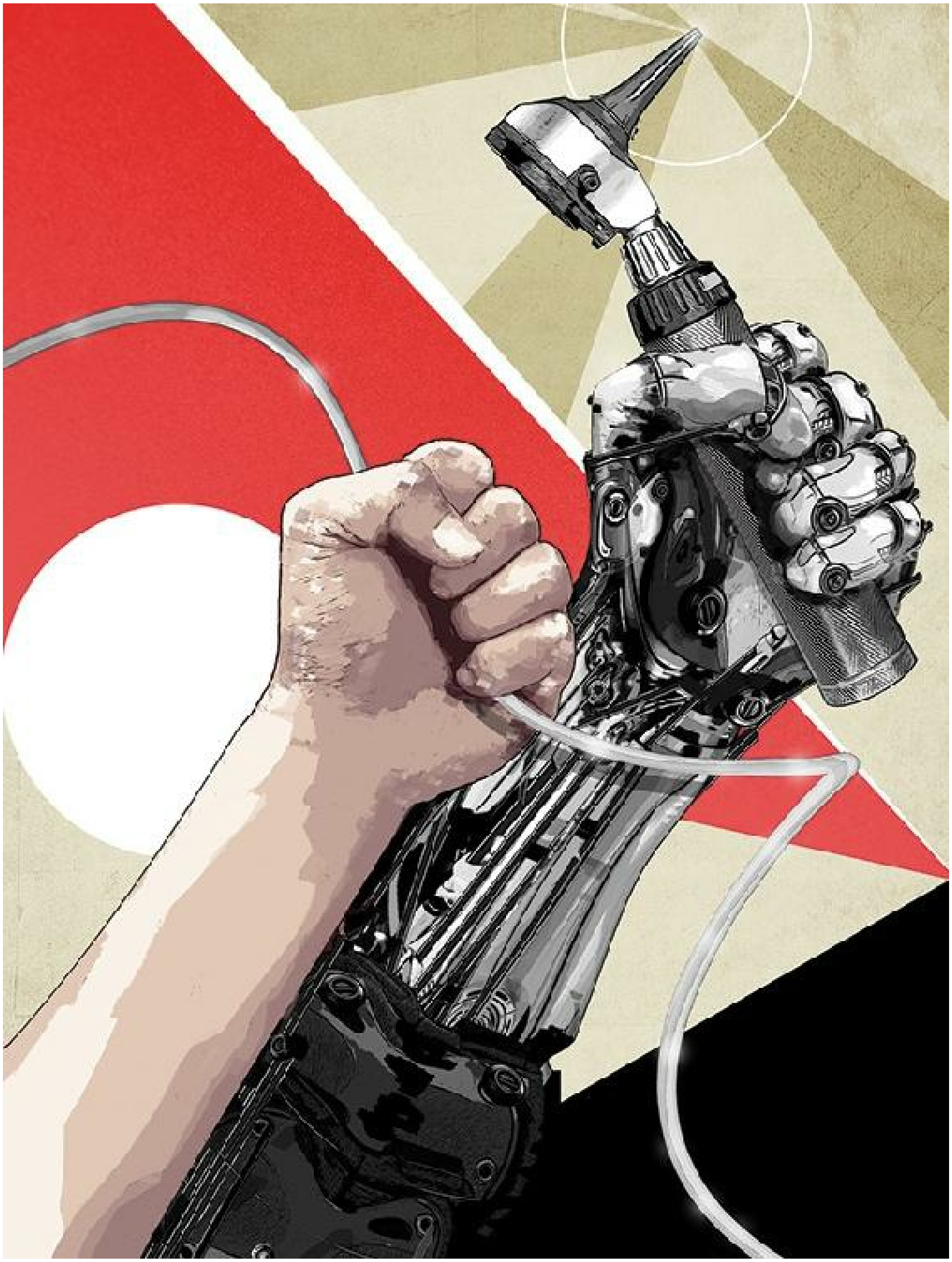


Illustration by Chris Malbon

Robots did not write this sentence, or any other part of *Nature*. But that could

change. Dramatic shifts in labour are reshaping society, the environment and the political landscape. Consider this disorienting estimate from the World Economic Forum: 65% of children entering primary schools now will grow up to work in jobs that do not yet exist. This week, *Nature* asks: what light is research shedding on the future of work, and how will the changes affect scientists' working world?

A News Feature explores which jobs are most at risk of being replaced by artificial intelligence and machine learning; whether a decentralized 'gig economy' will democratize work; and what programmes will best prepare workers. “There's a huge need, a huge opportunity, to study the changes,” says economist Erik Brynjolfsson. And the scientific workforce is feeling these shifts. A Careers Feature reports on people doing research outside the traditional career path. “I love the freedom,” says Cecile Menard, an independent land-surface modeller in Edinburgh, UK, “but for other people, it may be too stressful.”

Important lessons can be drawn from the past. Economic historian Robert Allen synthesizes three centuries of data to see when and where the relationship between wages and productivity was most like today's — and finds that some regions are in uncharted waters. These changes call for new socio-economic models and a revolution in education, concludes historian Yuval Noah Harari. And economist Ian Goldin argues that our era has more parallels with the Renaissance than the Industrial Revolution. This time, he urges, “knowledge and enquiry must find a way to conquer prejudice and ignorance”.

Journal name:
Nature
Volume:
550,
Pages:
315
Date published:
(19 October 2017)
DOI:
doi:10.1038/550315a

Comments

There are currently no comments.

The shape of work to come

Three ways that the digital revolution is reshaping workforces around the world.

18 October 2017

Illustration by Chris Malbon

Last year, entrepreneur Sebastian Thrun set out to augment his sales force with artificial intelligence. Thrun is the founder and president of Udacity, an education company that provides online courses and employs an armada of salespeople who answer questions from potential students through online chats. Thrun, who also runs a computer-science lab at Stanford University in California, worked with one of his students to collect the transcripts of these chats, noting which resulted in students signing up for a course. The pair fed

the chats into a machine-learning system, which was able to glean the most effective responses to a variety of common questions.

Next, they put this digital sales assistant to work alongside human colleagues. When a query came in, the program would suggest an appropriate response, which a salesperson could tailor if necessary. It was an instantaneously reactive sales script with reams of data supporting every part of the pitch. And it worked; the team was able to handle twice as many prospects at once and convert a higher percentage of them into sales. The system, Thrun says, essentially packaged the skills of the company's best salespeople and bequeathed them to the entire team — a process that he views as potentially revolutionary. “Just as much as the steam engine and the car have amplified our muscle power, this could amplify our brainpower and turn us into superhumans intellectually,” he says.

The past decade has seen remarkable advances in digital technologies, including artificial intelligence (AI), robotics, cloud computing, data analytics and mobile communications. Over the coming decades, these technologies will transform nearly every industry — from agriculture, medicine and manufacturing to sales, finance and transportation — and reshape the nature of work. “Millions of jobs will be eliminated, millions of new jobs will be created and needed, and far more jobs will be transformed,” says Erik Brynjolfsson, who directs the Initiative on the Digital Economy at the Massachusetts Institute of Technology in Cambridge.

But making firm predictions is difficult. “The technology is rushing ahead, which in a way is a good thing, but we have a huge gap in understanding its implications,” Brynjolfsson says. “There's a huge need, a huge opportunity, to study the changes.” Researchers are beginning to do just that, and the emerging evidence resists simple storylines. Advances in digital technologies are likely to change work in complex and nuanced ways, creating both opportunities and risks for workers (see 'More research needed').

More research needed

Illustration by Chris Malbon

Scientists are grappling with how technology could alter workplaces.

The changing world of work presents an almost endless number of topics for

scientists to explore. Here are two other workplace trends and the research questions — as yet mostly unanswered — that they raise.

How will workers respond to new forms of tracking and surveillance?

Although employers have long monitored the performance of their staff, workplace surveillance is entering a new era.

Companies can now log workers' keystrokes and remotely take screenshots of their computers, for example, or use motion sensors, biometrics, radio-frequency identification (RFID) chips and the Global Positioning System to track their movements, even after hours.

But it's not yet clear whether workers will show widespread resistance to the increasing use of surveillance technology, or where they might draw the line. And could new forms of surveillance backfire in less obvious ways, undermining trust, morale or innovation?

How will human-enhancement technologies affect worker health and safety?

Technologies for improving human performance — from cognition-boosting drugs to bionic 'exoskeletons' that are designed to make physical labour safer and easier — are beginning to make their way into the workplace.

In some cases, these technologies could help to protect the health and safety of workers. An alertness-enhancing drug, such as modafinil, might help long-haul drivers avoid accidents, and exoskeletons could reduce joint stress and muscle fatigue. But researchers don't know whether the long-term use of these technologies could harm workers, either directly or indirectly, perhaps by encouraging overwork or increased risk-taking.

Here are three pressing questions about the future of work in a digital world and how researchers are beginning to answer them.

Will machine learning displace skilled workers?

In previous waves of automation, technological advances have allowed machines to take over tasks that were simple, repetitive and routine. Machine learning opens up the possibility of automating more complex, non-routine cognitive tasks. “For most of the last 40 or 50 years, it was impossible to automate a task before we understood it extremely well,” Brynjolfsson says. “That's not true anymore. Now machines can learn on their own.”

Machine-learning systems can translate speech, label images, pick stocks, detect fraud and diagnose disease — rivalling human performance in some new and surprising domains. “A machine can actually look at many, many, many more data samples than a human can handle,” says Thrun. Earlier this year, he led a team that demonstrated that some 129,000 images of skin lesions could be used to train a machine to diagnose skin cancer with a level of accuracy that matches that of qualified dermatologists[1].

LISTEN

Reporter Benjamin Thompson finds out how lessons from the past can help explore the future of work.

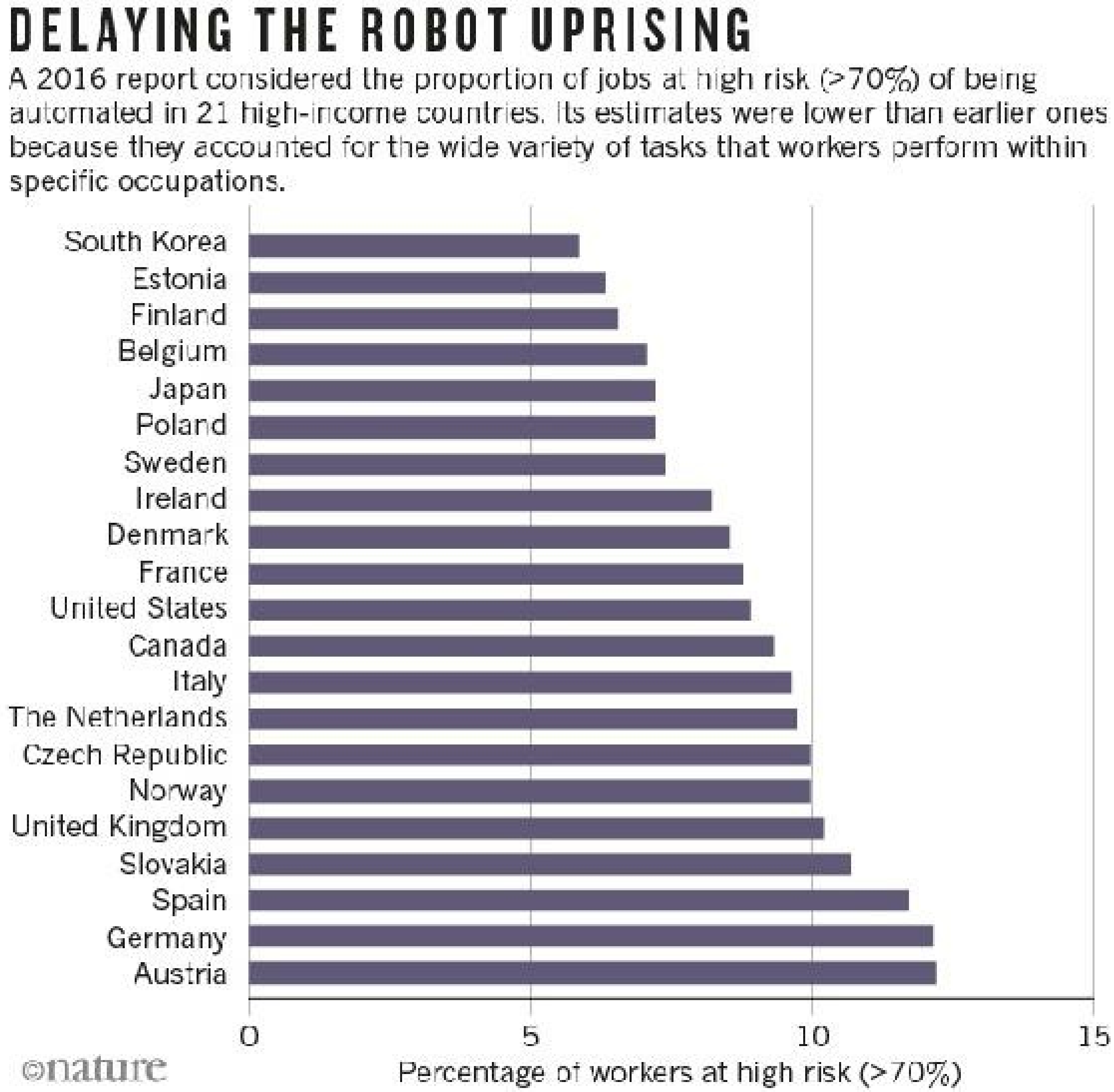
You may need a more recent browser or to install the latest version of the Adobe Flash Plugin.

These advances have raised concerns that such systems could replace human workers in fields that once seemed too complex to be automated. Early estimates seemed dire. In 2013, researchers at the Oxford Martin Programme on Technology and Employment at the University of Oxford, UK, reviewed the advances and lingering challenges in machine learning and mobile robotics to estimate how susceptible 702 different occupations were to automation[2]. Their startling conclusion was that 47% of jobs in the United States were at high risk of computerization, with jobs in transportation, logistics, production and administrative support particularly vulnerable. That spelt trouble for workers such as taxi drivers, legal secretaries and file clerks.

Since then, however, other researchers have argued that the 47% figure is much too high, given the variety of tasks that workers in many occupations

tend to perform. “Once you go deeper, once you look into the task structure of what people really do at work, then you find that the estimates get much lower,” says Ulrich Zierahn, a senior researcher at the Centre for European Economic Research in Mannheim, Germany.

For instance, the Oxford study reported that clerks in bookkeeping, accounting and auditing face an automation risk of 98%. But when Zierahn and his colleagues analysed survey data on what people in those professions actually do, the team found that 76% of them had jobs that required group work or face-to-face interaction. For now at least, such tasks are not easily automated[3]. When the authors extended their approach to other professions, they found less-alarming figures for the number of at-risk jobs in the 21 countries surveyed. In the United States, the share of workers at high risk of automation was just 9%, and the figure ranged from a low of 6% in South Korea and Estonia to a high of 12% in Germany and Austria (see 'Delaying the robot uprising').



Sources: OECD/Ref. [3] (http://go.nature.com/2KK4D4Y)

Brynjolfsson is now working with Tom Mitchell, a computer scientist at Carnegie Mellon University in Pittsburgh, Pennsylvania, to drill deeper into the impact of machine learning. They have developed a rubric outlining the characteristics that make certain tasks especially amenable to this approach. For instance, machine-learning systems are adept at tasks that involve translating one set of inputs — say, images of skin lesions — into another set of outputs, such as cancer diagnoses. They're also most likely to be used for tasks in which the large digital data sets required for training the system are readily available. Brynjolfsson and Mitchell are now going through several

large occupational databases to determine how well a variety of workplace tasks match up with these and other criteria.

Even with these kinds of analysis in hand, determining the consequences for the labour market is complex. Just because a task can be automated doesn't mean that it will be; new technologies often require costly and time-consuming organizational changes. Legal, ethical and societal barriers can also delay or derail their deployment. “AI is not yet an off-the-shelf product,” says Federico Cabitza, who studies health-care informatics at the University of Milano-Bicocca in Italy. Implementing medical machine-learning systems, for instance, requires both technological readiness and willingness to devote the thousands of person-hours necessary to make these systems operational, he says — not to mention buy-in from caregivers and patients.

Research suggests that the workforce is flexible in adapting to new technologies. In the second half of the twentieth century, increasing automation prompted shifts within occupations as employees began performing more complex and non-routine tasks. In some future cases, these shifts could be positive; if automated systems start making routine medical diagnoses, it could free doctors to spend more time interacting with patients and working on complex cases. “The fact that computers are becoming good at medical diagnosis doesn't mean that doctors will disappear as a job category,” Mitchell says. “Maybe it means we'll have better doctors.”

Indeed, many people might find themselves working alongside AI systems, as the Udacity salespeople did, rather than being replaced by them. Self-driving cars, for instance, are not yet able to navigate all situations on their own, so car manufacturer Nissan is developing a human-powered solution. If one of its autonomous cars encounters a situation it doesn't understand, such as roadworks or a traffic accident, it will contact a remote command centre where a human 'mobility manager' can take control until the car has passed the trouble spot. “Machines think in a very different way, fundamentally, than humans do, and each has its strengths,” says Pietro Michelucci, executive director of the Human Computation Institute in Fairfax, Virginia. “So there's a real natural marriage between machines and humans.”

Will the gig economy increase worker

exploitation?

Flexibility, variety and autonomy: these are the promises of the burgeoning gig economy, in which workers use online platforms to find small, short-term jobs. This sort of on-demand, digitally mediated gig work can take a variety of forms, from driving for the taxi service Uber to completing microtasks — including taking surveys, translating a few sentences of text or labelling an image — on a massive crowd-working platform such as Amazon Mechanical Turk.

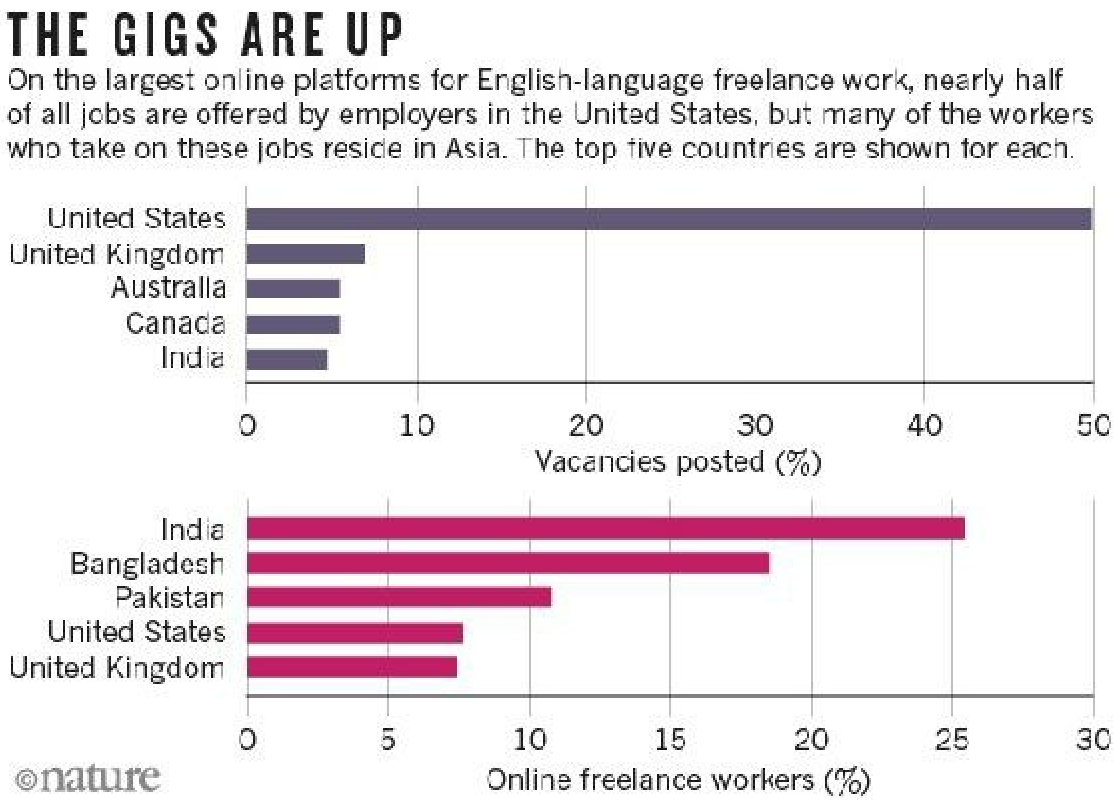
These digital platforms allow workers to complete tasks from anywhere, meaning they could remove some geographical barriers to getting good jobs. “Someone in Nairobi is no longer constrained by the local labour market,” says digital geographer Mark Graham of the University of Oxford.

Graham and his colleagues have spent several years studying the digital, on-demand economy in southeast Asia and sub-Saharan Africa. They have conducted face-to-face interviews with more than 150 gig workers in these regions, surveyed more than 500 people and analysed hundreds of thousands of transactions on online labour platforms.

Their preliminary results show that these jobs do pay off for some gig workers; 68% of the survey respondents said that the work makes up an important part of their household income. And digital platforms provided jobs to a variety of people — including women who were primary caregivers and migrants without work permits — who said that their employment opportunities were otherwise limited. “There are some people who really thrive in this system,” Graham says. “But it's not like that for everyone.”

There is a pronounced oversupply of labour in the gig economy, leading some workers to drop their rates below what they consider fair. Many also work long hours at high speeds and to tight deadlines. “They tend to have a very precarious existence, so they're worried about saying no to jobs that they do get,” Graham says. “We talked to quite a few people who have done things like stay up for 48 hours straight, just working solidly in order to get their contracts done on time.”

Considerable geographical inequities remain. In a 2014 study[4], Graham and several colleagues analysed more than 60,000 transactions on one major platform in March 2013. Most jobs, they found, were listed by employers in high-income countries and completed by workers in low- or middle-income countries (see 'The gigs are up').



Source: Ilabour (http://go.nature.com/2GZE5TZ)

But those who live close to where the jobs are still seem to have an advantage. They win a disproportionate share of jobs and earn significantly more — US$24.13 per hour, on average — than foreign workers, who earned $11.66 per hour for comparable work. And some low- and middle-income nations attracted many more jobs than others; India and the Philippines are the top two recipients in Graham's analysis.

Practical concerns could explain some of these disparities. Language and time-zone differences might make some employers reluctant to hire foreign workers, and the history of outsourcing labour to India and the Philippines

may have helped make workers there more attractive to employers. But discrimination, both conscious and unconscious, could play a part, too; Graham's team found task listings explicitly stating that people from certain countries need not apply. “Even though these technologies have been able to connect different parts of the world, they have not been able to bridge these kinds of differences as much as we hoped,” says Mohammad Amir Anwar, a researcher who works with Graham.

Another large ethnographic study of gig workers is beginning to reveal more about how this work gets done. It also provides some clues about what workers need to succeed. Between 2013 and 2015, two senior researchers at Microsoft Research — anthropologist Mary Gray in Cambridge, Massachusetts, and computational social scientist Siddharth Suri in New York City — surveyed roughly 2,000 gig workers in the United States and India and conducted longer interviews with nearly 200 of them.

One of the first things they discovered was that, although gig workers are often portrayed as independent, autonomous labourers, many of them were in fact communicating and collaborating with each other[5]. Workers helped each other to set up accounts and profiles, shared information about good employers and newly posted jobs, and provided technical and social support. Workers are making a deliberate effort to add human connections back into the system, Suri says, and they're doing it on their own time. “So they clearly must value it.”

In a more quantitative follow-up study[6], in which they mapped the social connections among more than 10,000 Amazon Mechanical Turk workers, Gray, Suri and their colleagues found that this kind of collaboration can have real pay-offs. Workers who had connections to at least one other person on the platform had higher approval rates, were more likely to gain elite 'master' status, and found out about a new task more quickly than unconnected workers. For people to be productive, says Gray, “it turns out that they really need to collaborate. They need each other.”

Can the digital skills gap be closed?

For years, experts have been sounding the alarm about a looming shortage of digital skills. They have warned that there are too few trained workers to fill high-tech jobs, and that a lack of basic digital literacy could prevent workers in certain geographical regions or demographic groups from thriving in the digital economy. In response, various innovative programmes for boosting digital literacy and skills have sprung up worldwide. Research is now starting to provide some clues about what does and doesn't work — and about where skills training might fall short.

There have been some documented successes. More than a decade ago, the US Defense Advanced Research Projects Agency began developing a personalized, interactive and adaptive 'digital tutor' system to train new recruits to the US Navy for jobs as information-systems technology (IT) technicians. Students would work with the tutor one-to-one, completing lessons on different topics and solving related problems. The system prioritized conceptual learning and reflection, regularly prompting students to review what they'd learnt. When the tutoring system judged that a student had mastered the material, it would move on to the next subject.

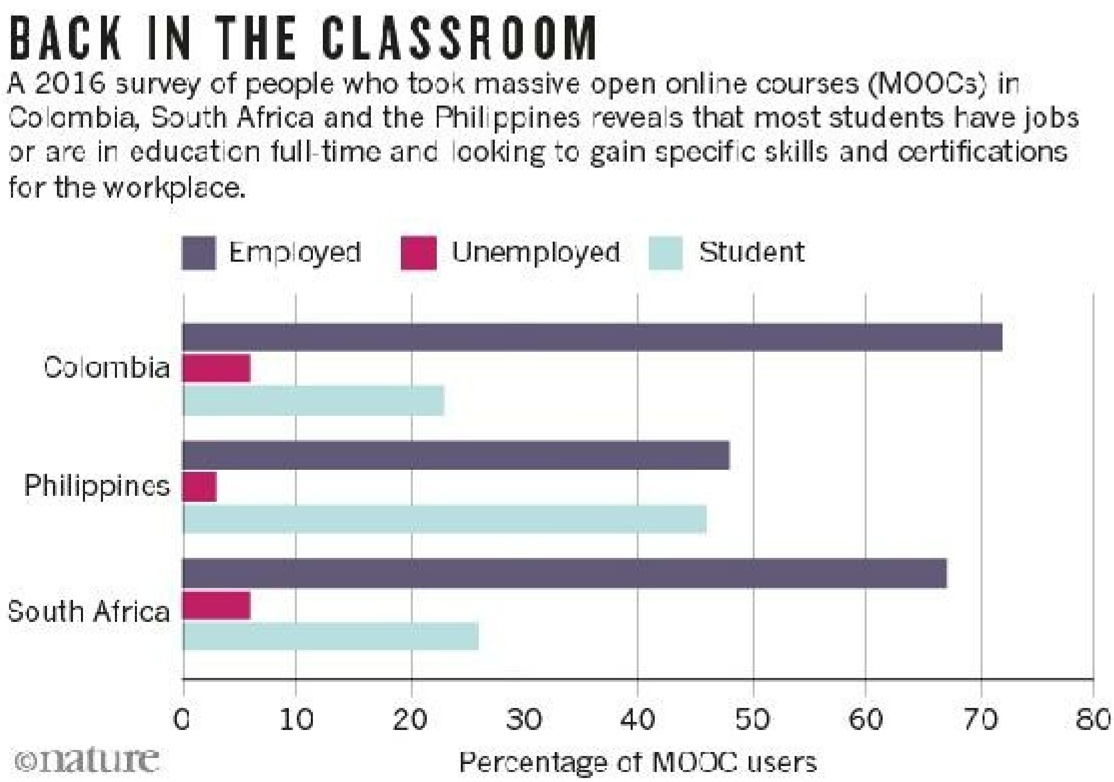
In a 2014 review[7] of the programme, researchers at the Institute for Defense Analyses in Alexandria, Virginia, found that 12 recruits who completed the 16-week course outperformed graduates of conventional, classroom-based US Navy IT training that lasted more than twice as long. The 12 even did better than a group of senior naval IT technicians — who each had an average of nearly ten years' experience — on almost every measure. “If we can do that, why not do more of it?” says Dexter Fletcher, who co-authored the review. “Why not begin to apply this seriously to workforce training?”

In a follow-up study[8], Fletcher found that a slightly modified version of the digital tutor yielded similar results when it was used to train 100 military veterans for civilian jobs in IT. Within six months of completing the programme, 97% of the veterans who wanted IT jobs had landed them, earning an average annual salary roughly equal to that of someone with 3–5 years of experience in the field.

Numerous other strategies have been promoted to improve digital skills and employment, including massive open online courses (MOOCs) — university-

level classes that are delivered over the Internet — and coding bootcamps, which are intensive, short-term training courses that teach the basics of computer programming.

In a 2016 analysis[9] of 1,400 MOOC users in Colombia, the Philippines and South Africa, researchers determined that 80% of students were from low- or middle-income backgrounds and that 41% had only basic computer skills. More than half of the students (56%) were female, and computer science was the most popular MOOC topic. “Women are actually engaging in MOOCs in areas where they are underrepresented,” says Maria Garrido, a co-author of the report at the University of Washington's Information School (see '[Back in the classroom]').



Source: Ref. [9] (http://go.nature.com/2YFAPWC)

But the quality of these programmes can vary enormously, and few have been rigorously evaluated. Coding bootcamps can be expensive, require a significant time investment and are located primarily in technology corridors

and urban settings. And achievement gaps remain; in a 2015 study[10] of more than 67,000 MOOC students, two Stanford researchers found that female students and students of both genders from Africa, Asia and Latin America were less likely to reach certain course milestones — such as watching more than 50% of the lectures — and earned lower grades than male students and MOOC students from North America, Europe and Oceania.

Even those who complete digital-skills courses can still face a variety of barriers to employment. When researchers interviewed students in a Kenyan IT programme at Strathmore University in Nairobi in 2004, some of the students said that they were worried about graduating into a local economy that didn't appreciate their expertise or have jobs in which they could put it to use[11]. “And this was especially true for the women,” says Lynette Yarger, an information scientist at Pennsylvania State University in University Park, who was involved in the research. As one student put it: “Because I am a woman, employers may not think that they should give me a job working in IT, so I may never fully get to use all that I have learned to do, work that I want to do.”

One thing the research is already making clear is that even well-designed training programmes might not be sufficient to ensure success in the world of digital work. “The fact that you have better skills and know how to use a computer doesn't necessarily mean that you automatically can get a good job,” Garrido says. “Digital skills are an important piece of the puzzle, but they're not enough.”

Journal name:
Nature
Volume:
550,
Pages:
316–319
Date published:
(19 October 2017)
DOI:
doi:10.1038/550316a

Comments

There are currently no comments.

Lessons from history for the future of work

18 October 2017

Global comparisons of previous social and economic upheavals suggest that what is to come depends on where you are now, argues Robert C. Allen.

Lewis Hine/Pictorial Press Ltd/Alamy

Children working in a cotton mill in Macon, Georgia, in January 1909.

Today is not the first time that people have worried that machines will render

human labour obsolete, making a few very rich and the majority very poor.

Since the Industrial Revolution, mechanization has been controversial. Machines pushed up productivity, raising incomes per capita. But they threatened to put people out of work, to lower their wages and to divert all the gains from growth to the owners of businesses. The stocking-frame operators of Nottingham, UK (the Luddites), wrecked improved knitting machines that threatened their jobs. Mobs burnt down the first mills housing spinning and weaving equipment in the 1760s and 1790s.

Now, it is robots that threaten work, wages and equality[1]. Are the gains of technological progress destined to benefit only the top 1% of earners?

Economists' stock answer to this question is 'no'[2]. Technical progress in the past three centuries has led to incomes in the West (that is, the developed nations of today) that are much higher than they were in 1700 in real terms, and the fraction of the adult population employed in these countries is at record levels. Despite mechanization, automation and computerization, people have found jobs. Somehow the economy has always adjusted; somehow in the future it always will.

I think this answer is too simplistic.

Phase shift

There have been long periods of economic history in which things did not work out well, and we must wonder whether we are in another. Also, the 'future of work' depends very much on where you are in the world. Most discussions in the West focus on how technological evolution in the West affects jobs in the West. This frame is too narrow for the twenty-first century: we must investigate the effect of technological change on work everywhere. For the past three centuries, the global economy has been sufficiently integrated that new technology in one place affects work in others.

LISTEN

Reporter Benjamin Thompson finds out how lessons from the past can help explore the future of work.

You may need a more recent browser or to install the latest version of the Adobe Flash Plugin.

Rather than ask (unanswerable) questions about how machines will affect work over the next centuries, we can ask what the invention of the textile mill meant for a girl growing up in Manchester, UK, in 1800 or the wife of a subsistence rice farmer in China's Yangtze Delta at the same time. Technological change affected their futures of work very differently and often detrimentally. Similar things are happening now.

We need to divide the past into periods defined by trends. The periods I suggest here reflect Western history, which is not as limiting as it sounds: globalization means that developments in one region affect others.

The three phases are: the Industrial Revolution (1750–1830); the Western ascent to affluence (1830–1970); and the problem-ridden present (since 1970). Each holds lessons and pressing research questions for today.

The industrial revolution

The Industrial Revolution was Britain's creative response to the globalization of the world economy that occurred after Columbus's voyage to America in 1492 and Vasco da Gama's sail around Africa to India in 1498. Britain's colonies in North America, the Caribbean and India formed a large market for Britain's handicraft industries. Exports boomed, and by the mid-eighteenth century about one-third of Britain's workforce was employed in making metal goods and cloth.

Large data sets of wages and prices over this period[3] have been assembled since the 1980s and show that real wages rose as a consequence of this export boom[4]. Inventors designed machines to save expensive labour. Mechanization paid in Britain rather than elsewhere because labour was more expensive relative to capital; that is why the Industrial Revolution was

primarily a British affair.

Textiles were the world's most important manufactured product in terms of employment before the Industrial Revolution, and the first to be mechanized. Indian cotton cloth was imported to Europe, where it was a smash hit. English manufacturers struggled to compete because English wages were so high. The invention in the 1760s and 1770s of spinning machines to speed up cloth-making, including Hargreave's spinning jenny, Arkwright's water frame and Crompton's spinning mule, solved the problem. The first victims of technological unemployment were the British women spinning cotton by hand and, later, the much-larger number spinning wool, once machinery was adapted to that fibre.

Soon jobs were lost from Casablanca to Canton. Investing in spinning machines made sense only in the high-wage economy of eighteenth-century England, thus they greatly increased English competitiveness without benefiting other nations. As jobs proliferated in the British cotton mills, massive technological unemployment spread across Africa and Asia[5]. The collapse of the Indian cotton trade around the 1830s led the British governor general to remark[6]: “The bones of the cotton-weavers are bleaching the plains of India.”

In 1820, the future of work for the wife of a farm labourer in England was an unhappy one. She had lost the opportunity to increase her family's income by spinning part-time, as her mother had done. The same impoverished fate befell a farmer's wife in the Ganges or Yangtze deltas. Some British women found work in the cotton mills (but a smaller number than had been employed to spin cotton by hand). By contrast, the future of work was auspicious for railway engineers, bricklayers and metal workers, to say nothing of the vast number of middle-class entrepreneurs and professionals who directed and serviced the industrial economy.

Machines were invented to save labour in most sectors of the economy in the first half of the nineteenth century. As one trade after another was eliminated in Britain, earnings collapsed in the affected trade, and that, in itself, lowered average national earnings. The displaced workers shifted into other trades, pushing down those wages. The Luddites and other opponents of

mechanization are often portrayed as irrational enemies of progress, but they were not the people set to benefit from the new machinery, so their opposition makes sense.

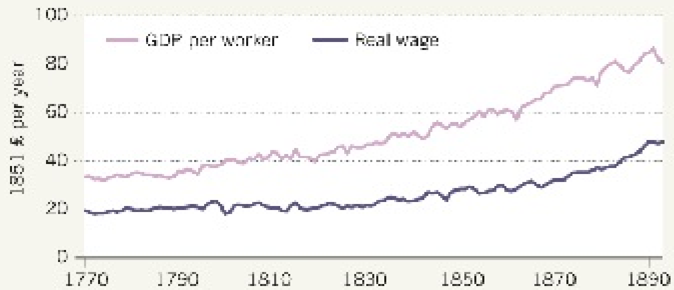
The implications were stark (see 'Trends in work, pay and manufacturing'). Although output per worker grew from 1770 to 1890, there was little growth in the real wage from 1770 to about 1830. During the Industrial Revolution (phase one) the 'normal' relationship was booming productivity and constant average wages — rather like the past 40 years.

TRENDS IN WORK, PAY AND MANUFACTURING

The relationship between wages and output has altered over time and place, as regions' roles in global trade have shifted. Understanding these fluctuations could help to predict future changes.

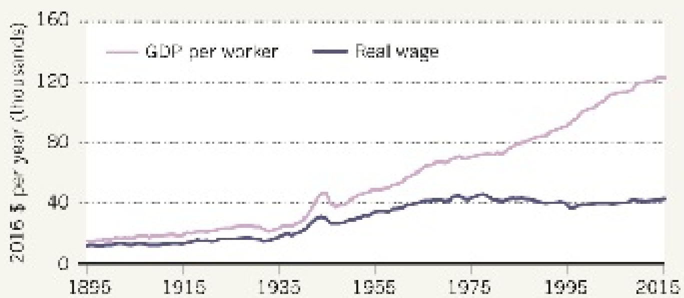
Wages in Britain 1770–1893

At the start of the Industrial Revolution, productivity grew, but wages did not; after 1830, as mechanization gathered pace, wages and output moved in lockstep.



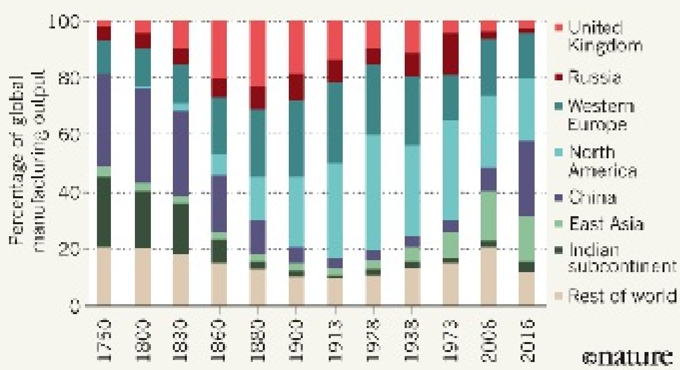
Wages in the United States 1895–2015

At the beginning of the twentieth century, wages rose with increasing productivity; since the 1970s, they have stagnated as output per worker has continued to rise.



Distribution of world manufacturing

Over the past three centuries, self-sufficiency gave way to shifting patterns of dominance in global trade.



Sources: See Supplementary Information

The western ascent to affluence

The average real wage only began to rise in the middle of the nineteenth century, when higher-productivity factory work replaced the hand trades. By 1850 Britain was the 'workshop of the world'. Comprising only around 3% of the world's population, the United Kingdom produced about half of the world's iron, for instance.

Industrial pre-eminence saw in the next phase of history. The new normal in the West was productivity and wages advancing together, as the Industrial Revolution spread across Europe and North America. Although there were shocks along the way owing to the depression of the 1930s and the Second World War, the period from the mid-nineteenth century to 1970 was one in which the working class benefited from the growth in productivity. Incomes became more equal. This is the economic performance that many have come to regard as normal.

How this favourable situation arose is a fundamental question. It seems that a positive-feedback system was in operation. Rising incomes led to the demand for fancier manufactured goods (for example, bicycles then cars) and more services (such as travel, retail trade and medical care). These created markets that encouraged technological change and led to jobs that were performed more effectively by educated people[7].

The need for educated workers led to the expansion of state provision of education. The increasing number of educated people prompted the invention of technologies that took advantage of education[8]. Those technologies led to further demand for education. At the same time, the public provision of infrastructure — roads and airports, for instance — was crucial for the development of industries involving cars and aircraft. Public support for research in medicine, agriculture and technologies with military applications, such as electronics and aircraft, underlaid many advances. The welfare state helped to spread the benefits of this economic development across the population.

The upshot was a pattern of economic growth in which technical progress benefited most people in the West.

The same was not true in Asia and Africa. Before the Industrial Revolution, China and India had the largest manufacturing sectors in the world because they had the largest populations, and nations were mostly self-sufficient in the pre-globalization era. As the Industrial Revolution gathered pace, Britain's share of goods manufactured worldwide increased, reaching a peak of about one-quarter in the late nineteenth century. Western Europe's share and that of North America also increased. In the same period, the shares of India and China collapsed. This drop represented absolute de-industrialization and not simply shifting percentages.

The technological revolution that spread prosperity in the West created modern 'underdeveloped countries' in the East (that is, Asia, Africa and South America). It converted them into economies that exported solely primary products — wheat, rice, bauxite, oil — rather than secondary ones such as cloth and porcelain.

By the 1830s, technological progress in the West meant a bleak future of work elsewhere.

The problem-ridden present

The past four decades have seen many job losses in the manufacturing sector in Western countries, static or falling real wages, and rising inequality as the gains from growth accrue to the top 1%. Did the 'new normal' end in 1970, or are the recent trends just a blip? Might what was 'normal' in 1850–1970 return soon — that is, the concurrent advance of productivity and wages?

Some people believe that the feedback loops between education and technology will kick in again, generating new knowledge-based, high-income jobs in the West to replace lost manufacturing jobs. Computers and robots will save us.

I am more pessimistic. The rise in real wages that began in the mid-nineteenth century and tracked the rise in output per worker ended in the 1970s (see 'Trends in work, pay and manufacturing'). Real wages rose at a slower rate than productivity in the 1980s and 1990s — or stagnated

altogether, as in the United States. In some cases (for example, the United Kingdom) wages have actually been falling in real terms over the past decade. A deviation of this magnitude from the trend suggests that the new pattern may not be transitory.

Similarly, the rebound in overall inequality in mature economies, such as the United States, over the past 40 years is unprecedented. Inequality rose in many countries as they industrialized and fell thereafter — this trend is called a Kuznets curve (after the Nobel laureate Simon Kuznets)[9]. The rise in inequality since 1970 has shown that this is a reversible feature of economic history.

Inequality is an area that has seen much recent research, with large data sets assembled and interrogated. Some scholars have focused on the share of total income going to the top 1% or 5%[10]. Others use indices that incorporate information from every level of the income distribution[11]. How we interpret the results depends on our breadth of vision. A common pattern in many countries is a fall in inequality from the early twentieth century to the 1970s and then a rise. This is true of the United States, the United Kingdom and China, for instance. At the global level, inequality increased steadily from 1820 to 1990 and then declined slightly. This pattern takes into account inequality between countries as well as within. Rising per capita incomes in the West in phase two increased global inequality. In phase three, global inequality fell even though inequality increased in many rich and poor countries[12].

Why are the feedback loops that led to general prosperity in the West between 1850 and 1970 seemingly inoperative now[13, 14, 15]? A big change is the industrialization of Asia — first Japan starting in the 1870s, then South Korea and Taiwan since the Second World War, and now China (see 'Trends in work, pay and manufacturing'). These countries have supplanted Western nations as the low-cost producers of manufactured goods. Trade flows have reversed, with Asia shipping textiles and steel to Europe rather than the other way around. Technological progress in Asia has raised incomes and levels of employment dramatically in the region.

The future of work to someone born in China in 1990 is bright indeed —

provided that the country can avoid environmental crises and resource depletion.

Globalization means that Asia's bright future causes havoc elsewhere. Imports of cheap Japanese steel and vehicles caused the collapse of the rust belt in the United States and its counterparts in Western Europe (with Germany as something of an exception). Western de-industrialization was the flip side of the East Asian miracles. And cheap Chinese imports may benefit Africans as consumers, but could blight their employment prospects as African industries struggle to compete. Indeed, China is now purchasing large areas of land in Africa to guarantee access to food and minerals. It is hard to believe that manufacturing or information technology will ever recover in the West, no matter how many robots are installed, visas rescinded, trade agreements ripped up or walls built.

We cannot forecast the future without an understanding of the relationships between science, technology and the economy, because technical change is such an important determinant of the future. I have studied these questions for the Industrial Revolution using business accounts and histories of inventions. The steam engine, for instance, was an application of seventeenth-century science (the discoveries that the atmosphere has weight and that condensing steam creates a vacuum). By contrast, the cotton mills owed little to science and much to attempts to cut costs of relatively expensive employment[16].

How has the balance between knowledge and incentives evolved? The more technology advances in response to economic incentives rather than 'random' scientific discoveries, the more feasible it is to direct the course of technical progress to benefit more people. Furthermore, the cotton mills of the Industrial Revolution increased the demand for workers without education, whereas more-recent technology requires more education. Why the difference? Will the recent trend of needing educated workers persist? If not, then the hope that a knowledge-based future will make everyone better off is doomed.

Journal name:
Nature
Volume:

550,
Pages:
321–324
Date published:
(19 October 2017)
DOI:
doi:10.1038/550321a

Supplementary information

PDF files

1. Supplementary Information 550321a (49K)

Comments

Comments

There are currently no comments.

The second Renaissance

18 October 2017

Ian Goldin calls on scientists to help society to weather the disruptive transformations afoot.

Jay Shaw Baker/NurPhoto/Getty

Workers protest in London in February.

The Renaissance that began in Europe in the mid-1400s and ended in the early 1500s brought a radical transformation of the sciences, the humanities and politics. Building on the invention of the printing press and cheap paper, information was democratized, there was a hunger for literacy and the Catholic Church's near-monopoly on knowledge was challenged. The

resulting breakthroughs took Europe from being one of the more backward regions of the world to being the most advanced by far, within just 80 years.

But it ended in tears. Extremists, pointing to growing inequalities and the corruption of the elite, called for a return to spiritual values. In Italy, thousands of artworks and books were burned, branded as irreverent. Across Europe, rising intolerance of scientists, intellectuals, foreigners and ethnic minorities became the norm, with religious wars and inquisitions playing out over the following centuries.

In my view, many parts of the world are now in the middle of a second Renaissance. This one is seeing even faster change than the last, and across the entire globe. History tells us that it will be disruptive. It will bring immense benefits and it will be highly destabilizing. We should expect more extremism and the rise of potentially catastrophic risks.

Innovation today is happening faster than ever, driven by the unlocking of individual and collective abilities in a booming population. On average, literacy levels, life expectancy and incomes have soared. Flows of goods, services, money, people and, most importantly, ideas across national borders — globalization — has unleashed unprecedented progress and a scientific and broader renaissance. They have also brought growing interdependence and new risks[1, 2].

The Internet helps to harness the global capacity for connectivity and innovation, but also brings us malware, cybercrime and the sacrifice of privacy. Airports are crucial to international integration of science and commerce, but they can also be super-spreaders of pandemics — just as explorers to the new world brought with them fatal diseases. Financial hubs create fresh opportunities for economies to prosper, but they simultaneously allow a financial crisis in one country to destroy jobs and pensions in distant parts of the world[3].

The tension between individual success and collective collapse is growing. As more people escape poverty and climb the energy curve, climate change and biodiversity loss accelerate. As more people benefit from better nutrition, ocean fisheries are at risk of collapse and forests are destroyed for cattle. Improvements in global health could soon be threatened by rapidly rising

antibiotic resistance.

Accelerating technological change will provide solutions for many challenges, from cancer to cleaner sources of energy. But our politics and our institutions are locked in past models that are increasingly unfit for purpose. Deep ethical issues arising from genomics research and the potential dangers of biological pathogens are not being adequately addressed. Improvements in computing and artificial intelligence will kill off many jobs. Breakthroughs in nanotechnology and materials science, augmented and virtual reality, 3D printing and other applications will also radically disrupt society. All are barely understood by politicians and most citizens.

Growing gap

Inequality is rising in almost all countries that are experiencing rapid change. The faster the pace of change, the more rapidly people are being left behind. The share of wealth enjoyed by the top 1% of citizens in the advanced economies has risen from an average of 17% in the late 1980s to more than 23% today (it is 39% in the United States). Countries starting from a more equal distribution of wealth, such as China and the nations of the former Soviet Union, have seen the most rapid rise in inequality[4].

John MacDougall/AFP/Getty

A robot sweeps food towards two dairy cows at an 'automated farm' exhibit at a food and agriculture fair.

Far from levelling the playing field and making the world more 'flat', as is alleged, globalization is making it more mountainous. Place matters more than ever. Cities hold a growing share of wealth and job opportunities, but it is increasingly difficult to afford to live in them. In dynamic ones, such as London, San Francisco, Paris, Berlin, Shanghai and Mumbai, house prices relative to average incomes are at an all-time high.

Technological change is already a key contributor to the growing inequality[5]. This is likely to be exacerbated as machine intelligence and automation take over a growing share of routine tasks in manufacturing and services, including retail, administration and call centres. Over the next 20 years, up to half of US jobs, one-third of jobs in the United Kingdom and the European Union and two-thirds of jobs in China and Mexico may be replaced by computers and robotics[6].

The future will bring new jobs, but their number will be small relative to those lost. And the quality of many of these new jobs will be inferior, in terms of the conditions of work and pay. Although it is tempting to imagine a world in which machines do dangerous and routine jobs, leaving more creative, stimulating and well-paid jobs for humans, this may not come to pass. The pace and scale of technological disruption, which far exceeds that of any previous industrial revolution, raises doubts about our capacity to keep up. We may not be able to redistribute enough funds from the wealthy, or come up with sufficiently creative changes to our systems of work and social safety, to prevent a further rise in inequality[6, 7]. Although this is a major issue for advanced economies, it is even more so for developing countries, because automation may remove key rungs of semi-skilled tasks from the development ladder.

Growing interdependence and complexity also mean that our politicians are increasingly unable to protect or shape our futures. Rather than pursue more cooperative politics, which enhance the benefits of connectivity and mitigate the risks, politicians increasingly blame foreigners and immigrants for the ills. This is profoundly misguided. Immigrants contribute disproportionately to the dynamism of our societies, as can be seen in the talent pool of leading universities, Silicon Valley firms, Nobel prizewinners and patent holders[8].

Those living in the fast-changing cosmopolitan cities of the world are embracing globalization and change: most Londoners did not support Britain's decision to exit from the European Union; people living in dynamic cities tended not to support US President Trump. The populist call for protectionism is driven by those in the United States who fear being left behind. This is not an irrational fear: as is evident from inequality, unemployment and health data, some people are being left behind. There is a correlation, for example, between those who voted for Trump and those whose jobs are vulnerable to having machines take over their jobs[9].

Alongside their anxieties about being left behind by globalization comes a deep mistrust of the 'experts' in charge of the global systems, and a rejection of evidence. Paradoxically, although we know more than ever, rising complexity and speed of change mean that experts are likely to be wrong more often. The financial system, for example, is home to numerous highly

qualified experts, housed in a formidable array of powerful institutions, who are handsomely paid to secure economic stability. Yet, as the 2008 financial crisis demonstrated, they have proved dismally unequal to the task. Similarly, experts in the European Commission seem to have failed to control reporting of emissions from leading car manufacturers. Little wonder that trust in authority has been severely eroded. When the evidence threatens entrenched elites, scepticism regarding expertise becomes particularly poisonous. Trump's dismissal of the science of climate change is an egregious example of this trend.

The flourishing of science was contested in the original Renaissance, too. Printing presses provided the means for experts and intellects to share knowledge, but also allowed fake news to flourish. In Medici Florence, fundamentalist Italian preacher Girolamo Savonarola circumvented the authority of popes and princes with the mass production of one-page pamphlets — the equivalent of today's tweets. Both Savonarola and the clergy denied that Earth went around the Sun, and that the heart was a pump.

Although history does not repeat itself, it does rhyme. In the United Kingdom, campaigners successfully used social media to convince people to support Brexit even when it was against their interests, as in the case of farmers who receive subsidies from the European Union. In the United States, social media that propagated fears rather than facts played a key part in shaping the outcome of the 2016 presidential election[10].

Rapid response

As societies change more rapidly, flexibility becomes more important. For individuals, it becomes more necessary to move to where the jobs are and to reskill. For governments, it is crucial to renew infrastructure and social safety nets. Regulatory frameworks also need to evolve rapidly, to address a widening range of risks — from the genetic enhancement of humans to geoengineering.

Unfortunately, at a time when the need to renew and invest in the future is rising, the ability of governments to keep pace with change is being

undermined. The use of off-shore tax havens — notably by companies at the frontier of technological change — as well as competition by governments to attract increasingly mobile individuals and companies by reducing taxes, together with austerity policies, have reduced the capacity of governments to invest in health, education, infrastructure, social security, research and other expenditures[11]. Lower investment leads to lower growth and political gridlock, as politicians fight over the allocation of fixed or diminishing resources.

Stronger safety nets are necessary to prevent poor and vulnerable individuals and families from being undermined by technological and other changes. If not, social cohesion will be eroded, fanning the flames of populist push-back against change and all things foreign.

Some Silicon Valley billionaires, fearing revolt against the growing wage gap, along with some social activists, have called for the introduction of a Universal Basic Income (UBI) for people working and not. But a UBI is not a panacea. The Organisation for Economic Co-operation and Development has shown that the policy could, perversely, increase inequality and poverty. And, because jobs are so important to our status and self-worth, having money alone does not protect against the increases in morbidity, criminal activity, opioid and alcohol abuse that have been associated with unemployment[12].

Instead, we need a broader change in attitudes towards work. We need to remove the stigmas associated with part-time employment, retirement and volunteer work. We should nurture a greater respect and pay for creative, caring and home-based activities.

There are reasons for optimism. There are more scientists alive today than all those who previously lived; citizen science adds millions more. As well as more minds at work, there are more-diverse collaborations, thanks to greater gender equality and the participation of more nations and peoples. The probability of unlocking mysteries and finding solutions to great challenges is rising, as is the global dissemination of the benefits. Cross-border collaborative projects, from the CERN particle-physics laboratory near Geneva, Switzerland, to the Human Genome Project, highlight the benefits of

cooperative activity, in stark contrast to isolationist politics.

Now, more than ever, scientists must engage and communicate, to ensure that science is not overrun by politics. Renaissance moments are associated with an intensifying battle of ideas. Scientists need to engage in this struggle over the development and application of their expertise and inventions.

In the first Renaissance, extremists won; reason and evidence did not prevail. In our second Renaissance, knowledge and enquiry must find a way to conquer prejudice and ignorance. Scientists know that they can never progress through isolationism or ignorance. Nor can our societies.

Journal name:
    Nature
Volume:
    550,
Pages:
    327–329
Date published:
    (19 October 2017)
DOI:
    doi:10.1038/550327a

Comments

6 comments

1. *Pentcho Valev* • 2017-10-20 06:53 AM
   Up until recently there was still hope that physics might be resurrected. Scientists had decided to abandon Einstein's absurd spacetime: Nima Arkani-Hamed (06:09): "Almost all of us believe that space-time doesn't really exist, space-time is doomed and has to be replaced by some more primitive building blocks." https://www.youtube.com/watch?v=U47kyV4TMnE Nobel Laureate David Gross observed, "Everyone in string theory is convinced...that spacetime is doomed. But we don't know what it's replaced by." https://www.edge.org/response-detail/26563 What

scientific idea is ready for retirement? Steve Giddings: "Spacetime. Physics has always been regarded as playing out on an underlying stage of space and time. Special relativity joined these into spacetime... [...] The apparent need to retire classical spacetime as a fundamental concept is profound..." https://www.edge.org/response-detail/25477 "Splitting Time from Space - New Quantum Theory Topples Einstein's Spacetime. Buzz about a quantum gravity theory that sends space and time back to their Newtonian roots." https://www.scientificamerican.com/article/splitting-time-from-space/ "And by making the clock's tick relative - what happens simultaneously for one observer might seem sequential to another - Einstein's theory of special relativity not only destroyed any notion of absolute time but made time equivalent to a dimension in space: the future is already out there waiting for us; we just can't see it until we get there. This view is a logical and metaphysical dead end, says Smolin." http://www.guardian.co.uk/books/2013/jun/10/time-reborn-farewell-reality-review Spacetime is a consequence of Einstein's constant-speed-of-light postulate, and since the combination "true postulate, wrong consequence" is forbidden by logic, scientists were actually moving towards the conclusion that the postulate, the "root of all the evil" in fundamental physics, is false: "Special relativity is based on the observation that the speed of light is always the same, independently of who measures it, or how fast the source of the light is moving with respect to the observer. Einstein demonstrated that as an immediate consequence, space and time can no longer be independent, but should rather be considered a new joint entity called "spacetime." http://community.bowdoin.edu/news/2015/04/professor-baumgarte-describes-100-years-of-gravity/ Then extremely dishonest people called LIGO came to power in physics, "discovered" (actually, faked) gravitational waves (ripples in spacetime), and all hope for resurrection of physics died. If you have ripples in spacetime, you cannot claim anymore that "space-time doesn't really exist, space-time is doomed and has to be replaced", can you? Pentcho Valev

2. *Pentcho Valev* • 2017-10-21 06:32 AM

Towards a uniform LIGO science (any theory that in some way contradicts LIGO fakes is doomed): "The simultaneous detection of gravitational waves and light from a cosmic collision has left a few theories of dark matter and dark energy dead in its wake. These theories require gravitational waves - ripples in the fabric of space-time - to travel slower or even faster than the speed of light. But recent observations have proved otherwise. [...] The signals from the smash-up, now named GW170817, show that gravitational waves do indeed travel at the speed of light, to an accuracy of about one in 1 million billion. This seriously undermines some theories that modify Einstein's general relativity to explain the mysterious dark energy thought to be driving the accelerated expansion of our universe, and the invisible dark matter that we detect only through its gravitational pull on ordinary matter." https://www.newscientist.com/article/2151020-dark-energy-survives-neutron-star-crash-test-while-rivals-fail/ Pentcho Valev

3. *Pentcho Valev* • 2017-10-19 06:50 AM

    "Look, my lad, I know a dead parrot when I see one, and I'm looking at one right now." https://www.youtube.com/watch?v=RQhVLHu8HRk Physicists know a dead science when they see one, and they've been looking at one since January 2001: Joao Magueijo, Faster Than the Speed of Light, p. 250: "Lee [Smolin] and I discussed these paradoxes at great length for many months, starting in January 2001. We would meet in cafés in South Kensington or Holland Park to mull over the problem. THE ROOT OF ALL THE EVIL WAS CLEARLY SPECIAL RELATIVITY. All these paradoxes resulted from well known effects such as length contraction, time dilation, or E=mc^2, all basic predictions of special relativity. And all denied the possibility of establishing a well-defined border, common to all observers, capable of containing new quantum gravitational effects." http://www.amazon.com/Faster-Than-Speed-Light-Speculation/dp/0738205257 Neil Turok: "It's the ultimate catastrophe: that theoretical physics has led to this crazy situation where the physicists are utterly confused and seem not to have any predictions at all." http://www2.macleans.ca/2013/09/05/perimeter-institute-and-the-crisis-in-modern-physics/ Frank Close: "In recent

years, however, many physicists have developed theories of great mathematical elegance, but which are beyond the reach of empirical falsification, even in principle. The uncomfortable question that arises is whether they can still be regarded as science. Some scientists are proposing that the definition of what is "scientific" be loosened, while others fear that to do so could open the door for pseudo-scientists or charlatans to mislead the public and claim equal space for their views." http://www.prospectmagazine.co.uk/features/what-happens-when-we-cant-test-scientific-theories Sabine Hossenfelder: "Many of my colleagues believe this forest of theories will eventually be chopped down by data. But in the foundations of physics it has become extremely rare for any model to be ruled out. The accepted practice is instead to adjust the model so that it continues to agree with the lack of empirical support." http://www.nature.com.proxy.readcube.com/nphys/journal/v13/n4/f Sabine Hossenfelder (Bee): "The criticism you raise that there are lots of speculative models that have no known relevance for the description of nature has very little to do with string theory but is a general disease of the research area. Lots of theorists produce lots of models that have no chance of ever being tested or ruled out because that's how they earn a living. The smaller the probability of the model being ruled out in their lifetime, the better. It's basic economics. Survival of the 'fittest' resulting in the natural selection of invincible models that can forever be amended." http://www.math.columbia.edu/~woit/wordpress/?p=9375 Peter Woit: "As far as this stuff goes, we're now not only at John Horgan's "End of Science", but gone past it already and deep into something different." http://www.math.columbia.edu/~woit/wordpress/?p=7266 "But instead of celebrating, physicists are in mourning after a report showed a dramatic decline in the number of pupils studying physics at school. The number taking A-level physics has dropped by 38% over the past 15 years, a catastrophic meltdown that is set to continue over the next few years. The report warns that a shortage of physics teachers and a lack of interest from pupils could mean the end of physics in state schools. Thereafter, physics would be

restricted to only those students who could afford to go to posh schools. Britain was the home of Isaac Newton, Michael Faraday and Paul Dirac, and Brits made world-class contributions to understanding gravity, quantum physics and electromagnetism - and yet the British physicist is now facing extinction. But so what? Physicists are not as cuddly as pandas, so who cares if we disappear?" http://www.guardian.co.uk/science/2005/nov/22/schools.g2 Peter Woit: "If, as seems increasingly all too possible, we're now at an endpoint of fundamental physics, with the field killed off by a pseudo-scientific argument..." http://www.math.columbia.edu/~woit/wordpress/?p=9444 Peter Woit: "I think the worst thing that has happened to theoretical physics over the past 25 years is this descent into ideology, something that has accelerated with the multiverse mania of the last 10-15 years." http://www.math.columbia.edu/~woit/wordpress/?p=9375 The last quotation is correct, except for the number 25 - it should be replaced by 112 (note the "embarrassing question" that will have to be answered soon): "This paper investigates an alternative possibility: that the critics were right and that the success of Einstein's theory in overcoming them was due to its strengths as an ideology rather than as a science. The clock paradox illustrates how relativity theory does indeed contain inconsistencies that make it scientifically problematic. These same inconsistencies, however, make the theory ideologically powerful. [...] The gatekeepers of professional physics in the universities and research institutes are disinclined to support or employ anyone who raises problems over the elementary inconsistencies of relativity. A winnowing out process has made it very difficult for critics of Einstein to achieve or maintain professional status. Relativists are then able to use the argument of authority to discredit these critics. Were relativists to admit that Einstein may have made a series of elementary logical errors, they would be faced with the embarrassing question of why this had not been noticed earlier. Under these circumstances the marginalisation of antirelativists, unjustified on scientific grounds, is eminently justifiable on grounds of realpolitik. Supporters of relativity theory have

protected both the theory and their own reputations by shutting their opponents out of professional discourse. [...] The triumph of relativity theory represents the triumph of ideology not only in the profession of physics bur also in the philosophy of science." Peter Hayes, The Ideology of Relativity: The Case of the Clock Paradox http://www.informaworld.com/smpp/content~content=a909857880 And when ideology replaces science, bureaucrats replace scientists of course: Mike Alder: "It is easy to see the consequences of the takeover by the bureaucrats. Bureaucrats favour uniformity, it simplifies their lives. They want rules to follow. They prefer the dead to the living. They have taken over religions, the universities and now they are taking over Science. And they are killing it in the process. The forms and rituals remain, but the spirit is dead. The cold frozen corpse is so much more appealing to the bureaucratic mind-set than the living spirit of the quest for insight. Bureaucracies put a premium on the old being in charge, which puts a stop to innovation. Something perhaps will remain, but it will no longer attract the best minds. This, essentially, is the Smolin position. He gives details and examples of the death of Physics, although he, being American, is optimistic that it can be reversed. I am not. [...] Developing ideas and applying them is done by a certain kind of temperament in a certain kind of setting, one where there is a good deal of personal freedom and a willingness to take risks. No doubt we still have the people. But the setting is gone and will not come back. Science is a product of the renaissance and an entrepreneurial spirit. It will not survive the triumph of bureacracy. Despite having the infrastructure, China never developed Science. And soon the West won't have it either." https://www.highbeam.com/doc/1G1-172684821.html Pentcho Valev

4. *Pentcho Valev* • 2017-10-18 04:30 PM

   Fundamental physics is paralyzed, even killed, by blind faith in false principles. The falsehood of Einstein's constant-speed-of-light postulate is easy to prove but I'm not going to do this here. Let me just call the attention, by quoting Joao Magueijo, to the validity of the following conditional: If Einstein's constant-speed-of-light postulate is false, fundamental physics is dead. "The speaker Joao

Magueijo, is a Reader in Theoretical Physics at Imperial College, London and author of Faster Than the Speed of Light: The Story of a Scientific Speculation. He opened by explaining how Einstein's theory of relativity is the foundation of every other theory in modern physics and that the assumption that the speed of light is constant is the foundation of that theory. Thus a constant speed of light is embedded in all of modern physics and to propose a varying speed of light (VSL) is worse than swearing! It is like proposing a language without vowels." http://www.thegreatdebate.org.uk/VSLRevPrnt.html "...Dr. Magueijo said. "We need to drop a postulate, perhaps the constancy of the speed of light." http://www.nytimes.com/2002/12/31/science/e-and-mc2-equality-it-seems-is-relative.html "But the researchers said they spent a lot of time working on a theory that wouldn't destabilise our understanding of physics. "The whole of physics is predicated on the constancy of the speed of light," Joao Magueijo told Motherboard. "So we had to find ways to change the speed of light without wrecking the whole thing too much." http://www.telegraph.co.uk/technology/2016/12/06/speed-light-discovered/ Joao Magueijo, Faster Than the Speed of Light, p. 250: "Lee [Smolin] and I discussed these paradoxes at great length for many months, starting in January 2001. We would meet in cafés in South Kensington or Holland Park to mull over the problem. THE ROOT OF ALL THE EVIL WAS CLEARLY SPECIAL RELATIVITY. All these paradoxes resulted from well known effects such as length contraction, time dilation, or E=mc^2, all basic predictions of special relativity. And all denied the possibility of establishing a well-defined border, common to all observers, capable of containing new quantum gravitational effects." http://www.amazon.com/Faster-Than-Speed-Light-Speculation/dp/0738205257 Pentcho Valev

5. *Pentcho Valev* • 2017-10-18 05:19 PM

   Another science killer is the false second law of thermodynamics. Systems violating the second law are commonplace but scientists always turn the blind spot of the eye to them. Here is vigorous motion of water in an electric field, obviously able to produce work

- e.g. by rotating a waterwheel: "The Formation of the Floating Water Bridge including electric breakdowns" https://www.youtube.com/watch?v=17UD1goTFhQ "The water movement is bidirectional, i.e., it simultaneously flows in both directions." https://www.wetsus.nl/home/wetsus-news/more-than-just-a-party-trick-the-floating-water-bridge-holds-insight-into-nature-and-human-innovation/1 The work (rotating a waterwheel) will be done at the expense of what energy? The first hypothesis that comes to mind is: At the expense of electric energy. The system is, essentially, an electric motor. However close inspection would suggest that the hypothesis is untenable. Scientists use triply distilled water to reduce the conductivity and the electric current passing through the system to minimum. If, for some reason, the current is increased, the motion stops - such system cannot be an electric motor. If the system is not an electric motor, then it is a heat engine violating the second law of thermodynamics. Here arguments describing such heat engines as impossible, idiotic, etc. are irrelevant - the following conditional is valid: IF THE SYSTEM IS NOT AN ELECTRIC MOTOR, then it is a a heat engine violating the second law of thermodynamics. In other words, if the work is not done at the expense of electric energy, it is done at the expense of ambient heat. No third source of energy is conceivable. In the electric field between the plates of a capacitor, the same turbulent motion can be seen: " Liquid Dielectric Capacitor" http://www.youtube.com/watch?v=T6KAH1JpdPg In the capacitor system the rising water can repeatedly do work, e.g. by lifting floating weights. The crucial question is: The work (lifting floating weights) will be done at the expense of what energy? Obviously "electric energy" is not the correct answer - the capacitor is not an electric motor. Then the only possible answer remains "ambient heat". The system is a heat engine violating the second law of thermodynamics! Pentcho Valev

6. *Pentcho Valev* • 2017-10-19 07:03 AM

   Why scientists are unable to see the obvious violations of the second law of thermodynamics: Clifford Truesdell, The Tragicomical History of Thermodynamics, 1822-1854, p. 6: "Finally, I confess to a heartfelt hope - very slender but tough - that

even some thermodynamicists of the old tribe will study this book, master the contents, and so share in my discovery: Thermodynamics need never have been the Dismal Swamp of Obscurity that from the first it was and that today in common instruction it is; in consequence, it need not so remain." [...] p. 333: "Clausius' verbal statement of the "Second Law" makes no sense, for "some other change connected therewith" introduces two new and unexplained concepts: "other change" and "connection" of changes. Neither of these finds any place in Clausius' formal structure. All that remains is a Mosaic prohibition. A century of philosophers and journalists have acclaimed this commandment; a century of mathematicians have shuddered and averted their eyes from the unclean." https://www.amazon.com/Tragicomical-Thermodynamics-1822-1854-Mathematics-Physical/dp/1461394465 Jos Uffink, Bluff your way in the Second Law of Thermodynamics: "I therefore argue for the view that the second law has nothing to do with the arrow of time. [...] Before one can claim that acquaintance with the Second Law is as indispensable to a cultural education as Macbeth or Hamlet, it should obviously be clear what this law states. This question is surprisingly difficult. The Second Law made its appearance in physics around 1850, but a half century later it was already surrounded by so much confusion that the British Association for the Advancement of Science decided to appoint a special committee with the task of providing clarity about the meaning of this law. However, its final report (Bryan 1891) did not settle the issue. Half a century later, the physicist/philosopher Bridgman still complained that there are almost as many formulations of the second law as there have been discussions of it. And even today, the Second Law remains so obscure that it continues to attract new efforts at clarification." http://philsci-archive.pitt.edu/313/1/engtot.pdf Pentcho Valev

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Brazilian Amazon still plagued by illegal use of natural resources

Practices such as poaching and illegal logging are concentrated near inhabited areas and along rivers, study finds.

17 October 2017

Jeff Hutchens/Getty

An official with Brazil's environmental enforcement agency arrests poachers caught near Manaus.

Despite Brazil's efforts to safeguard the Amazon rainforest by establishing protected areas and boosting law enforcement, illegal use of the region's natural resources is still widespread, according to a study[1] published on 10

October in *PeerJ*.

The researchers looked at 4,243 law-enforcement records from between 2010 and 2015, across 118 federally protected areas of the Brazilian Amazon. Although the overall number of citations decreased over those five years, illegal activities still occurred in nearly every protected area. The analysis highlighted the need for improved monitoring and enforcement, says study co-author Érico Kauano, a conservation biologist at the Chico Mendes Institute for Biodiversity Conservation (ICMBio), the Brazilian agency responsible for the management of the federal protected areas.

Kauano and his colleagues grouped illegal activities into ten categories, and found that 37% of the infractions fell into the “suppression and degradation of vegetation” group, which included deforestation, logging of endangered tree species and the unauthorized use of fire. Illegal fishing was the next most common citation at 27%, followed by hunting at 18%. Most of the illegal activity occured in more accessible and densely populated areas.

Roads have a major role in opening up the tropics to colonization and exploitation[2]. Deforestation of the Brazilian Amazon increased after the construction of the Belém–Brasília Highway in the 1960s, and continued with the opening of the Trans-Amazonian Highway in 1970s. A 2014 study[2] using satellite images found that around 95% of the deforestation in Brazil’s Amazon occurred within 5.5 kilometres of a road and within 1 kilometre of a navigable river.

Caught in the act

The availability and use of government data are what sets this study apart from others, says Emilio Bruna, a tropical ecologist at the University of Florida in Gainesville, who was not involved in the study. Past studies, including a paper[3] published last month in *Biotropica* (where Bruna is editor-in-chief), struggled to obtain even the most basic information, such as how many staff members were employed by the agency that manages protected areas, and how much they were paid, Bruna says.

Data from efforts on the ground are important because, although remote-sensing instruments such as satellites can detect deforestation, for example, they fail to identify threats present beneath the forest canopy. Law-enforcement records, when available, can complement remote-sensing data sets, the study authors say.

“You can actually tell what it is they’re writing infractions for, and that’s valuable,” says Bruna. But he points out that, without knowing where law-enforcement efforts are being allocated, it’s only a partial picture. “It could be that the reason certain protected areas have the most infractions is because those are the places that are under the greatest threat,” he says. “Or it could be because that’s where the greatest enforcement is being focused.”

Greater enforcement

“We are still far from having adequate staff in the protected areas,” Kauano says. In 2014, a local news outlet reported that the Brazilian Institute of Environment and Renewable Natural Resources had only 47 agents to monitor environmental crimes in Amazonas, the country’s largest state in the Amazon region, which covers an area of about 1.6 million square kilometres.

Hiring more enforcement officials looks unlikely in the short term, however, owing to Brazil’s ongoing political and economic crisis, says Kauano. “What ICMBio seeks to do to overcome this is to prioritize some regions with greater problems.”

Bruna cautions against jumping to conclusions from the study’s results, however. “Not all infractions are created equal,” he says. It’s important to differentiate between a resident fishing out of season and a fishing charter operator. Bruna worries that some may look at this study and think that the people living near protected areas are the problem. But they aren’t the only ones breaking the law, he says. And the demand for the fruits of this illegal labour comes from all over the world.

Local people can, in fact, be part of the solution. There is some evidence that people living in or near protected areas are helping with conservation, says

Kauano. But he adds that the government needs to make a greater effort to work with local communities.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22830

Comments

Commenting is currently unavailable.

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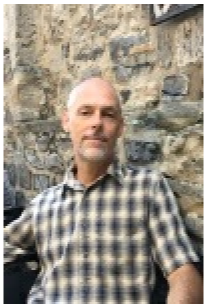


Ellie R.
Martinson

Give researchers a lifetime word limit

Brian C. Martinson[1] imagines how rationing the number of publications a scientist could put out might improve the scientific literature.

17 October 2017

A dirty truth pervades academic publishing: we write papers to gain credit in an academic marketplace. Almost a quarter of a century ago, academic worthies lamented that scholarly publications had become “the coins academics must use to get through the tollgates on their way to academic promotion” (D. Rennie and A. Flanagin *J. Am. Med. Assoc.* **271**, 469–471; 1994). In some cases, papers in flashy journals truly do bring in hard cash — reportedly more than US$40,000 at some universities in China. And plenty of people reading this will have felt they’d better squeeze a paper or two out soon to have any chance of getting their next grant proposal funded.

The purpose of authorship has shifted. Once, its primary role was to share knowledge. Now it is to get a publication — ‘pubcoin’ if you will. Authorship has become a valuable commodity. And as with all valuable commodities, it is bought, sold, traded and stolen. Marketplaces allow

unscrupulous researchers to purchase authorship on a paper they had nothing to do with, or even to commission a paper on the topic of their choice. ‘Predatory publishers’ strive to collect fees without ensuring quality.

I have spent much of my career studying how academic and clinical workplaces influence how carefully researchers conduct their studies. The commodification of authorship encourages all manner of corner-cutting, sloppiness in research, and other degradations in the quality of publications, not to mention an obvious motive for plagiarism. A quest for high-profile papers leads researchers to favour a spectacular result, even if it is specious. Authors cite themselves to boost the impact of publications, and cite colleagues to curry favour.

At this point, it is hard even to envisage a world in which the communication of knowledge could return to its rightful place as the focus of academic authorship. But if we cannot imagine something, we cannot attain it. So let me try. Imagine a world in which each scientist is allotted a fixed number of words that they can publish over her or his career. I’m not the first person to suggest this: the Australian writer Michael McGirr has proposed a word limit for every person.

What would happen? Might authorship regain its original purpose?

Lifetime limits would create a natural incentive to do research that matters. Researchers would have to ask themselves, “Is this project I’m pursuing worth the words it will cost me?” I see several articles in my own CV that did not contribute much knowledge to the world. I cannot help but think that I might have pursued better questions had a word limit been in place.

Ideally, limits would encourage researchers to ensure that research is conducted with the utmost care. (Imagine losing part of your allotment of words to a paper that is discredited or even retracted.) This would provide a counterweight to the pressure to publish quickly for priority. It would also lead to increased value being placed on concision and clarity, improving readability and efficiency. Honorary authorship would become much less attractive.

With less time needing to be spent on papers of low quality or containing

little new information, readers and editors would be able to give the smaller number of articles more attention. Editorial workload would be reduced by virtue of the lower volume and the higher quality of material. This might reduce editorial costs, enhance quality, and quite possibly enhance the job satisfaction and quality of life of editors and readers. Predatory publishers would vanish.

With a boost in the quality of scientific papers, the communal work of peer review would get easier. Individual researchers would be asked to carry out fewer reviews. Reviewing invitations would be for work of higher quality, making the job more enjoyable and less aggravating. And knowing the stakes for the authors in expending their precious words, reviewers themselves might be inclined to put more time and effort into their reviews, further improving quality.

The task of evaluating candidates for jobs, advancement and prizes would become less scattershot. With fewer publications per candidate, promotion and tenure committees could become less reliant on tallying counts of first-authored publications, and devote time to reading and critiquing the published work. This, in turn, should reduce their use of journal impact factors as proxies for quality.

Limits would of course bring a new set of problems: if we don't also address our own cognitive biases and penchant for compelling narratives, word limits could exacerbate tendencies to publish only positive findings, leading researchers to explore blind alleys that others' negative results could have illuminated. Researchers might skimp on a full description of caveats, previous work and methods. Some subjects and pursuits might be inherently wordier than others. Exceptions might have to be made for experts such as statisticians and bioinformaticians whose skills are required on many papers — but perhaps this would boost the quality of collaborations. Perhaps researchers could apply for word bonuses for careful reproductions, cautious interpretations and meticulously described methods.

Would these drawbacks be worse than the current incentives to publish as much as you can? We have lost sight of information sharing as the primary reason for publishing. Perhaps my flight of fancy is a rose-tinted remembrance of times past. Or perhaps it can serve as a guide to restore the

exchange of ideas to its rightful, pithy, place.

Journal name:
Nature
Volume:
550,
Pages:
303
Date published:
(19 October 2017)
DOI:
doi:10.1038/550303a

Comments

Commenting is currently unavailable.

Japanese research leaders warn about national science decline

Concern mounts over budget cuts and other changes that undermine basic science.

17 October 2017 Corrected:

1. 20 October 2017

Toru Hanai/Reuters

People gather for a rally in Fukushima, Japan, for Prime Minister Shinzo Abe and the Liberal Democratic Party.

As Japan heads towards a national election on 22 October, scientific leaders worry that the outcome will do little to address long-standing concerns about the country's deteriorating research landscape. They say that a decline in funding and a shift away from basic research has undermined Japan's capacity to compete against both established scientific powerhouses and emerging ones such as China.

Since 25 September, when Prime Minister Shinzo Abe called for a snap election, science has barely featured in the campaign. Debate has focused on the government's plan to amend the constitution and increase taxes. The latest polls suggest that Abe's conservative Liberal Democratic Party could lose some seats, but will retain enough to lead a coalition government.

If Abe is re-elected, he says, his government will pursue an innovation agenda. At a meeting of global science leaders in Kyoto on 1 October, Abe reaffirmed his pledge to turn Japan into "a cradle of innovation" by cutting regulations that impede new technologies.

Despite Abe's lofty ambitions, the ruling party coalition has decreased the science and technology budget by more than 5% overall since it came to power in 2012. And the budget for universities has dropped by about 1% a year for a decade. "This has been pointed out as the major cause of the deterioration of research performance and, eventually, the global rank of Japanese universities," says Takashi Onishi, president of Toyohashi University of Technology and a former president of the Science Council of Japan, which advises the government. In the past two decades, the country's share of highly cited papers has stagnated, whereas those of many other leading nations are rising, according to publisher Elsevier's Scopus database.

In an attempt to elevate Japan's top research universities, the government has introduced reforms that categorize institutions according to their research or teaching focus, and that allocate funding on the basis of performance. The government wants leading research institutions to compete globally for the best students and faculty.

Atsushi Sunami, a science-policy specialist at the National Graduate Institute for Policy Studies (GRIPS) in Tokyo, agrees with this aim, but says that to succeed, the government will need to increase its research funding. And

money alone will not be enough, says Hiroshi Nagano, also a science-policy specialist at GRIPS. For universities to become world class, they need autonomy to decide their research and teaching focus, he says. “The current policy is oriented in the opposite direction.”

Basic research left behind

Changes to the university system implemented by Abe’s government are designed to make academia more responsive to the needs of society and industry, in the hope that it will boost low private-sector investment in research. Although scientists broadly encourage this increased collaboration, some say that it has compromised support for basic research. “The government should focus on the development of basic research to supply seeds or ideas to applied sciences,” says Onishi.

Science leaders point to other big concerns about the future of Japanese research. Michinari Hamaguchi, head of the Japan Science and Technology Agency in Tokyo, says that the domestic workforce will be insufficient to keep up with changes in science, technology and innovation, given the country’s rapidly ageing population. He says that policies are urgently needed to encourage more women and foreigners into science and to boost the number of students in doctoral courses, which has dropped by 18% since 2003.

Students who pursue research careers are finding it harder to get jobs. Budget cuts have depleted permanent research positions at universities, and fewer younger researchers are securing permanent posts: the number of research associates on short-term contracts more than doubled from 2007 to 2013.

Biologist and 2016 Nobel prizewinner Yoshinori Ohsumi has warned that the situation for young researchers will jeopardize the country’s chances of winning future Nobel prizes. Japan has the second-highest number of science laureates in the twenty-first century after the United States — but, Ohsumi says, that record is unlikely to hold.

Journal name:

Nature
Volume:
550,
Pages:
310–311
Date published:
(19 October 2017)
DOI:
doi:10.1038/550310a

Corrections

Corrected:

An earlier version of this story misspelled the name of Michinari Hamaguchi. Also, he is based in Tokyo, not in Kawaguchi.

Comments

Comments

There are currently no comments.

Reboot for the AI revolution

17 October 2017

As artificial intelligence puts many out of work, we must forge new economic, social and educational systems, argues Yuval Noah Harari.

Laura Lezza/Getty

A robot conducts the Orchestra Filarmonica di Lucca at Teatro Verdi in Pisa, Italy, this September.

The ongoing artificial-intelligence revolution will change almost every line of work, creating enormous social and economic opportunities — and challenges. Some believe that intelligent computers will push humans out of the job market and create a new 'useless class'; others maintain that

automation will generate a wide range of new human jobs and greater prosperity for all. Almost everybody agrees that we should take action to prevent the worst-case scenarios.

The automation revolution is emerging from the confluence of two scientific tidal waves. Computer scientists are developing artificial intelligence (AI) algorithms that can learn, analyse massive amounts of data and recognize patterns with superhuman efficiency. At the same time, biologists and social scientists are deciphering human emotions, desires and intuitions. The merger of infotech and biotech is giving rise to algorithms that can successfully analyse us and communicate with us, and that may soon outperform human doctors, drivers, soldiers and bankers in such tasks. These algorithms could eventually push hundreds of millions out of the job market.

Governments might decide to deliberately slow down the pace of automation, to lessen the resulting shocks and allow time for readjustments. But it will probably be both impossible and undesirable to prevent automation and job loss completely. That would mean giving up the immense positive potential of AI and robotics. If self-driving vehicles drive more safely and cheaply than humans, it would be counterproductive to ban them just to protect the jobs of taxi and lorry drivers.

A more sensible strategy is to create new jobs. In particular, as routine jobs are automated, opportunities for new non-routine jobs will mushroom. For example, general physicians who focus on diagnosing known diseases and administering familiar treatments will probably be replaced by AI doctors. Precisely because of that, there will be more money to pay human experts to do groundbreaking medical research, develop new medications and pioneer innovative surgical techniques.

This calls for economic entrepreneurship and legal dexterity. Above all, it necessitates a revolution in education.

Lifelong learning

To make use of the new opportunities, people will need radical, lifelong

retraining. The AI revolution won't be a single event after which the job market and the educational system will settle into a new equilibrium. Rather, it will be a cascade of ever-bigger disruptions. Even today, few employees expect to work in the same job for their entire life (see go.nature.com/2ymdvjs). By 2050, not just the idea of 'a job for life', but even the idea of 'a profession for life' might seem antediluvian. It will become increasingly difficult to know what to teach schoolchildren and university students.

Predicting the future was never easy. If you lived in China 1,000 years ago, there were many things you didn't know: the empire might collapse in 50 years; the Khitans might invade, or a new plague might kill millions. Nevertheless, you did know that most people would still work as farmers and weavers, rulers would still need men to fight in their armies and administer their taxes, women would still have few opportunities beyond marriage and life expectancy would still be about 40 years.

LISTEN

Reporter Benjamin Thompson finds out how lessons from the past can help explore the future of work.

You may need a more recent browser or to install the latest version of the Adobe Flash Plugin.

Hence, in 1017, poor Chinese parents taught their children how to plant rice or weave silk, and wealthier parents taught their boys how to read and write, or to fight on horseback, and their girls to be modest and obedient housewives. It was obvious that these skills would still be needed. In 2017, by contrast, we have no such certainties about the future of jobs, gender, economics or even death.

Human psychology, too, might turn out to be a key hurdle. Change is always stressful. Already we face an epidemic of stress and anxiety (see go.nature.com/2z96s57). As the volatility of the job market and of individual careers increases, we may wonder whether everyone will have the emotional

stamina necessary for a life of constant flux. We may need more-effective stress-reduction techniques — ranging from drugs through neurofeedback to meditation — to cope.

Creating new jobs might prove easier than retraining people to fill them. A huge useless class might appear, owing to both an absolute lack of jobs and a lack of relevant education and mental flexibility.

Test cases

It is particularly important to identify as early as possible the potential winners and losers from new technologies. Rosy overall statistics can hide growing gaps between disparate groups. Automation might have a very different impact on men and women, on 40-somethings and 20-somethings, on the university-educated and the illiterate.

The winners and losers are not the usual suspects. In the clinic, for example, automation might prove more of a threat to doctors than to nurses. Many physicians focus almost exclusively on processing information: they absorb medical data, analyse them and produce a diagnosis. Nurses also need good motor and emotional skills, to give a painful injection, replace a bandage and listen with care. We will probably have an AI family doctor on our smartphone years before we have a reliable nurse robot[1].

Exploring the relationship between intelligence and consciousness will also be crucial to understanding the economic, professional and ethical rapport between future computers and humans. We are seeing a tremendous development in computer intelligence, but zero development in computer consciousness. Just as aeroplanes fly faster than birds without ever developing feathers, so computers could come to solve problems and even to analyse human feelings much better than humans, without ever developing feelings. Studying these differences will help us to predict what AI can and cannot do, and to decide what should be kept out of its control.

There are a few areas in which AI has already made significant strides that, in my view, offer test cases for the impact of modern automation on the world

of work.

In chess, it has been 20 years since IBM's Deep Blue computer thrashed Gary Kasparov. Yet humans still play chess, and 'centaur' teams of humans-plus-AIs can outperform both. This seems at first to bode well for the future: the job market could nurture people who can leverage, rather than compete with, AI. Yet the balance of power in centaur teams is constantly shifting. Computers are becoming so good at chess that the humans are gradually losing value, and could soon become irrelevant. The same thing might happen in other human–AI teams[2].

Laura Lezza/Getty

A woman with a robot at an Italian nursing home in 2015.

Self-driving vehicles are another important test case. The race to produce self-driving vehicles now pits old steel giants such as Mercedes-Benz against new silicon giants such as Google. Transport leverages one of the core advantages of AI: connectivity. Even if a single computer-driven car is less

competent than a good human driver, a network of computer-driven cars is still likely to be much safer and more efficient than the chaos of fallible human drivers that currently dominates the roads.

Today, about 1.25 million people are killed annually in car accidents[3], more than 90% of which are estimated to be caused by human errors[4]. When two human drivers approach the same junction, they might miscommunicate and collide. But computer-driven vehicles can be connected — the chances that they might miscommunicate and collide are therefore much smaller. Similarly, it is easier to ensure that automated vehicles comply with rules such as speed limits (not to mention the ban on drink driving), even as those rules change[5, 6, 7].

Self-driving vehicles illustrate two important points. First, that in some fields it might make sense to replace all humans with robots and computers, even if individually some humans do a better job. Second, that when change comes to some realms, it might do so suddenly, not step-wise.

The military is another important bellwether, because armies are early adopters of much technology. Human soldiers carry a very high economic and political price tag, so replacing people with computers on the battlefield has proved attractive. The most advanced armies now increasingly rely on relatively small numbers of experts coupled with sophisticated and autonomous technologies, such as drones, robots, smart bombs, cyberworms and algorithms that sift through a mass of data[8, 9].

This shift has produced new classes of military jobs in maintenance, remote control, programming and cybersecurity. The US armed forces need 30 people to operate every Predator or Reaper drone flying over Syria, and analysing the harvest of information occupies at least 80 more. A careful study of the military job market might tell us a lot about potential future developments in the civilian economy.

New order

With insights gleaned from early warning signs and test cases, scholars

should strive to develop new socio-economic models. The old ones no longer hold. For example, twentieth-century socialism assumed that the working class was crucial to the economy, and socialist thinkers tried to teach the proletariat how to translate its immense economic power into political clout. In the twenty-first century, if the masses lose their economic value they might have to struggle against irrelevance rather than exploitation.

One new model has been gaining increasing attention and popularity: universal basic income (UBI). UBI suggests that the government should tax the rich and big corporations to provide every person with a stipend covering his or her basic needs. This will cushion the poor against job loss and economic dislocation, and protect the rich from populist rage. It will also free the masses to engage in more creative forms of work that might not currently have economic value, or to pursue further education.

In January 2017, Finland began a 2-year experiment, providing 2,000 unemployed citizens with €560 (US$657) per month, irrespective of whether they work. Similar experiments are under way in the Canadian province of Ontario, in the Italian city of Livorno and in several Dutch cities[10].

Of course, such national and municipal schemes might not solve the worst problems. Globalization has made people in one country utterly dependent on markets in others, and automation might unravel large parts of this global trade network with disastrous consequences for the weakest links. AI might generate immense wealth in hi-tech hubs such as Silicon Valley and Bangalore, while devastating the economies of underdeveloped countries that rely on cheap labour, such as Honduras and Bangladesh.

US voters might conceivably agree that taxes paid by tech giants Amazon and Google for their US business should be used to give stipends to unemployed coalminers in Pennsylvania or jobless taxi-drivers in New York. But they are unlikely to send their taxes to Honduras. We are still far from having any feasible models for a post-work economy, society or political system, and we don't have much time to formulate them.

In the nineteenth century, the Industrial Revolution created new conditions and problems that none of the existing social, economic and political models could cope with. Consequently, humankind had to develop completely new

models — liberal democracies, communist dictatorships and fascist regimes. It took more than a century of terrible wars and revolutions to experiment with these, separate the wheat from the chaff and implement the best solutions.

The challenges posed in the twenty-first century by the merger of infotech and biotech are arguably bigger than those thrown up by steam engines, railways, electricity and fossil fuels. Given the immense destructive power of our modern civilization, we cannot afford more failed models, world wars and bloody revolutions. We have to do better this time.

Journal name:
Nature
Volume:
550,
Pages:
324–327
Date published:
(19 October 2017)
DOI:
doi:10.1038/550324a

Comments

Comments

There are currently no comments.

Eye in the sky offers clearest vision of Earth

The world's latest carbon-monitoring satellite has advanced our understanding of how the planet functions. US politicians should take note.

16 October 2017

Bill Ingalls/NASA

Launched in 2014, the OCO-2 satellite has offered unprecedented views of carbon flow on Earth.

When a rocket failure saw NASA's first carbon-monitoring satellite plunge

into the ocean in 2009, it was a major blow for climate scientists. Space-based greenhouse-gas monitoring was a promising new frontier — and perhaps an eventual tool for monitoring international climate commitments. It took several years to get a replacement into space, but the Orbiting Carbon Observatory-2 (OCO-2) began taking measurements in 2014. The first major scientific results were published last week in *Science*[1–5], and there can be no doubt that the mission is delivering. No doubts, either, that the US government should launch a successor.

The results give an unprecedented insight into one of the most important planetary phenomena: El Niño, the subtle but massively influential gathering of warm waters in the tropical Pacific Ocean. The 2015–16 El Niño was a monster, changing weather patterns and driving the largest and longest coral-reef-bleaching event on record. Through it all, scientists used OCO-2 to watch carbon move through oceans and ecosystems.

The overall trend came as little surprise — a massive increase in global atmospheric carbon levels. Scientists have measured similar rises in carbon dioxide during past El Niños. But the precise mechanism was elusive. OCO-2 helped clarify the matter by producing detailed maps. Researchers saw an initial decrease in the amount of CO_2 coming out of the tropical Pacific Ocean, a dip later swamped by CO_2 originating from Africa, South America and southeast Asia as the event wore on.

Tracking carbon is just the first step. Those data feed into atmospheric models that can provide a more comprehensive explanation for the origin — and destination — of any given CO_2 molecule. Fortunately, sensors on board OCO-2 can assess the amount of photosynthesis using methods other than measuring carbon flux. They detect a photosynthesis-linked signal called solar-induced chlorophyll fluorescence, which gives an independent measure of how much CO_2 plants are taking up.

With this suite of tools, scientists have managed to paint a finer picture of how the 2015–16 El Niño affected individual regions. Heat and drought set the stage for the massive wildfires that ravaged Indonesia during the event, whereas drought-stricken trees in the Amazon rainforest took up less carbon than usual. In Africa, the higher temperatures probably boosted plant

respiration. All three mechanisms for increasing atmospheric CO_2 have been proposed in the past, but it was a surprise to see all play out on different continents simultaneously.

Plenty of questions remain. The satellite measurements are not as precise as scientists would like, and they don’t always align perfectly with data from the ground. And getting the models right is a never-ending challenge. It will be some time before satellites are able to provide the precision needed to quantify the natural carbon cycle, let alone to separate out human emissions with enough confidence to verify whether countries are meeting their obligations to cut greenhouse-gas emissions. But OCO-2 is further validation that the effort is worth pursuing.

US politicians should take note. President Donald Trump has proposed scrapping a follow-on mission, OCO-3, presumably because it falls under the rubric of climate — a topic that is anathema to this administration. That would be a self-defeating and damaging move. The bulk of the budget for OCO-3 — which was built from the spare parts of its predecessor — has already been spent; all that’s left is the expense of launch and operation. Killing the mission now would waste time and money. But more importantly, as these latest studies show, humanity can learn from the measurements that it will make.

OCO-2 is an affirmation of climate science that everybody should be able to appreciate, regardless of political leanings. Trump might not like talking about climate. But surely his administration — and the lawmakers on Capitol Hill who will decide whether OCO-3 survives — cares about the weather.

El Niño has an impact on weather systems around the world. It raises the likelihood of heavy rainfall from California to the Gulf of Mexico, while increasing the chances of drought and extreme heat in areas farther north. El Niño and its opposite sister system La Niña factor heavily in longer-term seasonal forecasts, which can help governments prepare for fires like those tearing through California at the moment. The more we understand this system, the better we will be at forecasting changes in the weather, the climate — and the economy. A 2014 report from the International Monetary Fund argued that effects of El Niño should be taken into account when

nations plan their finances. This has nothing to do with politics, and everything to do with understanding the world in which we live.

Journal name:
Nature
Volume:
550,
Pages:
301
Date published:
(19 October 2017)
DOI:
doi:10.1038/550301a

Comments

Comments

There are currently no comments.

Colliding stars spark rush to solve cosmic mysteries

Stellar collision confirms theoretical predictions about the periodic table.

16 October 2017

Cosmic furnace

A simulation of the merger of two neutron stars, leading to the formation of a black hole. About 2% of the stars' mass gets ejected at high speed, producing radioactive, heavy atoms.

Credit: W. Kastaun/T. Kawamura/B. Giacomazzo/R. Ciolfi/A. Endrizzi via Caltech

Gold, platinum, uranium and many of the rare-earth elements that are crucial to today's high-tech gadgets are generated during the formation of black holes, astronomers have said. The collision of two small but dense stars simultaneously solved several cosmic mysteries, researchers announced at a press conference in Washington DC on 16 October. More than 30 papers have been published so far in five journals — *Physical Review Letters, Science*, *Nature*, *Nature Astronomy* and *Astrophysical Journal Letters*.

Astronomers watched as two neutron stars — small but very dense objects formed after the collapse of stars bigger than the Sun — collided and merged, forming a black hole, in a galaxy 40 million parsecs (130 million light years) away, according to two dozen researchers interviewed by *Nature*'s News team.

The collision generated the strongest and longest-lasting gravitational-wave signal ever seen on Earth. And the visible-light signal generated during the

collision closely matches predictions made in recent years by theoretical astrophysicists, who hold that many elements of the periodic table that are heavier than iron are formed as a result of such stellar collisions.

Neutron-star mergers are also thought to trigger previously mysterious short γ-ray bursts, a hypothesis that now also seems to have been confirmed.

Astronomers have good reasons to believe that they are looking at the same source of both the gravitational waves and the short γ-ray bursts, says Cole Miller, an astronomer at the University of Maryland in College Park, who was not involved in the research but who has seen some of the papers ahead of their publication.

Bright object

The event was detected on Earth on 17 August, and triggered weeks of febrile, round-the-clock activity on all 7 continents, as more than 70 teams of researchers scrambled to observe the aftermath.

The collision was felt first as a space-time tremor by the Laser Interferometer Gravitational-wave Observatory (LIGO) in the United States and by its Italy-based counterpart Virgo, and seen seconds afterwards as a smattering of high-energy photons by NASA’s Fermi Gamma-ray Space Telescope.

Alerted by the LIGO–Virgo team, astronomers then raced to find and study what was seen as a bright object in the sky using telescopes big and small, famous and obscure, on land and in orbit, and spanning the spectrum of electromagnetic radiation, from radio waves to X-rays.

Cody Messick was at his home at 08:41 local time (12:41 UT) on 17 August when he first found out about the event. “I remember standing on my stairs and looking at my phone, thinking: ‘Wow!” he says. Messick, who is a physicist at Pennsylvania State University in University Park, belongs to a small team of LIGO first-responders who receive frequent automated alerts from the two interferometers, which are based in Livingston, Louisiana, and Hanford, Washington. Normally, LIGO’s algorithms flag a potential signal in real time only if both interferometers detect it. Messick was surprised,

because the message on his smartphone mentioned a strong signal — but one seen only at the Hanford site.

Messick quickly got on a conference call with his team leader, Chad Hanna, also at Pennsylvania State, and other colleagues. Together, they examined the data online. The Hanford signal looked like a textbook example of the waveform of the gravitational waves emitted by two compact objects, each slightly more massive than the Sun, as they spiral into each other, he says. In particular, the waves lasted much longer — about 100 seconds — and had a higher pitch than the signals from the much more massive black-hole mergers that LIGO had previously detected.

When they looked at the data stream coming from Livingston, the LIGO researchers found a similar signal there as well, but one with a loud, spurious glitch towards the end. It was that anomaly that had caused the real-time-analysis software to ignore the signal, says David Shoemaker, a physicist at the Massachusetts Institute of Technology in Cambridge who is LIGO's spokesperson.

Meanwhile, researchers received another alert: Fermi had detected a short γ-ray burst that had occurred 1.7 seconds after the gravitational waves had ended. Called GRB170817A, it was unusually faint for such a burst.

Second signal

In Italy, another technical glitch had suspended the continuous stream of data normally sent out by Virgo. So it took another 40 minutes for researchers to realize that they, too, had a signal — albeit a faint one. It transpired that the waves had travelled close to one of the interferometer's four blind spots, says Jo van den Brand, a physicist at the Vrije Universiteit Amsterdam and spokesperson for the Virgo Collaboration.

By 13:21 UT, 40 minutes after the event, the LIGO–Virgo team had decided to notify its roughly 70 follow-up partners — teams of astronomers on standby to look for related events using conventional telescopes.

Four and a half hours later, the team sent a second, much more useful alert.

The timing of Virgo's feeble signal had been sufficient for the LIGO-Virgo team to identify the source of the waves. It pointed to a region of the sky spanning an angle of just a few degrees, in the southern sky. They called the event GW170817, after the date it was detected.

Virgo had joined LIGO's observation campaign only on 1 August, after a five-year shutdown for upgrades. And just three days before the event's detection, on 14 August, LIGO and Virgo had made their first joint detection. It enabled them to rehearse the more precise identification of the patch of sky of interest. The event on 17 August enabled them to narrow it down even further. And the estimated distance was ten times closer to Earth than in the previous events. They could tell this because of how loud and persistent the waves were: it was the strongest signal LIGO had ever sensed. After the fact, Hanna's team was able to extract a signal that lasted a full six minutes.

Together, the alerts from LIGO–Virgo and Fermi sent astronomers into a frenzied rush. Each team wanted to be first to spot the fireworks produced by a neutron-star merger. It was daytime on most of the world's land mass, so teams began to formulate strategies for their nocturnal observations. They knew that, at that time of the year, the region to search was not far from the Sun. That left a window of observation of a couple of hours after dusk, before the region of sky would set below the horizon.

"We had a complicated, choreographed dance of telescopes that night," says Iair Arcavi, an astrophysicist at the University of California, Santa Barbara, whose team made non-stop observations using the Las Cumbres Observatory, a worldwide network of robotic telescopes. It began by activating a number of telescopes in Chile.

Three messengers

The first person to see the event may have been Charles Kilpatrick, an astronomer at the University of California, Santa Cruz. He was part of a team that was scanning the sky with the more modest means of the single one-metre Swope Telescope in Chile. Like his competitors, Kilpatrick was closely watching the exposures one by one as they came out, comparing them with

archival images of the same patch of sky. By the ninth exposure, he saw something very conspicuous in a galaxy called NGC 4993. “It looked exactly like a point source in this image that wasn’t in the reference image,” Kilpatrick says. The team named it SSS17a.

At least two other groups say they spotted the bright dot independently. They and other teams also made sure that there were no other plausible candidates within the search region. GW170817, GRB170817A and SSS17a really seemed to be three different messengers from the same source.

LIGO and Virgo lacked a sufficiently detailed signal of the final instants of the collision to be certain that the objects were neutron stars, Shoemaker says. From gravitational-wave data alone, they could have been two unusually small black holes. But the presence of visible light strongly suggested that at least one of the objects in the merger was a neutron star, he and other researchers say.

The group at the University of California, Santa Cruz, was also the first to measure the optical spectrum of SSS17a. On the first night, the dot was bright blue, says astronomer Ryan Foley, who led that effort. NASA’s Swift telescope also detected blue, as well as ultraviolet, light. But during the next few nights of observation, those colours faded away, and the object became more red, according to multiple teams.

Colliding neutron stars should spread debris — a mix of neutrons, but also some protons — in three ways, says Brian Metzger, a theoretical astrophysicist at Columbia University in New York City. First, they fling matter out from their outer layers during the final orbits. Then some matter gets squeezed out in the actual collision. Finally, as the two stars begin to collapse into a black hole, it forms an accretion disk of matter, some of which flies out instead of falling in.

Over the past decade or so, astrophysicists had come to believe that this was the most plausible mechanism to explain the abundance of the heavier elements of the periodic table[1]. The theory held that, overall, about 2% of the combined mass of the stars would escape the fate of the rest. Within one second of the collision, this material would have expanded to become a cloud tens of thousands of kilometres across, but still about as dense as the Sun. In

this cauldron, protons and neutrons would immediately clump together to form neutron-heavy nuclei, which would then begin to decay radioactively. This radioactivity would keep the cloud glowing hot for several days, even as it reached the size of the Solar System. Within a million years, it would spread across an entire galaxy.

As predicted

Metzger says that the switch from blue to red was just what he expected to see. His models suggest that nuclei in this early cloud would reach the masses of many of the elements beyond iron, although not the heaviest ones. This chemical composition would cause the cloud to glow blue.

But the real smoking gun for this model, the signatures of the formation of the heaviest elements, would be a cloud that glowed in the red and infrared. These would be elements forged in a separate wave of the explosion, probably the one coming from the accretion disk, says Metzger.

“We had predicted exactly what kind of red,” says Daniel Kasen, a theoretical astrophysicist at the University of California in Berkeley. Jennifer Barnes, another theorist then in Kasen’s team who is now at Columbia University, had run the supercomputer simulations that predicted the experimental signatures in 2013[2]. “I had just finished my PhD thesis predicting what these things would look like,” she says.

Eleonora Troja, an astronomer at NASA Goddard Space Flight Center in Greenbelt, Maryland, was part of one of the first teams to use the Hubble Space Telescope to view the event. “The spectra were phenomenal,” she adds, and almost indistinguishable from the theoretical predictions. “You could clearly see the fingerprints of the metals that had formed.”

But Troja and other observers were also puzzled, because they couldn't find any signal in the X-ray and radio regions of the spectrum. These would be expected during the formation of a black hole, which is thought to shoot jets of out of its poles at close to the speed of light. Nine days later, Troja’s team was the first to find the X-rays.

Alessandra Corsi, an astronomer at Texas Tech University in Lubbock, and her collaborators kept looking for radio emissions using the Very Large Array in New Mexico. Day after day, the dishes recorded nothing. “It turned out we had to wait 16 very long days in order to see the first radio glow,” she says.

The late onset of the radio and X-ray signals, together with the weakness of the initial γ-rays, suggest that the jets were pointed away from the line of sight to Earth. Gamma-ray bursts that happen to be pointed in the right direction can look very bright even from billions of parsecs away.

After a few weeks, most observatories had to stop looking at the object, because that part of the sky had got too close to the Sun. But radio telescopes are still tracking it to this day, Corsi says. More discoveries might yet be made.

“The idea that all this stuff has happened, it’s too much. It is just hard to process,” says Daniel Holz at the University of Chicago in Illinois. “It’s unreasonable that we have done so much with just one event of its kind.”

“All our hopes and dreams have basically come true,” says Jocelyn Read, an astrophysicist at California State University, Fullerton. “All this time we have been saying, look at this amazing thing we are going to be able to see. And it is still hard to believe when it actually happens.”

Journal name:
Nature
Volume:
550,
Pages:
309–310
Date published:
(19 October 2017)
DOI:
doi:10.1038/550309a

Comments

Commenting is currently unavailable.

Nature News

周三, 01 11月 2017

Nature News

[周三, 01 11月 2017]

- **Nature News**

Nature News

Nature is a weekly international journal publishing the finest peer-reviewed research in all fields of science and technology on the basis of its originality, importance, interdisciplinary interest, timeliness, accessibility, elegance and surprising conclusions. Nature also provides rapid, authoritative, insightful and arresting news and interpretation of topical and coming trends affecting science, scientists and the wider public.

- **Spanish government takes control of Catalonian universities** [周二, 31 10月 08:00]
  Madrid will oversee the finances of the region's research centres and seven public universities.
- **Seeds, sponges and spinal surgery** [周二, 31 10月 08:00]
  October’s sharpest science shots, selected by Nature ’s photo team.
- **Small group scoops international effort to sequence huge wheat genome** [周二, 31 10月 08:00]
  Just six scientists conquer one of the most complicated genomes ever read.
- **Astronomers race to learn from first interstellar asteroid ever seen** [周二, 31 10月 08:00]
  Wonky orbit confirms that this visitor isn’t from around here.
- **How baby bats develop their dialects** [周二, 31 10月 08:00]
  The young animals crowdsource the pitch of their calls from colony members.
- **US environment agency bars scientists it funds from serving on advisory boards** [周二, 31 10月 08:00]
  The US Environmental Protection Agency says the policy will address potential conflicts of interest, but scientists raise alarms.
- **Frédéric Chopin’s telltale heart** [周二, 31 10月 08:00]
  Scientists have written another chapter in the curious case of the composer’s heart. But it is unlikely to be the end of the story.
- **Lower emissions on the high seas** [周二, 31 10月 08:00]
  Global regulations to limit carbon dioxide from the shipping industry are overdue.
- **Lessons from first campus carbon-pricing scheme** [周二, 31 10月 08:00]
  Putting a value on emissions can lower energy use, write Kenneth Gillingham, Stefano Carattini and Daniel Esty.
- **Geneticists are starting to unravel evolution's role in mental illness** [周一, 30 10月 08:00]

Hints emerge that past environments could have influenced psychiatric disorders.

- **Huge microwave observatory to search for cosmic inflation** [周一, 30 10月 08:00]
  Multi-telescope project has ambitious goals and a big price tag.
- **Ageing satellites put crucial sea-ice climate record at risk** [周五, 27 10月 08:00]
  Scientists scramble to avert disruption to data set that has tracked polar ice since the late 1970s.
- **3D map of mouse neurons reveals complex connections** [周五, 27 10月 08:00]
  Reconstructions of single cells highlight how far they can reach into the brain.
- **US March for Science group faces growing pains** [周五, 27 10月 08:00]
  A group of volunteers claims that the organization that spearheaded global protests in April has been unduly secretive about its management practices.
- **Genomic studies track early hints of cancer** [周五, 27 10月 08:00]
  Pilot projects aim to pinpoint how benign tumours turn into lung, breast, prostate and pancreatic cancers.
- **Plans rejected for East Antarctic marine park** [周五, 27 10月 08:00]
  Negotiations to conserve unique ecosystems fail for the sixth year running.
- **China announces plans to fast-track drug approval** [周四, 26 10月 08:00]
  Policies are expected to speed up access to medicines and boost the country’s pharmaceutical industry.
- **Bitter CRISPR patent war intensifies** [周四, 26 10月 08:00]
  Gene-editing pioneers prepare for next stage of intellectual-property disputes in the United States and Europe.
- **First living human cells added to brain database** [周三, 25 10月 08:00]
  Measurements show how neurons behave in healthy living tissue.
- **Many junior scientists need to take a hard look at their job prospects** [周三, 25 10月 08:00]
  Permanent jobs in academia are scarce, and someone needs to let PhD students know.
- **Data science can improve aid distribution** [周三, 25 10月 08:00]
  Online platforms can help to steer emergency response and ensure money is well spent.
- **A death sentence, Hawking's thesis and China's ambitions** [周三, 25 10月 08:00]
  The week in science: 20–26 October 2017.
- **CRISPR hacks enable pinpoint repairs to genome** [周三, 25 10月 08:00]
  Precision tools expand the number of ‘base editors’ available for manipulating DNA and RNA.
- **Out of the Syrian crisis, a data revolution takes shape** [周三, 25 10月 08:00]
  Aid organizations have been piloting a nimble approach to cut through the fog of war.

- **[History: Science and the Reformation]** [周三, 25 10月 08:00]
  The scientific and religious revolutions that began 500 years ago were not causally related, but were both stimulated by printing, argues David Wootton.
- **[Disaster preparedness: Risk, rout and ruination]** [周三, 25 10月 08:00]
  Anthony King navigates a show on catastrophe, from nuclear apocalypse to γ-ray bursts.
- **[Public engagement: Young scientists welcome at IPBES]** [周三, 25 10月 08:00]
- **[Poaching: Is snow leopard tally underestimated?]** [周三, 25 10月 08:00]
- **[Construction: limit China's sand mining]** [周三, 25 10月 08:00]
- **[Construction: use waste for building]** [周三, 25 10月 08:00]
- **[Science writing: On what's neither clear nor obvious]** [周三, 25 10月 08:00]
- **[Nicolaas Bloembergen (1920–2017)]** [周三, 25 10月 08:00]
  Laser and optics pioneer whose work led to magnetic resonance imaging.
- **[The Everywhere Bus]** [周三, 25 10月 08:00]
  It's the latest in travel technology.
- **[French scientists in uproar over changes to medical-research clusters]** [周二, 24 10月 08:00]
  Biomedical-research agency accused of attempting to undermine autonomy of university–hospital groups.
- **[Wait for Trump's science adviser breaks modern-era record]** [周二, 24 10月 08:00]
  Top White House science job stays empty more than nine months after president took office.
- **[Reclassify waste to shift the nuclear landscape]** [周二, 24 10月 08:00]
  The US Department of Energy should classify and dispose of nuclear rubbish according to risk.
- **[Cancer biology still needs physicists]** [周二, 24 10月 08:00]
  Considering game theory and the role of physical forces could lead to better treatments for cancer, says Robert Austin.
- **[India gears up for second Moon mission]** [周二, 24 10月 08:00]
  The Chandrayaan-2 orbiter, lander and rover will track how lunar dust might scupper settlement.
- **[To stay young, kill zombie cells]** [周二, 24 10月 08:00]
  Killing off cells that refuse to die on their own has proved a powerful anti-ageing strategy in mice. Now it's about to be tested in humans.

Spanish government takes control of Catalonian universities

Madrid will oversee the finances of the region's research centres and seven public universities.

31 October 2017

Alain Pitton/NurPhoto/Getty

Supporters of independence for Catalonia.

The Spanish government has taken over responsibility for higher education and research in Catalonia, following the region’s unilateral declaration of independence on 27 October. It will retain control of spending on research centres and universities, which the League of European Research Universities says threatens institutional autonomy.

The Catalonia region of north-east Spain has been in political turmoil ever since a highly controversial vote on independence was taken on 1 October. For the past 32 years the Catalan government has set and financed the budgets of universities, which were allocated €700 million (US$814 million) of the nearly €1-billion Catalan budget for science and universities in 2017. The region is strong in science: between 2007 and 2015, its universities won a 210 grants from the European Research Council, totalling €334 million. In the most recent round, 10 of the 22 ERC starting grants awarded to researchers in Spain were won by researchers based at Catalan institutions.

The Ministry of Education, Culture and Sport in Madrid will run Catalan universities and the Ministry of Economy, Industry and Competitiveness will oversee the region's research policy with immediate effect.

The changes mean that the Spanish government will be able to make decisions affecting research centres and universities in Catalonia, after it dismissed all the members of the Catalan government.

Carmen Vela, Spain's secretary of state for research, development and innovation, says that the government hopes the difficulties will be resolved shortly. "Today's situation is a bit different, but it has a very clear goal: restoring normality and tranquility. We are going to work to ensure that there are no negative impacts on research and innovation in Catalonia." She says that the Spanish government will manage but not devise science policy in Catalonia ahead of regional elections due in December.

University connections

Santi Vila, minister of business and knowledge in the Catalan government, stepped down a day before the independence declaration. Arcadi Navarro, secretary of state for universities and research in the Catalan government and a geneticist at Pompeu Fabra University in Barcelona, who used to report to Vila, might yet remain in his job. Vela says that she would like him to continue. "Arcadi is an excellent researcher and someone with whom we have always had an excellent relationship,” Vela says. “We want to keep working with him.”

Jaume Casals, rector of Pompeu Fabra University, says that he does not expect the Spanish government to interfere directly in universities’ affairs. “The relationship between Madrid and Barcelona when it comes to science and universities has always been fluid, and I hope that will not change,” says Casals, who also leads the Alliance 4 Universities, a group of research-intensive universities consisting of two based in Madrid and another two in Catalonia.

Enric Banda, senior adviser at the Barcelona Supercomputing Centre and former president of the grass-roots association EuroScience, agrees. “This is the first time these type of measures, stipulated in the Spanish constitution, are applied. The uncertainty is high because nobody knows exactly how they will be implemented. But I don’t expect any additional disruption in the daily activities of the Catalan universities,” he says.

Financial ties

The League of European Research Universities, headquartered in Leuven, Belgium, has criticized the financial arrangements on the grounds that they undermine institutional autonomy. In a statement issued on 23 October, the group’s secretary-general, Kurt Deketelaere, wrote: “Just like academic freedom, institutional autonomy is key for the academic world and society at large. It cannot be limited on the basis of political considerations, or to serve political goals.”

Ahead of the Catalan elections in December, both Casals and Banda are calling on the Spanish government to lift the financial controls and to minimise the impact of the political upheaval on the region's international image. “Catalonia has done very well at attracting international researchers and students and we would like that to continue,” says Casals.

Journal name:
Nature

DOI:
doi:10.1038/nature.2017.22922

Comments

Commenting is currently unavailable.

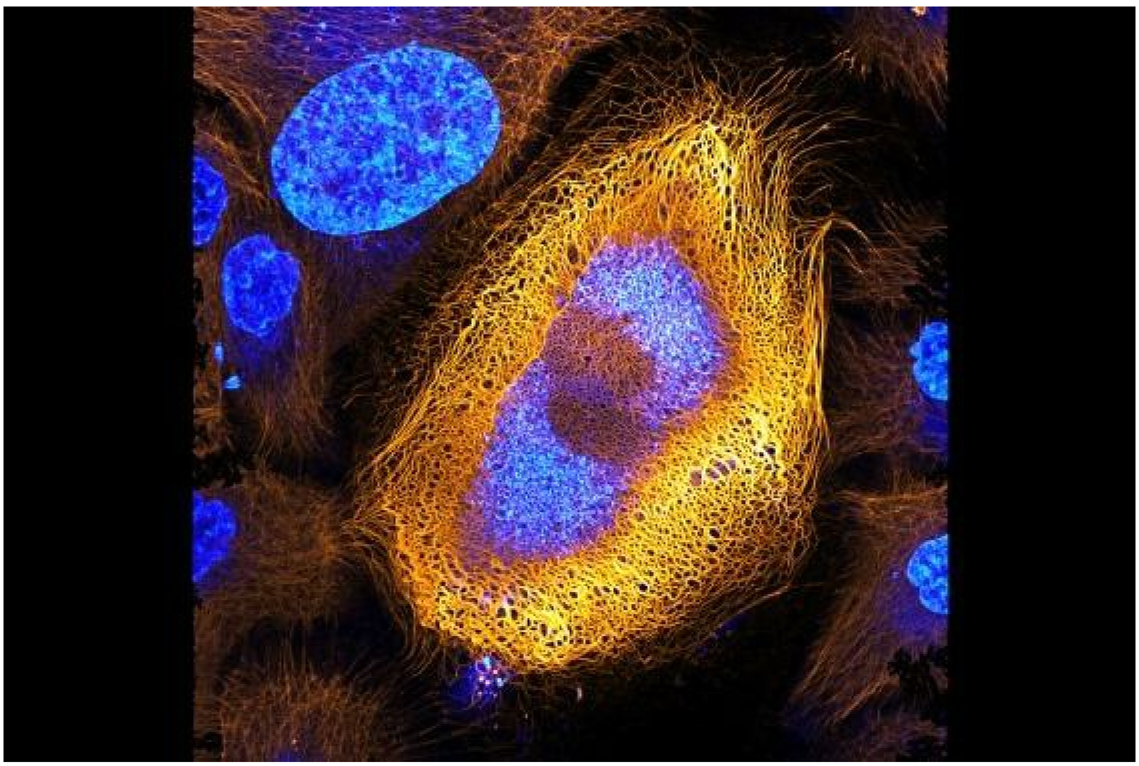
Seeds, sponges and spinal surgery

October’s sharpest science shots, selected by *Nature*’s photo team.

31 October 2017

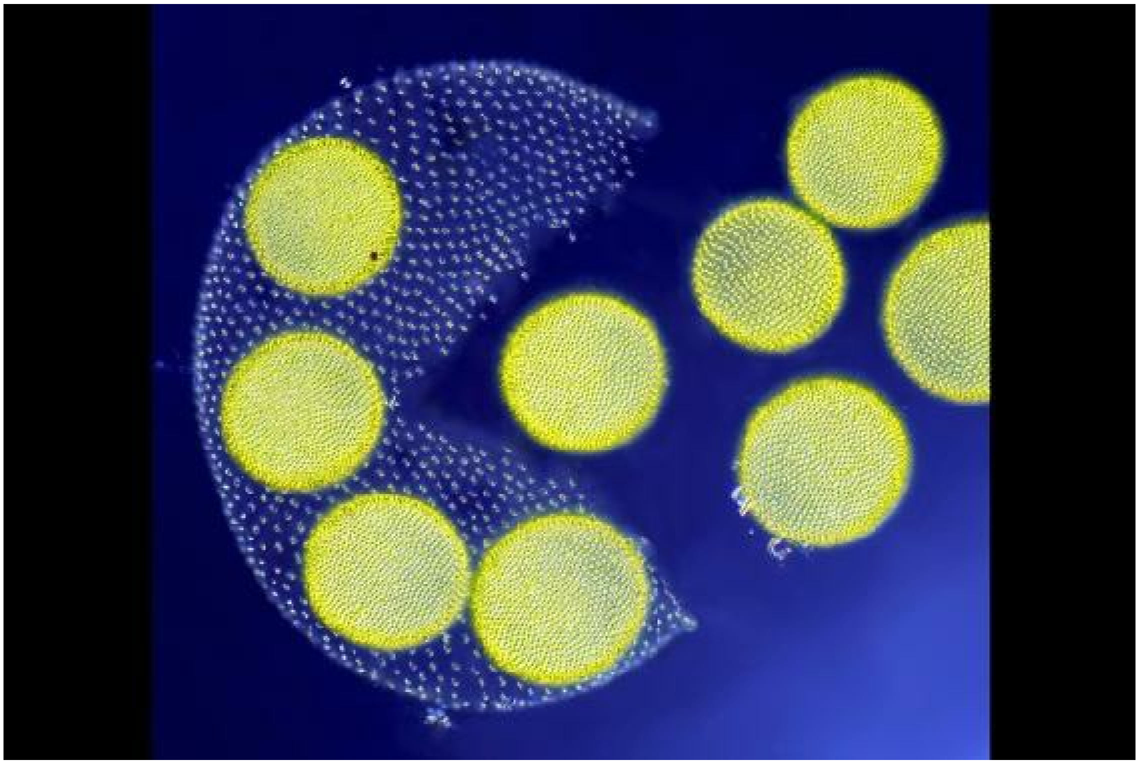
Small beauties

Image Slideshow

1. 

   This image of an immortalized human skin cell won first place in the Nikon Small World Photomicrography Competition. It was taken by Bram van den Broek, a biophysicist at the Netherlands Cancer Institute in Amsterdam.

B. van den Broek, A. Volkov, K. Jalink, N. Schwartz, R. Windoffer/Nikon Small World 2017

2. 

This might look like computer-game character Pac-Man, but it is actually a type of alga called Volvox releasing daughter colonies to continue its line.

Jean-Marc Babalian/Nikon Small World 2017

3. 

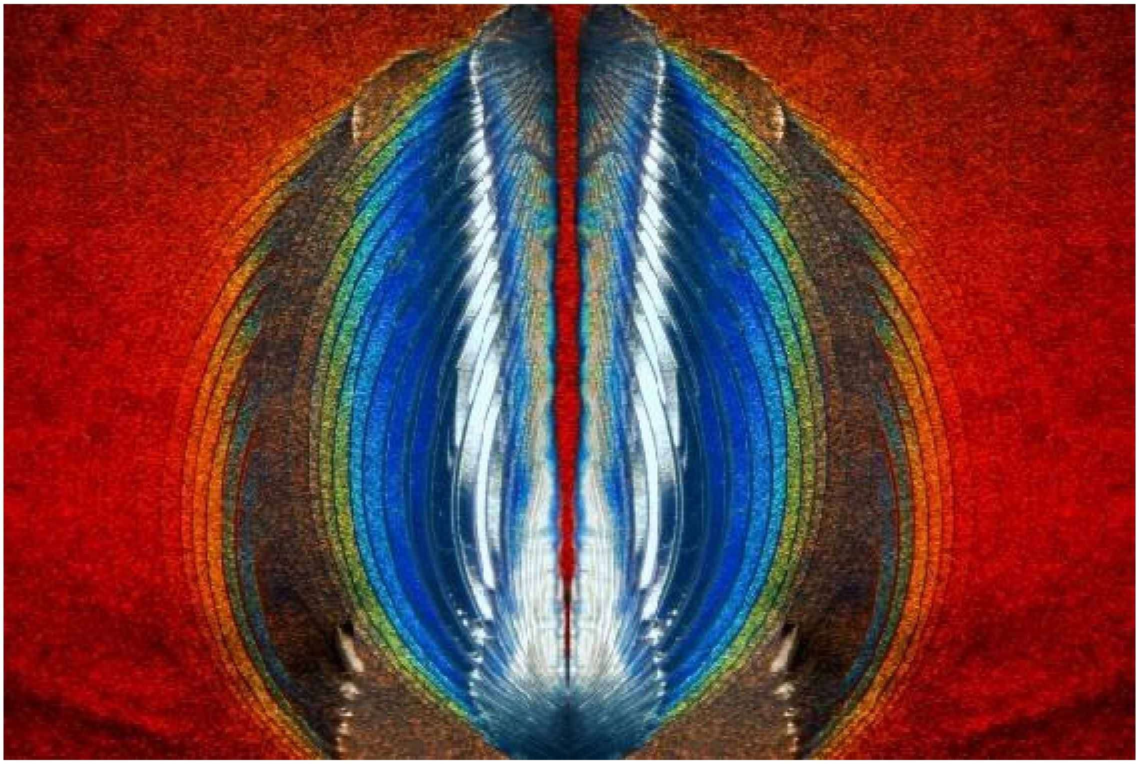
This portrait of a tropical weevil (*Rhigus nigrosparsus*) was given an 'image of distinction' award.

M. Clemens/Nikon Small World 2017

4. 

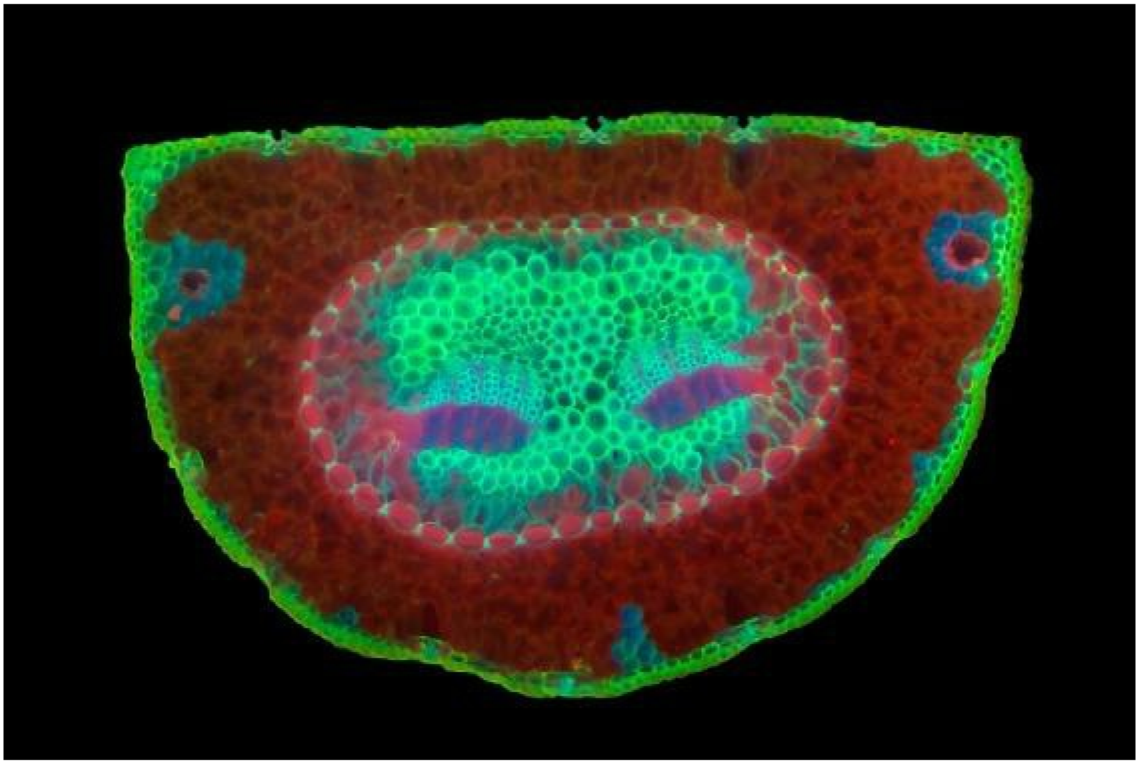
An eerie green crystal of the mineral pyromorphite featured in another shot that received an image of distinction.

E. C. Márquez/Nikon Small World 2017

5. 

This butterfly-like shape is in fact the fractured plastic of a credit-card hologram, seen at ten times its real size.

S. Simon/Nikon Small World 2017

6. 

This startlingly alien shape is a cross-section through something very common: a needle from a Scots pine tree (*Pinus sylvestris*).

A. Klepnev/Nikon Small World 2017

From tragic to touching

Image Slideshow

1. 

The grand-title winner of this year’s Wildlife Photographer of the Year competition features a black rhino (*Diceros bicornis*) in Hluhluwe Imfolozi Game Reserve in South Africa, after it was butchered by poachers who were after its horns. Brent Stirton has seen more than 30 such tragic scenes.

Brent Stirton/Wildlife Photographer of the Year

2. 

This Maori octopus (*Macroctopus maorum*) was spoilt for choice when it came across a huge congregation of giant spider crabs off Tasmania, Australia. The photograph won the invertebrate-behaviour category of the Wildlife Photographer of the Year competition, which is developed and produced by the Natural History Museum, London.

Justin Gilligan/Wildlife Photographer of the Year

3. 

Divers from the Dumont d'Urville scientific base in East Antarctica worked for 3 days in the frigid waters off the continent to capture this image of an ice berg, which was stitched together from 147 separate shots. It won the Earth's environments category.

Laurent Ballesta/Wildlife Photographer of the Year

4. 

These polar bears (*Ursus maritimus*) near Norway’s Arctic island of Svalbard were photographed feeding on waste from a ship’s kitchen. The image won the black-and-white category in this year’s awards.

Eilo Elvinger/Wildlife Photographer of the Year

5. 

Controversial oil drilling is [an increasing threat] to the residents of Yasuní National Park in Ecuador. Among the animals imperilled is this toad, the star of this finalist in the animal-portraits category.

Jaime Culebras/Wildlife Photographer of the Year

6. 

The Sonoran Desert in the United States and Mexico hosts many saguaro cacti (*Carnegiea gigantea*), including this example that has suffered frost damage, causing its limbs to fall to the ground. The image is a finalist in the plants and fungi category.

Jack Dykinga/Wildlife Photographer of the Year

Syrian seeds

Diego Ibarra Sanchez/The New York Times/eyevine

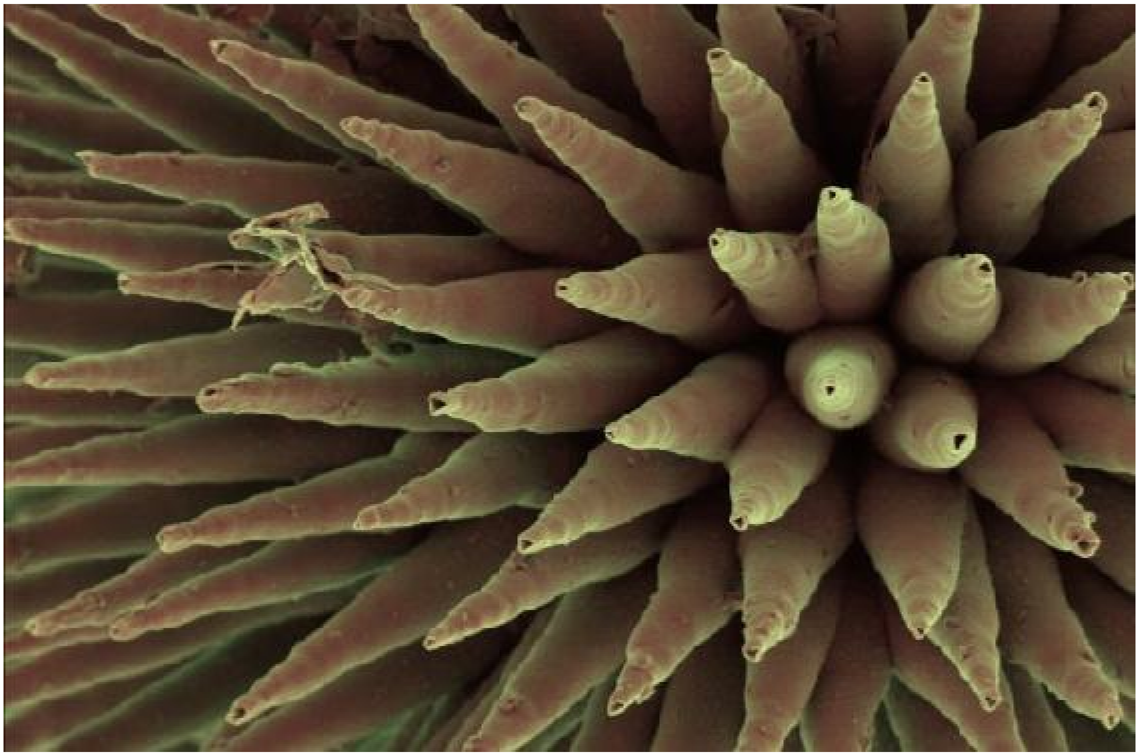
Among the people forced out of their country by the war in Syria are researchers from the nation's seed bank, who are now rebuilding their lives in locations around the world. Ali Shehadeh (pictured) is one of them. A researcher who was based at a International Center for Agricultural Research in the Dry Areas seed bank in Aleppo, he now works in Terbol, Lebanon.

Capturing sunlight

Xu Haijing/Xinhua/ZUMA Wire

The 2017 World Solar Challenge this month saw strange vehicles racing 3,00(kilometres across Australia, powered only by sunlight. Here, the Dutch-built vehicle RED Shift passes a rock formation known as the Devil’s Marbles, near Tennant Creek in the Northern Territory.

Sponge spikes



Zlotnikov Group, B CUBE, TU Dresden

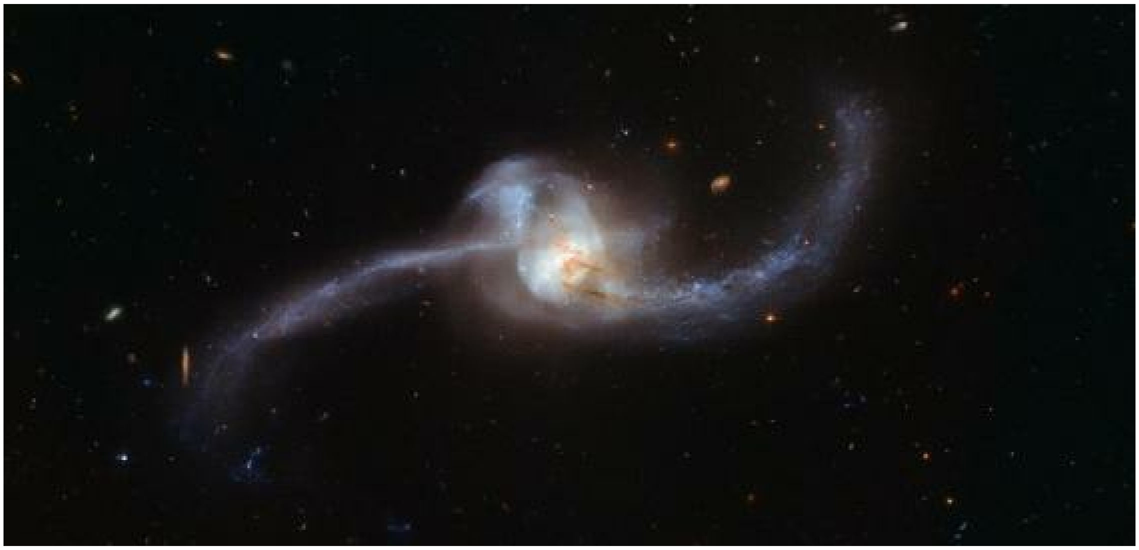
Marine sponges called demospongiae make their skeletons out of silica-glass structures called spicules. Using this image and others, researchers have been unpicking what they call the “half-a-billion-year-old fabrication concept” that produces these structures.

Spinal surgery

Beatrice de Gea/The New York Times/Redux/eyevine

Physicians at Texas Children’s Hospital in Houston now operate on fetuses with spina bifida while they are still in the womb using a new, experimental technique. This technique involves lifting the mother’s uterus out of her body to operate on the spine of the baby inside it.

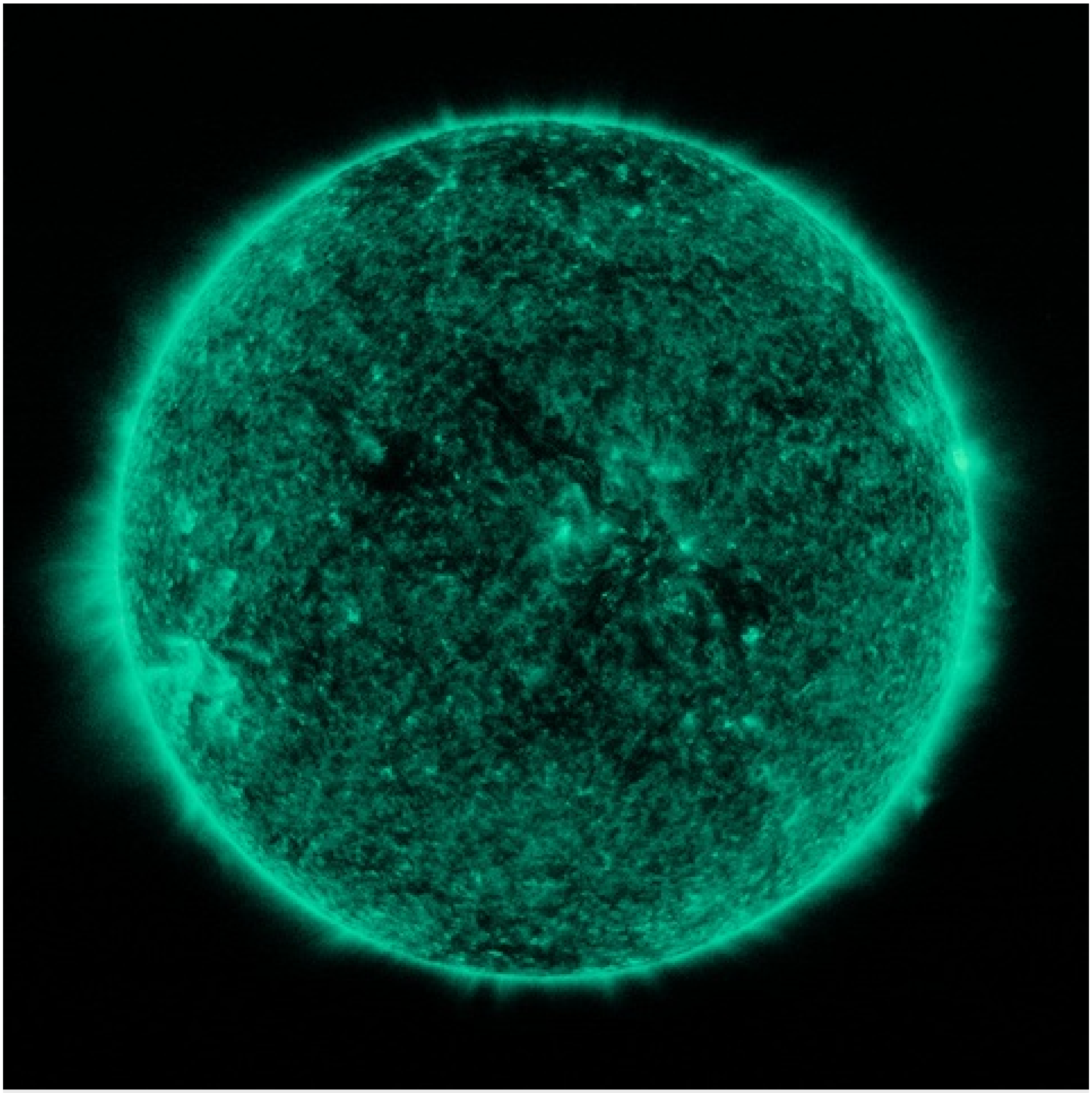
A cosmic collision’s aftermath



ESA/Hubble & NASA

Two galaxies smashed together into one to form this cluster of stars, with tails some 15,000 parsecs (50,000 light years) long. NASA released the image this month, and cheerfully pointed out that this is what our Milky Way will look like in 4 billion years' time, after it collides with neighbouring galaxy Andromeda.

Sun block



NASA’s Goddard Space Flight Center/SDO/Joy Ng

NASA’s Solar Dynamics Observatory was launched into space in 2010 to supply researchers back on Earth with an uninterrupted view of the Sun. Uninterrupted, that is, except when the Moon gets in the way, as shown in this ultraviolet spectrum from 19 October.

Journal name:
Nature

DOI:
doi:10.1038/nature.2017.22923

Comments

Comments

There are currently no comments.

Small group scoops international effort to sequence huge wheat genome

Just six scientists conquer one of the most complicated genomes ever read.

31 October 2017

Nico van Kappel/Minden Pictures/Getty

The genome of wheat (*Triticum aestivum*) is huge, and full of repetitive sequences.

The wheat genome is finally complete. A giant international consortium of academics and companies has been trying to finish the challenging DNA sequence for more than a decade, but in the end, it was a small US-led team that scooped the prize. Researchers hope that the genome of bread wheat (*Triticum aestivum*) — described in the journal *GigaScience* this month[1] — will aid efforts to study and improve a staple crop on which around 2 billion people rely.

The wheat genome is crop geneticists' Mount Everest. It is huge — more than five times the size of a single copy of the human genome — and harbours six copies of each chromosome, adding up to between 16 billion and 17 billion letters of DNA. And more than 80% of it is made of repetitive sequences. These stretches are especially vexing for scientists trying to assemble the short DNA segments generated by sequencing machines into much longer chromosome sequences.

It’s like putting together a jigsaw puzzle filled with pieces of blue sky, says Steven Salzberg, a genomicist at Johns Hopkins University in Baltimore, Maryland, who led the latest sequencing effort. “The wheat genome is full of blue sky. All these pieces look like a lot of other pieces, but they’re not exactly alike.”

As a result, previous wheat-genome sequences contained gaps that made it hard for scientists to locate and examine any particular gene, says Klaus Mayer, a plant genomicist at the Helmholtz Center in Munich, Germany, and one of 1,800 members of the International Wheat Genome Sequencing Consortium (IWGSC) that have been tackling the genome since 2005.

A sequence released by the consortium in 2014 covered about two-thirds of the genome, but it was highly fragmented and lacked details about the sequences between genes[2]. Improved versions were released in 2016 and 2017, but the use of these data is restricted until the IWGSC publishes its analysis (Mayer says the team is preparing to submit its report to a journal). The sequence was also produced using proprietary software from a company called NRGene, preventing other scientists from reproducing the effort.

Puzzle pieces

Salzberg, who specializes in assembling genome sequences, and his five colleagues decided to tackle the problem themselves. To overcome the challenge of ordering repetitive DNA — the puzzle pieces of blue sky — the researchers used a sequencing technology that generates very long DNA stretches (often in excess of 10,000 DNA letters). They also created much shorter, but highly accurate sequences, using another technology.

Stitching these ‘reads’ together — which amounted to 1.5 trillion DNA letters and consumed 880,000 hours of processor time on a cluster of parallel computers — resulted in nearly continuous chromosome sequences that encompassed 15.3 billion letters of the wheat genome.

Mayer calls the new sequence “a major leap forward”. Postdocs can spend whole fellowships locating a single wheat gene of interest, he says. “Those genes which took 10 man- or woman-years to clone, this will melt down to a couple of months, hopefully.” The results of such research should help breeders to develop strains of wheat that are better able to tolerate climate change, disease and other stresses.

Some scientists are already using the new wheat genome — including, Salzberg says, members of the IWGSC working on one particular chromosome. But if it is to be of widespread use, all of the genes and sequences will need to be identified and labelled, a laborious process known as annotation. Salzberg says that a collaborator of his is planning to do this, “unless someone does it sooner”.

Neil Hall, a genomicist and director of the Earlham Institute, a genomics research centre in Norwich, UK, sees Salzberg’s approach as a sign of the times. If the wheat genome — considered one of the most complicated to be tackled by scientists — can be sequenced by a small team using the latest technology, almost any genome could.

“I think we’ve moved beyond the era where genome projects have to be these monolithic international cooperations,” Hall says. “Genomics is more like the gig economy now.”

Journal name:
Nature

DOI:
doi:10.1038/nature.2017.22924

Comments

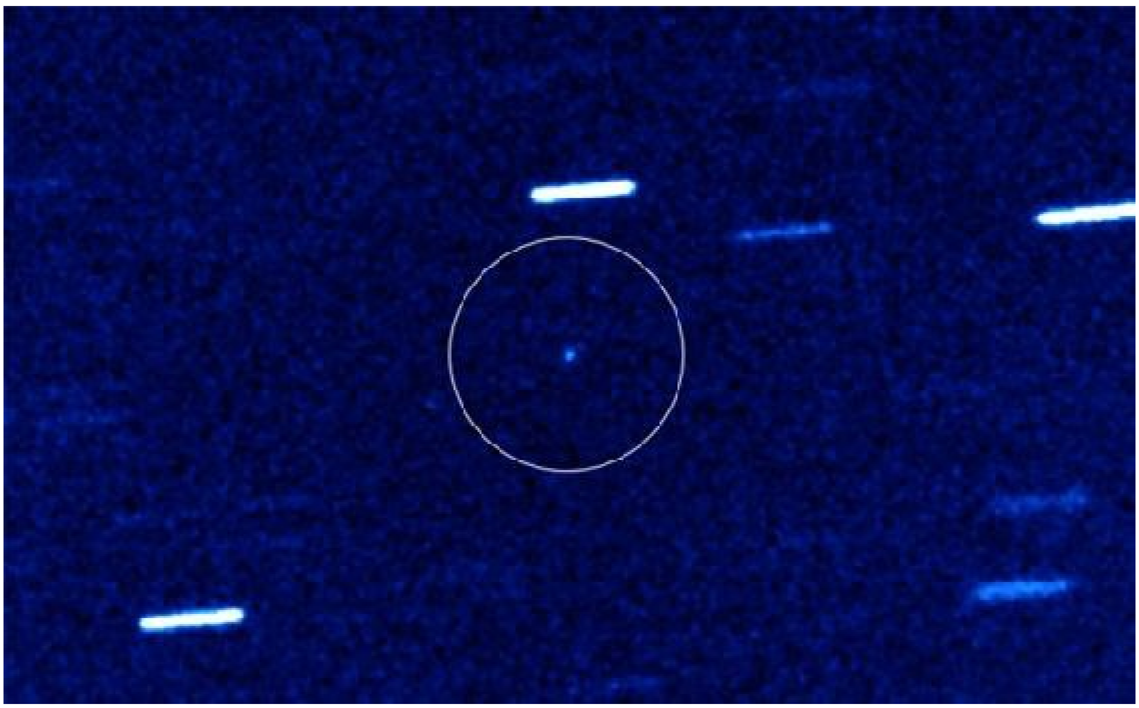
Comments

There are currently no comments.

Astronomers race to learn from first interstellar asteroid ever seen

Wonky orbit confirms that this visitor isn't from around here.

31 October 2017



Alan Fitzsimmons, Queen's University Belfast/Isaac Newton Group, La Palma.

The interstellar asteroid A/2017 U1 (circled) is rushing away from Earth and is currently traversing the Pisces constellation.

Scientists are trying to learn everything that they can from the first interstellar asteroid they have ever observed crossing into our Solar System. Spotted less than two weeks ago, the object is now whizzing across the constellation Pisces and, in a couple of months, will be too faint and far away for even the largest telescopes to see.

“It’s fascinating,” says astronomer David Jewitt of the University of California, Los Angeles. “We are seeing a body from elsewhere in the Galaxy passing through our Solar System. It’s the first time we’ve seen such a thing.”

Unfortunately, the asteroid, dubbed A/2017 U1, is dashing away, never to return. “It’s going really fast,” says Jewitt. “So we have a limited time to get any measurements at all.” Astronomers would love to know what it’s made of, but it’s so dim that spectra — light that observers use to determine the compositions of celestial objects — have so far revealed little information[1]. Nor can anyone say what solar system it came from, or how old it is.

A curious path

Researchers with the Pan-STARRS1 telescope atop Haleakala in Maui, Hawaii, spied the first images of the intruder, made during the new Moon, in mid-October. “It didn’t move like comets or asteroids normally do,” says astronomer Rob Weryk at the University of Hawaii at Manoa, who first noticed the object on the morning of 19 October.

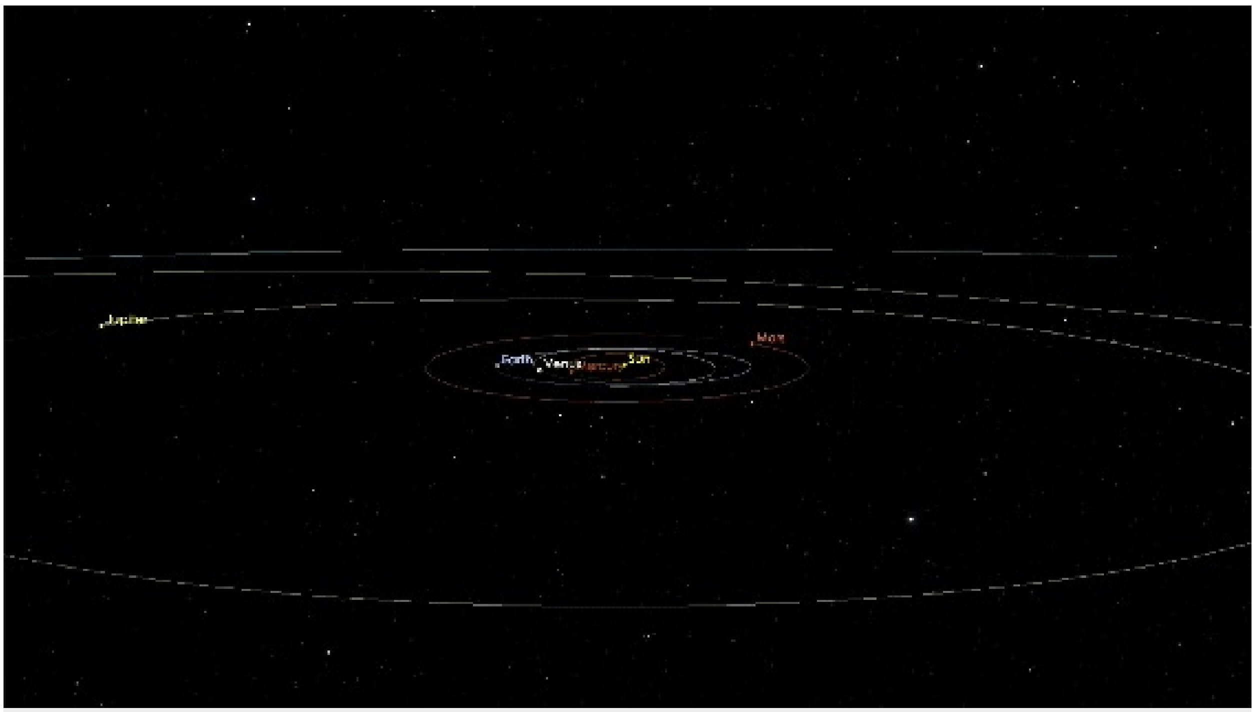
Comets and asteroids usually move on elliptical orbits around the Sun. These orbits have an eccentricity — a measure used to describe orbital shape — of less than 1. But an object zipping through the Solar System from beyond should instead follow a hyperbolic orbit, whose eccentricity exceeds 1.

The latest observations of the asteroid’s changing position indicate that its orbital eccentricity is a whopping 1.20. “It is virtually certain that the object moves in a hyperbolic trajectory,” says Carlos de la Fuente Marcos, an astronomer at the Complutense University of Madrid.

The asteroid skirted the Sun on 9 September, when it was inside Mercury’s orbit, and then passed by Earth at a distance of 24 million kilometres on 14 October.

On the lookout

Astronomers know little else about the exotic visitor. It’s faint, which means that it’s small: fewer than 400 metres across. And despite its excursion near the Sun, it did not develop a tail — as a comet would — and so astronomers are currently classifying it as an asteroid.



NASA/JPL-Caltech

The path of A/2017 U1, an interstellar object that swung through our Solar System.

Researchers have anticipated interstellar visitors for years. “We have waited a long time,” says planetary scientist Alan Stern at the Southwest Research Institute in Boulder, Colorado, who studied the matter in the 1990s.

That expectation is based on the knowledge that the gravitational pulls of the giant planets Jupiter, Saturn, Uranus and Neptune catapulted trillions of comets and asteroids from the young Solar System into interstellar space. Planets in other solar systems presumably did the same, littering interstellar space with rogue objects. “By measuring how many there are sweeping through our Solar System, we can get a gauge of how many are in the entire Galaxy, and how many solar systems have contributed to that population,” says Stern.

“If one hadn’t been discovered fairly soon, that would start to worry me a bit,” says astronomer David Hughes, emeritus professor at the University of Sheffield, UK.

The asteroid came from the direction of the constellation Lyra, which is roughly where our Solar System is heading. Given this trajectory, researchers are expecting to see more objects coming from this direction than from elsewhere, just as runners heading into the rain encounter more drops on their chests than their backs.

A/2017 U1 is the first of many such objects, predicts Jewitt.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22925

Comments

Comments

There are currently no comments.

How baby bats develop their dialects

The young animals crowdsource the pitch of their calls from colony members.

31 October 2017

Joel Sartore/National Geographic Creative

Adult Egyptian fruit bats have a hand in what young bats learn.

It takes a village to teach a bat how to communicate. Baby Egyptian fruit bats learn calls from their mothers, but research now shows that they can learn new dialects, or the pitch of their vocalizations, from the colony members around them.

Learning to communicate by repeating the noises that others make is something only a few mammal groups — including humans, whales and dolphins — are known to do. Researchers call this vocal learning, and it's something that they're starting to study in bats. Findings published on 31 October in *PLOS Biology*[1] show that bats can also pick things up from the group around them, a process that the authors dub crowd vocal learning.

Bats are becoming the best organism to use in studies of how mammals learn to vocalize, because they're more easily manipulated in the lab than whales or dolphins. The latest research underscores their importance, says neuroscientist Michael Yartsev of the University of California, Berkeley, who was not involved with the work.

Songbirds demonstrate vocal learning beautifully, but their brains are organized differently from human brains. Pinning down a mammalian model to explore how this function develops is important for neurologists studying vocal learning, says Yartsev.

The call of the colony

Egyptian fruit bats (*Rousettus aegyptiacus*) are highly social and live in colonies with dozens to thousands of other bats. To see how the pups learn dialects, researchers caught 15 pregnant Egyptian fruit bats and took them into the lab. To control for potential genetic effects, they ensured that the mothers weren't closely related. The team then split the mothers into three groups of five and put each group into one of three chambers, where the mothers gave birth to their young. The scientists used recordings of wild Egyptian fruit bat colonies that were low in frequency, high or a mix of both frequencies, and then piped one pitch into each chamber.

The team released the mothers back into the wild after 14 weeks, around the time the young would naturally be weaned. After another 17 weeks in the enclosures, the young bats were mimicking the pitch of the recordings they had grown up with: bats in the high-frequency chamber made more high-frequency calls than the bats that grew up hearing the other two frequency soundscapes.

The findings make sense, says Yossi Yovel, a neuroecologist at Tel Aviv University in Israel and a study co-author. Baby bats grow up in the dark, surrounded by noisy neighbours, so it would be odd if they didn't pick things up from the animals around them. "It's perhaps not surprising, but it was never demonstrated before now."

Yovel and his team plan to release the young bats into the wild and observe whether their dialect changes to match that of the wild bats, or whether the colony members pick up the experimental bats' dialect.

Studying how this process works in mammalian brains could provide insight into how humans learn language, too, says Sonja Vernes, a neurogeneticist at the Max Planck Institute for Psycholinguistics in Nijmegen, the Netherlands. "If we can understand how bats do it, I think we can learn something about how humans do it."

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22926

Comments

Comments

There are currently no comments.

US environment agency bars scientists it funds from serving on advisory boards

The US Environmental Protection Agency says the policy will address potential conflicts of interest, but scientists raise alarms.

31 October 2017 Corrected:

1. 31 October 2017

Andrew Harrer/Bloomberg/Getty

EPA administrator Scott Pruitt is poised to reshape the mix of experts that advise his agency.

The US Environmental Protection Agency (EPA) moved today to ban researchers with active agency grants from serving on EPA advisory boards.

In crafting the policy, EPA administrator Scott Pruitt sided with his agency's most vociferous critics, who claim that EPA science panels are stacked with scientists who are biased in favour of the agency's regulatory agenda. The policy excludes scientists who work for local, state and tribal agencies that receive EPA grants, instead focussing on academic researchers. At a press conference, Pruitt said that scientists on EPA advisory panels have received US$77 million in grants over the last three years.

"When you receive that much money, there's a question that arises about independence," Pruitt said. "Moving forward, he said, scientists "will have to choose — either the grant, or service, but not both."

Scientists and environmentalists blasted the policy as hypocritical and dangerous, saying it will exclude many top researchers while rendering the volunteer posts less attractive for those who remain eligible.

"It's a disturbing and short-sighted action," says Peter Thorne, a toxicologist who chaired the agency's main science advisory board through September. Thorne, a professor at the University of Iowa in Iowa City, says that the board already has policies in place to deal with conflicts of interest — such as those related to research by a board member or financial interests among industry scientists. "I'm really baffled as to why this is necessary," Thorne says.

The EPA's new policy borrows from legislation backed by Republican lawmakers that has been circulating in the US Congress for several years. In March, the US House of Representatives passed the latest version, which would restrict scientists with EPA grants from serving on advisory panels and loosen rules that seek to address any conflicts of interest related to industry scientists who serve on the panels. The fate of that bill is uncertain, however, since the Senate — which would have to give its approval before the legislation could become law — has not taken action on the matter.

“The reason it couldn’t get through Congress is that it doesn’t make any sense,” says Andrew Rosenberg, who heads the Center for Science and Democracy at the Union of Concerned Scientists (UCS), an advocacy group in Cambridge, Massachusetts. “It turns the idea of conflict of interest on its head.”

Competing interests

Rosenberg’s group analysed the current membership of the EPA’s main science advisory board and found that five of the 47 members could be barred by the new policy. But the EPA restrictions on advisory-board members could soon affect a much larger swathe of panel appointments. The terms of 15 people on the agency's main science advisory board expired at the end of September. EPA watchers are also expecting to soon see appointments to the Board of Scientific Counselors, which advises the EPA’s main research arm, and a third panel that advises the agency on air regulations.

All three of those boards have new leaders, Pruitt announced today. Michael Honeycutt, a toxicologist at the Texas Commission on Environmental Quality, will lead the agency's main science advisory board. Honeycutt has long opposed EPA proposals to enact stricter air-quality standards. Tony Cox, an independent consultant, will lead the Clean Air Safety Advisory Committee, while Paul Gilman, chief sustainability officer at Covanta Energy in Morriston, New Jersey, will lead the Board of Scientific Counselors.

One senior EPA official, who declined to be named for fear of retaliation, says senior leadership initially considered barring any scientist who had ever received an EPA grant from serving on any agency advisory panel. Ultimately, the agency decided to focus on researchers with active grants—in part because EPA officials discovered that it was hard to find qualified scientists who had never held EPA grants.

The agency's overhaul of its advisory boards has been in the works for months. The EPA sparked an uproar in May and June by dismissing dozens of scientists who had served a single three-year term on the Board of Scientific Counselors. In the past, the agency has appointed many scientists for a second term to provide more continuity for programme managers who are seeking input on the vast array of research efforts at the agency.

For Thorne, the question is how the administration is going to engage with its new science advisors. In September, the main science advisory board issued a letter describing its activities and inviting Pruitt to attend one of its meetings. Whether Pruitt will take the committee up on its invitation remains to be seen, but Thorne says one thing is clear: If the agency chooses to marginalize or ignore the board, it will do so “at its own peril.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22929

Corrections

Corrected:

The story has been updated with information from the EPA press conference.

Comments

Comments

There are currently no comments.

Frédéric Chopin’s telltale heart

Scientists have written another chapter in the curious case of the composer’s heart. But it is unlikely to be the end of the story.

31 October 2017

De Agostini/A. Dagli Orti/Getty

The composer Frédéric Chopin died in 1849, but the debate about what killed him continues.

Edgar Allen Poe was a master of the macabre. His 1843 *The Tell-Tale Heart* is a classic gothic tale for Halloween with its roots in guilt and fear: a murderer is haunted by the imagined beating of the excised heart of his victim.

The piano works of Frédéric Chopin — one of the greatest composers of the same period — tend more towards the uplifting. But events after his death have puzzled experts for more than a century and are worthy of any horror story. Scientists in Poland now claim to have solved the mystery. As the researchers conclude in a long-awaited report, he almost certainly died of complications caused by tuberculosis (M. Witt *et al. Am. J. Med.*; in the press; available at http://doi.org/cfpt). The evidence? The scientists have examined Chopin's own telltale heart.

The macabre afterlife of Chopin began with his recorded last words: "Swear to make them cut me open, so that I won't be buried alive." Taphephobia, as this fear is called, was a nineteenth-century obsession (shared by Alfred Nobel, among others), and saw some coffins made with alarm systems to be rung from within. Chopin's sister had an autopsy performed on him, during which his heart was removed. So although most of her brother lies in the famous Père Lachaise Cemetery in Paris, the city in which he died, she sealed his heart in a jar of (probably) brandy and took it back to Warsaw, the city closest to where he was born.

This wasn't too unusual. Remote burial of the heart was a fairly common practice, partly because it was too difficult to repatriate the bodies of kings and nobles who fell in foreign fields. (The heart of the English writer Thomas Hardy is said to be buried in his beloved Dorset, UK, although a more gruesome version of the story has the precious organ being eaten by a cat, and that of the offending animal interred instead.) But Chopin's status as a Polish national hero has helped to make sure that his heart never really rested in peace. His sister smuggled it into Poland past Russian border guards and it was later sealed inside a church pillar. Decades afterwards, during the Second World War, it was retrieved and protected by a Nazi SS commander who claimed to love Chopin's music. After the war, the heart was returned to rest in the church — but only until 2014.

Then, scientists were invited to join an official inspection of the jar and its contents. Their examination — and brief comments to journalists months later — focused on how he died. The original autopsy notes are lost, and an entire academic subfield across many disciplines has emerged to discuss whether Chopin had tuberculosis or something much rarer, perhaps an early known case of cystic fibrosis. Those academics now have a Halloween treat: a draft of a paper to appear in *The American Journal of Medicine* offers more details on the state of the heart.

The original autopsy caused significant damage to both atria, but the paper claims “with high probability” that the remains show that Chopin had chronic tuberculosis, and that the immediate cause of death was a life-threatening complication called pericarditis — inflammation of the membrane enclosing the heart.

Chopin is not the only ghost from the past to offer their secrets to scientists. The artist Salvador Dalí was exhumed in July, moustache reportedly intact, to provide samples to decide a paternity case (he was not the father); and 2015 tests on bones of the Communist poet and winner of the Nobel Prize in Literature, Pablo Neruda, have fuelled theories that he was poisoned in Chile after Augusto Pinochet seized power in 1973.

There could yet be a twist in Chopin’s tale. Some scholars are unsure that the heart is the composer’s, and DNA tests to check for cystic fibrosis have so far been refused. The scientists were not allowed to open the jar in 2014, and Michał Witt at the Polish Academy of Sciences’ Institute of Human Genetics in Poznan, who worked on the project, says that they didn’t want to. The next opportunity will be in 50 years, when the heart is again scheduled for inspection. Witt does not expect to be around to see it. Still, he does have something more planned: the team was allowed to take photographs of the embalmed heart, and although none is yet public, he does plan to include them in the final manuscript. The full tale, after all, has not yet been told.

Journal name:
Nature
Volume:
551,
Pages:
5
Date published:

(02 November 2017)
DOI:
doi:10.1038/551005a

Comments

Comments

There are currently no comments.

Lower emissions on the high seas

Global regulations to limit carbon dioxide from the shipping industry are overdue.

31 October 2017

Getty

Voluntary efforts to tackle carbon pollution from the shipping industry have failed.

In Herman Melville's novel *Moby-Dick*, seafaring is the occupation of adventure-lovers. But since the maritime classic was published in 1851, the act of 'sailing about a little' has become a huge commercial undertaking. Today, a massive fleet of cargo ships transports 90% of global consumer goods. Shipping is efficient — but comes with an environmental cost that has not been adequately accounted for.

Worldwide, there are about half a million ships in operation, together producing almost one billion tonnes of carbon dioxide each year. That’s between 2% and 3% of the global total, and more CO_2 than Germany emits annually. But unlike greenhouse-gas emissions from Germany and other nations, shipping emissions are not subject to the reduction pledges made by individual nations under the Paris climate agreement. (The Paris deal does, however, include shipping emissions in its global carbon-budget calculations.)

After years of inaction, the great white whale of greenhouse-gas pollution is now in the cross hairs of the International Maritime Organization (IMO), the specialized United Nations agency that sets safety and environmental standards for the global shipping industry. The IMO is under pressure from campaigners and representatives of other, regulated sectors to agree a global cap on shipping emissions.

Following sharp increases in the early 2000s, the sector’s emissions have remained more or less stable since the global financial crisis of 2008. But that is unlikely to continue. The current overcapacity in the maritime cargo market means that ship traffic (and emissions) can increase quickly to meet demand. Moreover, the shipping industry at large — including the cruise sector — has potential to grow, and rapidly.

The IMO has a specialist greenhouse-gas working group that is grappling with the idea of a cap. But its latest meeting, held last week in London, closed without declaring much progress. Overall, the IMO is committed to tightening environmental standards for new ships. Yet its technology-oriented strategy — including an Energy Efficiency Design Index that requires the engines of vessels to burn less fuel — is unlikely to be enough. Cleaning up the industry will require adequate market instruments and economic incentives to encourage owners and operators of both ships and ports to adopt climate-friendly practices, such as enforcing lower speeds.

Owing to the peculiarities of this volatile business, the routes, speed and fuel consumption of tens of thousands of container ships are hard to monitor and verify. An emissions-trading system, for example, would be difficult to implement and even harder to manage. The IMO agreed last year to set up a global CO_2 data-collection system that will yield welcome knowledge, as will improvements in tracking the positions and movements of ships from space. But a tax by national governments on fossil fuels used by ships — incurred at refinery level — might be a more effective economic mechanism.

Voluntary efforts alone will not do. The industry has set up a series of half-hearted and overlapping eco-ratings schemes since the 2000s. But an analysis published online on 16 October shows that these have had no notable effect on the environmental performance of ships (R. T. Poulsen *et al. Mar. Policy* **87,** 94–103; 2018). Whereas eco-ratings can steer companies to make more-efficient refrigerators and washing machines in line with the preferences of consumers and regulators, maritime transport is different. The pressure of end-users is too distant to influence ship owners and operators. And price remains the dominant factor for builders and buyers of cargo ships.

As a global business, shipping must be tackled by global regulations, and not through a patchwork of voluntary efforts and regional laws. It is true that some regional efforts, such as the European Union's scheme to monitor, report and verify CO_2 emissions from large ships using its ports, might be a step towards global regulations.

The IMO has already shown that it can tackle other environmental issues. Measures it introduced in the wake of the *Exxon Valdez* oil spill in 1989 ensure that oil tankers are now much safer. An international convention for ballast-water management, which aims to control the spread of harmful invasive species, came into force in September after years of preparation (although it does not address biofouling on ships' hulls, which is potentially more harmful to local ecology). The IMO has also agreed measures to encourage environmentally responsible ship recycling and minimize uncontrolled shipbreaking, much of which occurs on South Asian beaches. However, this 2009 Hong Kong convention is still not implemented and is awaiting ratification by most member parties.

When it comes to the impact on climate, there is no excuse for delay. Emissions from shipping largely escape the public scrutiny and criticism attracted by those from aviation. Parties to the IMO should step up and hasten the implementation of the necessary standards.

Journal name:
Nature
Volume:
551,
Pages:
5–6
Date published:
(02 November 2017)
DOI:
doi:10.1038/551005b

Comments

Comments

There are currently no comments.

Lessons from first campus carbon-pricing scheme

31 October 2017

Putting a value on emissions can lower energy use, write Kenneth Gillingham, Stefano Carattini and Daniel Esty.

Enzo Figueres/Getty

Kroon Hall, home to Yale University's environment school in New Haven, Connecticut, reduced emissions substantially in the face of the carbon charge.

In July, Yale became the first university to launch a carbon-price programme across its campus. More than 250 buildings, together accounting for nearly

70% of the institution's emissions, will be charged US$40 per tonne of carbon dioxide that they emit as a result of energy use. Buildings that reduce their emissions more than the average will receive a share of the funds collected.

More than 500 firms around the world — three times more than a year ago — consider a carbon price of some kind when judging where to invest their money. Hundreds more are expected to start doing so in the coming months. Faced with higher prices, these organizations are shifting to forms of energy that generate less emissions and are more efficient.

Although some large companies have tried internal carbon pricing over the past two decades — BP was the first, in 1998 — little has been published about the value of such programmes. Here, we share initial insights and ideas for future research from a pilot scheme tried in 2015–16 at Yale — a prelude to the university's decision to roll out carbon pricing more broadly this year.

Price signals

Carbon pricing offers a direct incentive to reduce energy consumption and thus mitigate global climate change. In 2015, 13% of global greenhouse-gas emissions were subject to some form of carbon price, and this percentage is rising[1], despite the challenges currently facing government-backed schemes (see 'Faltering policies').

Faltering policies

Governments are struggling to put an appropriate price on carbon dioxide. In 2016, voters in the state of Washington rejected an initiative that would have set a tax on carbon emissions, despite broad support in polls for policy action on climate change. US President Donald Trump has backed away from the previous administration's Clean Power Plan. South Africa has delayed implementing a carbon tax. The United Kingdom has frozen its price floor for trading carbon at £18 (US$24) per tonne of CO_2 until 2021, rather than gradually raising it, as intended. According to the International Monetary Fund, most developed countries should price carbon at at least US$100 per tonne of CO_2 equivalent to reach their emissions-reduction targets for the 2015 Paris climate -change agreement. The longer they wait, the higher these prices will need to be.

A company or institution can implement a carbon price through an internal emissions-trading programme, a carbon charge or a 'proxy price' (or 'shadow price') on greenhouse-gas emissions.

In the first case, the firm caps its emissions at a given level for a fixed period and divides its allowances between its organizational units — in a similar way to the European Union Emissions Trading Scheme. Units then trade their allowances with each other. Buying allowances from units with lower pollution-reduction costs minimizes the overall cost to the company. BP used this approach to reduce its company emissions, quickly achieving its goal of a 10% cut from 1990 levels by 2010[2].

An internal charge increases the price of carbon-intensive goods and services exchanged within the organization. The higher the price, the greater the incentive for the firm to decarbonize.

Companies can redistribute the revenue raised, or invest it in emissions-abatement schemes, as the luxury-goods conglomerate LVMH does. Ice-cream manufacturer Ben & Jerry's invests its revenue in programmes to reduce emissions across its supply chain, on the basis of a “cow-to-cone” life-cycle analysis.

For the past five years, Microsoft has charged its business groups a carbon fee that appears quarterly in their profit-and-loss statements. The fee covers energy consumption (adjusted for employee count) from data centres, offices and software-development labs, as well as from business air travel[3]. The revenue raised goes towards buying renewable energy or improving the treatment of electronic waste or the energy efficiency of lighting, heating, ventilation and air-conditioning systems[4]. In 2015, this fee was about $4 per tonne of CO_2 (ref. 5); this is much less than the US government estimate of the 'social cost of carbon', which is $44 per tonne. Low fees are common, with most internal carbon charges below $30 per tonne of carbon dioxide.

Proxy prices — which involve no financial transactions but are taken into account when weighing up business decisions — are often higher. No revenue is raised, but the carbon price shapes long-term investment choices. When deciding what sorts of buildings to construct or equipment to buy, the proxy price favours low-carbon solutions.

Ben & Jerry's

A solar-energy installation under construction next to the Ben & Jerry's ice-cream factory in Vermont.

For example, ExxonMobil, the Texas-based oil-and-gas multinational, is using a proxy price of $10 per tonne of CO_2; that will rise to $80 per tonne by 2040 (ref. 5). Proxy pricing drove Bristol Water, a British public utility company, to install more energy-efficient water pumps[6]. Saint-Gobain, a building-materials manufacturer based in Paris, uses a carbon price to drive investments in research and development for breakthrough technologies[6]. Some companies, such as the Dutch multinational Royal DSM in Heerlen, present two business cases for investments: one with and one without carbon pricing[6].

Getting ahead

Organizations are implementing internal carbon pricing for many reasons. By aligning investment decisions now, firms are preparing for more-stringent domestic climate policies and for future mandatory carbon pricing. They are also avoiding becoming locked into unprofitable investments and 'stranded assets', which are a concern for investors and others, and are preparing for changed future circumstances. For example, more than 80% of current coal reserves might need to remain untouched if countries are to limit warming to 2° C (ref. 7). Committing to carbon pricing sends a signal to rating agencies and regulators that an enterprise is forward-looking and attentive to emerging climate risks[8].

Internal carbon pricing is part of broader corporate or organizational social-responsibility efforts[4]. By using a carbon price rather than targets for renewable-energy procurement, or internal energy-efficiency standards, organizations achieve those goals in the most cost-effective way. Innovations may result from directing managerial attention to cheaper projects that improve operations or that reduce energy expenditure[2]. Managers do not need to know the exact costs of abatement to achieve progress.

Organizations can also pilot internal carbon-pricing schemes to shape future governmental decisions. Policy leadership was one of the motivations behind BP's internal carbon pricing[9].

Lessons from Yale

Yale University's carbon-charge pilot was launched as part of the university's broader sustainability initiative and ran from December 2015 to May 2016. The charges covered direct and indirect emissions from consuming energy sources such as electricity, gas, steam and chilled water. The price was set at \$40 per tonne of CO_2, which was close to the US government's estimated social cost.

Each of the 20 buildings selected for the pilot received a monthly report that detailed energy consumption and carbon use. They were all randomly allocated to one of four approaches: no carbon price; carbon pricing with 20% of the revenue earmarked for energy-efficiency actions; pricing with the revenue redistributed to buildings that reduced their emissions by at least 1% relative to their historic level of emissions; and pricing with revenue that was returned to buildings whose percentage reduction in emissions exceeded the average. This last approach is revenue-neutral: a net charge applied if emissions reductions were below average, and a net rebate if cuts were above average. Campus buildings outside the scheme served as a control group. Emissions were estimated in proportion to the amount of energy used, with different factors for different sources.

By the end of the trial, buildings that had faced carbon charges had used less energy than those that had not (see 'Energy savings'). Reasons for this included increased awareness of energy use, competition between buildings and the higher price of energy.

Building managers were mainly responsible for responding to the charge. Some favoured cheap options, such as turning down the heat by 1° C. Behavioural or operational changes, such as turning off lights and unused electrical equipment, also cost little. Others, including the departments of economics, environmental studies, public health and the boathouse, took more expensive measures such as installing occupancy sensors, thermal window shades or bulbs that use light-emitting diodes.

At the end of the pilot, the university selected the revenue-neutral pricing structure to implement campus-wide, because of its financial stability. The structure is not subject to potentially large outflows of funds if buildings exceed a target, saving energy because of an unusually mild winter, for example, or if energy needs rise unexpectedly owing to a cold snap or other reasons.

Of course, there are caveats. The scheme's novelty might have boosted engagement. Academics might be more interested than others in adopting challenging and original innovations. The sample size is small and the findings might not generalize to other situations.

Nonetheless, we feel that Yale's experience highlights important ingredients and challenges for internal carbon pricing.

First, information and incentives must be conveyed clearly for carbon charges to change behaviour.

After the pilot, more than half of the staff involved reported an improved understanding of energy use. The flow of information began with the energy reports to managers and spread through meetings with the staff and faculty, and through posters that explained energy savings. Students carried out energy audits. Actions were often collectively identified and followed up by monthly e-mail updates.

Second, the details of the scheme matter. How energy information is presented and carbon-charge revenue is redistributed influence the effectiveness of the scheme. For example, exit surveys of managers indicated that they responded more to the 'net' carbon charge, calculated after they had received a rebate, than to the higher 'gross' charge. Thus, many perceived the price signal as smaller. To increase managers' response to the price signal, one of them suggested a “bump in pay” for good performance on the carbon charge.

Third, carbon pricing is more effective when participants consider the rules to be fair. Perceived fairness increases engagement and encourages competition. The baseline from which emissions reductions are compared is a crucial design factor because it influences winners and losers. Yale's carbon-pricing system recognizes that buildings vary in size, age and energy efficiency, and that research in some disciplines is more energy-intensive than in others. Hence, only emissions above the historic baseline count towards the carbon charge. Emissions in the divinity school might be 100 times lower than those in the medical school, which hosts magnetic-resonance equipment.

For the pilot, the average emissions in the previous three fiscal years, 2013–15, were used as the baseline. In the campus-wide scheme, fiscal years 2011–15 are being used, with adjustments for a few buildings with large renovations, additions, construction or directed growth. For example, emissions at Ezra Stiles College were exceptionally low in 2011–12. during a period of major renovation. Brand new buildings will require projections.

Future research

Four areas of research could improve the design of internal carbon-pricing schemes. First, scientists, engineers and economists need to identify and test design options using rigorous pilot projects, similar to Yale's. These should span organizations of many different sizes and complexities. Such tests would provide insights for policymakers.

Second, no evidence exists on how internal carbon charges interact with non-carbon-pricing policies, such as tax credits or other incentives for renewable energy or energy efficiency. Economists should explore these interactions through data analysis and natural experiments, such as from regulatory changes, including effects on consumers.

Third, building scientists and other metrics experts must develop methods to assure high-quality benchmarking and data analytics for emissions inventories and baseline calculations. Ideally, these metrics should cover a wide range of energy uses before an internal carbon price is set up.

Fourth, accounting and managerial expertise is required to define the tax and financial implications of internal carbon pricing, in particular for multinational and transnational organizations.

We are only beginning to understand internal carbon pricing, but it seems to hold great promise as a way to sharpen incentives and reduce greenhouse-gas emissions.

Journal name:
Nature
Volume:
551,
Pages:
27–29
Date published:
(02 November 2017)
DOI:
doi:10.1038/551027a

Supplementary information

PDF files

1. Supplementary information (258K)

Comments

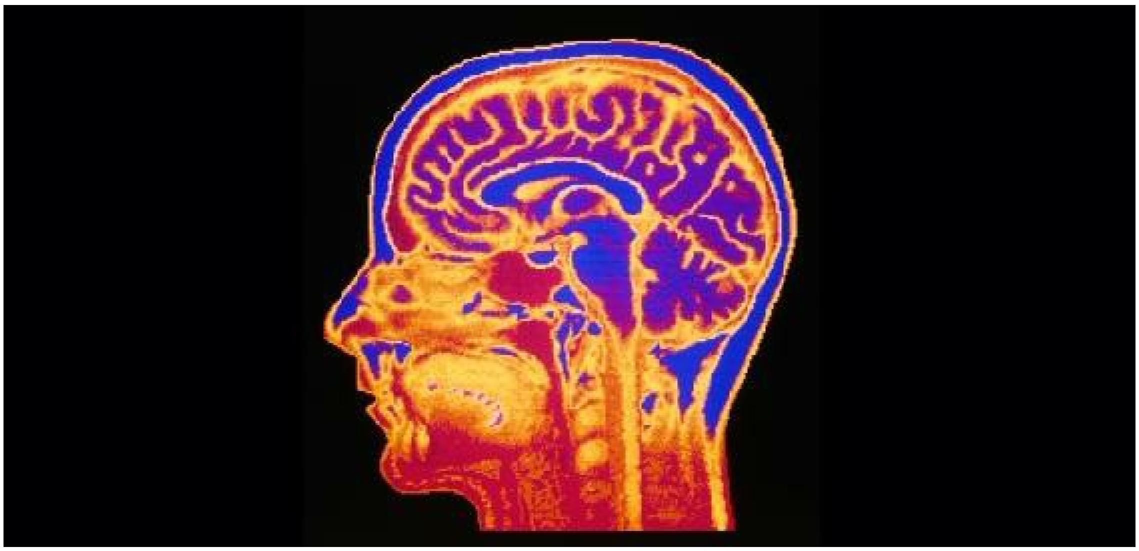
Comments

There are currently no comments.

Geneticists are starting to unravel evolution's role in mental illness

Hints emerge that past environments could have influenced psychiatric disorders.

30 October 2017



Mehau Kulyk/SPL

Human genome databases are enabling researchers to take a deeper dive into the evolution of psychiatric disorders.

Psychiatric disorders can be debilitating and often involve a genetic component, yet, evolution hasn’t weeded them out. Now, recent work is beginning to reveal the role of natural selection — offering a peek at how the genetic underpinnings of mental illness has changed over time.

Many psychiatric disorders are polygenic: they can involve hundreds or thousands of genes and DNA mutations. It can be difficult to track how so many genetic regions evolved, and such studies require large genome data sets. But the advent of massive human genome databases is enabling researchers to look for possible connections between mental illnesses and the environmental and societal conditions that might have driven their emergence and development. Others are looking to Neanderthal genetic sequences to help inform the picture of these disorders, as well as cognitive abilities, in humans. Several of these teams presented their findings at the American Society of Human Genetics (ASHG) meeting in Orlando, Florida, in late October.

One project found that evolution selected for DNA variants thought to protect against schizophrenia. The study, led by population geneticist Barbara Stranger of the University of Chicago in Illinois, looked at hundreds of thousands of human genomes using a statistical method that identified signals of selection over the past 2,000 years[1]. There were no signs of selection in genetic regions associated with any other mental illness.

Many of schizophrenia's symptoms, such as auditory hallucinations and jumbling sentences, involve brain regions tied to speech, says Bernard Crespi, an evolutionary biologist at Simon Fraser University in Burnaby, Canada. Over the course of hominid evolution, he says, the ability to speak could have outweighed the small, but unavoidable risk that the genes involved in language could malfunction and result in schizophrenia in a small percentage of the population.

A quest for context

Another team, lead by human geneticist Renato Polimanti at Yale University in New Haven, Connecticut, is trying to tease out links between environmental factors, mental illnesses and behavioural traits. Polimanti and his colleagues looked at 2,455 DNA samples from individuals at 23 sites across Europe and quantified each person’s overall genetic risk for mental disorders, such as autism, and personality traits, such as extraversion. They then calculated whether that risk was associated with certain environmental factors, such as rainfall, winter temperatures or the prevalence of infectious disease — exploring the idea that these factors might have been involved in selecting for the human traits.

People who live in European regions with relatively lower winter temperatures, they found, were slightly more genetically prone to schizophrenia. Polimanti suggests that if genes that helped people tolerate cold were located close to variants that promote schizophrenia in the genome, then the latter could have been inadvertently carried along during evolution as a “fellow traveller”.

“This was a nice first attempt to put some environmental context” on the polygenic variants associated with mental illness, says Tony Capra, an evolutionary geneticist at Vanderbilt University in Nashville, Tennessee. Polimanti now plans to repeat the study in other parts of the world.

For and against

Untangling the roles of genetics and the environment will be difficult, however, because unknown environmental conditions in the past could have selected for traits that were advantageous then, but considered negative today. And other evolutionary factors could contribute to mental illness indirectly. An overactive immune system is thought to be involved in many psychiatric disorders, such as depression[2], but a stronger immune system would have made human ancestors more resistant to diseases, says Stranger.

Some researchers are exploring the evolution of mental illness through a different lens: by looking at possible differences in gene activity in tissues of Neanderthals and humans. A group lead by Capra and Vanderbilt human geneticist Laura Colbran used databases of modern human genomes to find DNA markers that suggest a gene is differently regulated in various tissues in the body. They then looked for these markers in two Neanderthal genomes. The team found that genes associated with neurological development were regulated differently in the Neanderthal brain compared with that of humans.

So while the DNA sequence of a gene such as *FOXP2* — which is associated with language — is identical[3] in humans and Neanderthals, human brains might have produced more of the associated protein, accounting for increased language ability. The results could eventually lead to a better understanding of how Neanderthal brains functioned, if they were similar to human brains and whether they might have suffered from similar psychiatric disorders.

Studying how mental illness evolved is still at an early stage, but the ability to use massive human genome databases is an exciting step forward, says Capra. He and his colleagues plan to take advantage of this with a survey of genetic areas that differ between Neanderthals and humans, searching for differences in how the genes are expressed.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22914

Comments

Comments

There are currently no comments.

Huge microwave observatory to search for cosmic inflation

Multi-telescope project has ambitious goals and a big price tag.

30 October 2017

NSF/Steffen Richter/Harvard Univ./SPL

Telescopes in Antarctica track the cosmic microwave background radiation left over from the Big Bang.

US researchers have drafted plans to study the faint afterglow of the Big Bang using a new facility. They hope it will be sensitive enough to confirm whether or not the infant Universe underwent a brief period of explosive expansion known as inflation.

The Cosmic Microwave Background Stage-4 experiment (CMB-S4) would comprise three 6-metre and 14 half-metre telescopes distributed across two sites in Antarctica and Chile, according to a preliminary design due to be made public this week. Potentially up and running within a decade, the facility would be nearly 100 times as sensitive as existing ground-based CMB experiments.

It won't be cheap, however. Construction will cost a little over US$400 million, according to the expert task force commissioned by the US Department of Energy (DOE) and National Science Foundation (NSF) to produce the design. That is at least twice as much as envisioned in a less-detailed review 3 years ago, and 30 times the cost of existing experiments.

The price tag is "not necessarily" a showstopper, says Richard Barvainis, who directs the NSF's extragalactic astronomy and cosmology programme. But CMB-S4 will have to compete for limited funding with other large proposed facilities.

Primordial ripples

The CMB provides an image of the Universe as it was just 380,000 years after the Big Bang. Discovered in 1964, the radiation has since been observed by experiments on the ground, on balloons and in space, yielding increasingly precise insights into the Universe's geometry, contents and age — currently calculated at a little under 14 billion years.

But physicists think that the CMB has more to offer. In particular, distinctive patterns in its polarization known as B modes could reveal the existence of primordial gravitational waves. Gravitational waves — ripples in space-time — were first observed directly in 2015, but their detection in the very early Universe would be a major breakthrough, providing the strongest evidence yet for inflation, according to Charles Lawrence, an astrophysicist at NASA's Jet Propulsion Laboratory in Pasadena, California, who chairs the CMB-S4 task force.

Current ground-based CMB experiments typically detect microwaves using a few thousand pixels and are based either near the South Pole or in Chile's Atacama Desert, where very dry conditions make the atmosphere nearly transparent to microwave radiation. None of the experiments has so far spotted the telltale B mode. One group did make a well-publicized claim in 2014, but it transpired that the sighting was actually caused by emissions from Galactic dust. Researchers are now building several more experiments that will be ten times as sensitive.

But Lawrence says that detecting the gravitational waves predicted by many of today's models of inflation would require sensitivity boosted by a further order of magnitude. Hence CMB-S4, which would comprise nearly 400,000 pixels. If it, too, came up empty-handed, the task force writes, it might be necessary "to give up on inflation".

Fight for funding

CMB-S4 is too large for any single group to build, so researchers across the US started collaborating on the design in 2013. Their initial plans were approved a year later by a panel advising the DOE on particle physics. But they must wait until 2020 to see how they fare in the next round of the once-per-decade survey of astronomy and astrophysics that the NSF uses to assess funding priorities.

Barvainis says that the agency will support CMB-S4 only if it gets "a very high priority" in the decadal survey, which is also likely to include a proposed upgrade to the National Radio Astronomy Observatory's Very Large Array in New Mexico, along with the development of one or more large optical telescopes. Even if the project does prevail, he adds, further agency reviews could delay the envisaged start of operations — due in 2026 — by at least two years.

The task force suggests that instead, CMB-S4 could be started by adding DOE detectors to existing telescopes in Chile while installing a few of the smaller telescopes at the South Pole. Under that strategy, the NSF would initially fund only operations. However, officials at the DOE also foresee snags. James Siegrist, the agency's associate director for high-energy physics, says budgetary disagreements between the White House and Congress are creating “a lot of uncertainty” in Washington DC. A delay until 2027 or 2028 “could easily happen”, he predicts.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22920

Comments

2 comments

1. *Pentcho Valev* • 2017-10-30 10:41 PM
   Vacuum is not empty, and this makes the Cosmic Microwave Background concept rather silly. It is unreasonable to believe that the vacuum is full of energy and at the same time to claim that the noise known as CMB is not a product of this energy but just traverses it, unchanged. You have vacuum energy, detectors in contact with the vacuum which register strange noise coming from all directions, and you conclude that the noise is not produced by the vacuum energy but comes from the miraculous beginning of space and time. In addition, you implicitly assume that the vacuum energy does not change the noise. Silly, isn't it? Vacuum slows down light - this explains the Hubble redshift (in a STATIC universe): "...explains Liberati. "If spacetime is a kind of fluid, then we must also take into account its viscosity and other dissipative effects, which had never been considered in detail". Liberati and Maccione catalogued these effects and showed that viscosity tends to rapidly dissipate photons and other particles along their path, "And yet we can see photons travelling from astrophysical objects located millions of light years away!" he continues. "If spacetime is a fluid, then according to our calculations it must necessarily be a superfluid. This means that its viscosity value is extremely low, close to zero"." https://phys.org/news/2014-04-liquid-spacetime-slippery-superfluid.html Nature: "As waves travel through a

medium, they lose energy over time. This dampening effect would also happen to photons traveling through spacetime, the researchers found." http://www.nature.com/news/superfluid-spacetime-points-to-unification-of-physics-1.15437 "Some physicists, however, suggest that there might be one other cosmic factor that could influence the speed of light: quantum vacuum fluctuation. This theory holds that so-called empty spaces in the Universe aren't actually empty - they're teeming with particles that are just constantly changing from existent to non-existent states. Quantum fluctuations, therefore, could slow down the speed of light." https://www.sciencealert.com/how-much-do-we-really-know-about-the-speed-of-light?perpetual=yes&limitstart;=1 The transition from expanding to STATIC universe is unavoidable because the implications of the expanding universe theory are absurd: Sabine Hossenfelder: "If The Universe Is Expanding, Then Why Aren't We? The solution of general relativity that describes the expanding universe is a solution on average; it is good only on very large distances. But the solutions that describe galaxies are different - and just don't expand. It's not that galaxies expand unnoticeably, they just don't. The full solution, then, is both stitched together: Expanding space between non-expanding galaxies." https://www.forbes.com/sites/startswithabang/2017/07/28/most-things-dont-actually-expand-in-an-expanding-universe/ "The Multiverse Is Inevitable, And We're Living In It. Alan Guth: "It's hard to build models of inflation that don't lead to a multiverse. It's not impossible, so I think there's still certainly research that needs to be done. But most models of inflation do lead to a multiverse, and evidence for inflation will be pushing us in the direction of taking [it] seriously." The Multiverse itself may not give rise to any observable, testable predictions, but arises as a direct consequences of other physical theories that have already been validated." http://scienceblogs.com/startswithabang/2017/10/12/the-multiverse-is-inevitable-and-were-living-in-it-synopsis/ Pentcho Valev

2. *Pentcho Valev* • 2017-10-31 07:35 AM

   In my view, the following dialog marks the beginning of a sweeping revolution in cosmology: http://backreaction.blogspot.bg/2017/10/space-may-not-be-as-immaterial-as-we.html Sabine Hossenfelder: "Is Space-Time Fluid? We have known at least since Einstein that space and time are inseparable, two hemispheres of the same cosmic brain, joined to a single entity: space-time. Einstein also taught us that space-time isn't flat, like paper, but bent and wiggly, like a rubber sheet. Space-time curves around mass and energy and this gives rise to the effect we call gravity. That's what Einstein said. But turns out... [...] That space itself isn't fundamental but made of other things is one way to approach the problem. Not everyone likes the idea. What irks physicists most about giving substance to space-time is that this breaks Einstein's bond between space and time which has worked dramatically well - so far. Only further experiment will reveal whether Einstein's theory holds up." Arun: "How does a fluid analog of general relativity avoid having a preferred reference frame?" Sabine Hossenfelder: "Arun, it doesn't. It's why I write it breaks the union between space and time." [END OF QUOTATION] Sabine Hossenfelder is on the right track. The "preferred reference frame" does not affect the validity of the principle of relativity in its traditional usage - it is only responsible for the vacuum friction that slows down photons coming from distant stars, in a STATIC universe. So the Hubble redshift is produced, but at the end of their journey photons redshift less vigorously than at the beginning. This has wrongly been interpreted as accelerating expansion: "In the mid 1990s two teams of scientists, one led by Brian Schmidt and Adam Riess, and the other by Saul Perlmutter, independently measured distances to Type 1a supernovae in the distant universe, finding that they appeared to be further way than they should be if the universe's rate of expansion was constant. The observations led to the hypothesis that some kind of dark energy anti-gravitational force has caused the expansion of the universe to accelerate over the past six billion years." https://cosmosmagazine.com/physics/dark-energy-may-not-exist Below I'm showing that the redshifting varies EXPONENTIALLY with time. The "finding that they appeared to be further way than they should be" is an illusion due to using an approximation to the exponential function. Assume that, as the photon travels through space (in a STATIC universe), a factor equivalent to vacuum friction (see relevant references below) slows it down so that the photon loses speed in much the same way that a golf ball loses speed due to the resistance of the air. On this hypothesis the resistive force (Fr) is proportional to the speed of the photon (V): Fr = - KV That is, the speed of light decreases with time in accordance with the equation: dV/dt = - K'V Clearly, at the end of a very long journey of photons (coming from a very distant object), the contribution to the redshift is much smaller than the contribution at the beginning of the journey. Light coming from nearer objects is less subject to this effect, that is, the increase of the redshift with distance is closer to LINEAR for short distances. For distant light sources we have: f' = f(exp(-kt)) where f is the initial and f' the measured (redshifted) frequency. For short distances the following approximations can be made: f' = f(exp(-kt)) ~ f(1-kt) ~ f - kd/λ where d is the distance between the light source and the observer and λ is the wavelength. The approximate equation, f' = f - kd/λ, is only valid for short distances and corresponds to the Hubble law. The original equation, f' = f(exp(-kt)), shows that at the end of a very long journey (in a STATIC universe) photons redshift much less vigorously than at the beginning of the journey. This means that photons coming from very distant objects have undergone some initial "vigorous" redshifting which is unaccounted for by the Hubble law. This explains why the very distant objects "appeared to be further way than they should be if the universe's rate of expansion was constant". Is there "vacuum friction" that slows down photons? Yes there is: "This leads to the prediction of vacuum friction: The quantum vacuum can act in a manner reminiscent of a viscous fluid." http://philpapers.org/rec/DAVQVN New Scientist: "Vacuum has friction after all." https://www.newscientist.com/article/mg20927994.100-vacuum-has-friction-after-all "So how can a vacuum carry force? One of the first things we learn in classical physics is that in a perfect vacuum - a place entirely devoid of matter - friction can't exist, because empty space can't exert a force on objects traveling through it. But, in recent years, quantum physicists have shown that vacuums are actually filled by tiny electromagnetic fluctuations that can interfere with the activity of photons - particles of light - and produce a measurable force on objects." http://www.businessinsider.com/casimir-effect-vacuum-space-nanoparticles-2017-4 Pentcho Valev

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Ageing satellites put crucial sea-ice climate record at risk

Scientists scramble to avert disruption to data set that has tracked polar ice since the late 1970s.

27 October 2017

Mario Tama/Getty

The footprint of Arctic sea ice has shrunk dramatically in the last four decades.

One of the most important continuous records of climate change — nearly four decades of satellite measurements of Arctic and Antarctic sea ice — might soon be interrupted.

Scientists all over the world rely on the sea-ice record compiled by the US National Snow and Ice Data Center (NSIDC) in Boulder, Colorado. But the US military satellites that collect the data, by measuring ice extent using microwave sensors, are approaching the end of their lives. Three are still working but ageing, and their intended successor started experiencing glitches in 2016, before conking out for good this month. The next possible replacement won't launch until at least the early 2020s (see 'Seeing ice').

That means the most complete and most scientifically significant sea-ice record is at risk of breaking. Any gap in satellite coverage is not just a short-term problem: it would compromise future research, because scientists would not be able to accurately compare observations made before the gap with those from afterward.

“Sea ice is the canary in the coal mine, and the canary’s about to fall off its perch,” says David Gallaher, an expert in satellite remote sensing at the NSIDC.

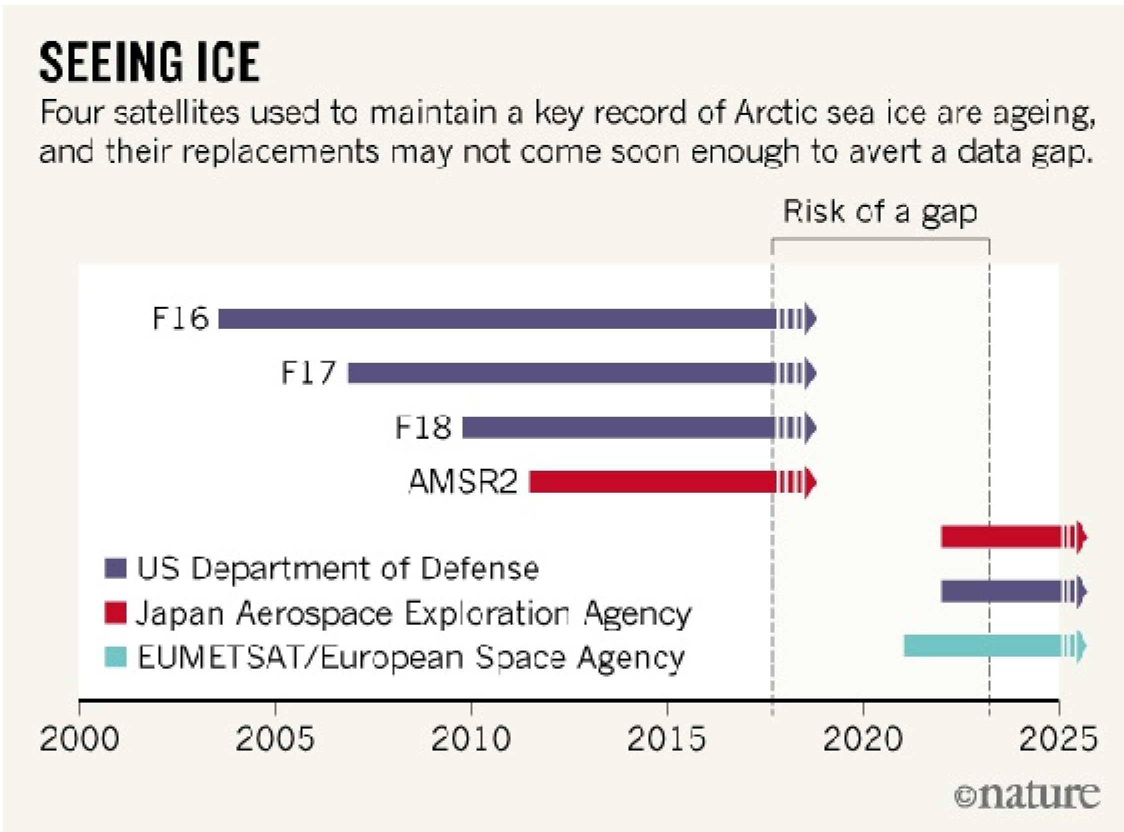
Centre analysts have begun testing the inclusion of sea-ice data from a Japanese satellite, but that spacecraft — designed to last five years — is now five years old. Experts looking to avert the looming gap will gather to debate other options, including the potential use of data from a Chinese satellite, in December, at a meeting of the American Geophysical Union in New Orleans, Louisiana.

Eyes in the sky

In addition to tracking Arctic change, the sea-ice record is also important for climate modellers. Knowing that sea ice formed at a particular location at a particular time gives the air and ocean temperature for that spot, allowing researchers to test simulations of the atmosphere and the ocean.

The data to assess sea-ice coverage come from polar-orbiting satellites carrying passive-microwave sensors that can see through clouds. The sensors detect the brightness of the surface below and translate those measurements into how much ice and water are present.

NASA began taking passive-microwave measurements of sea ice in 1972, using an instrument aboard its Nimbus-5 satellite. That sensor's failure four years later interrupted observations of phenomena such as an Oregon-sized hole that opened in the Antarctic sea ice in successive winters during the mid-1970s. By the time NASA restarted its passive-microwave measurements in 1978, the hole had vanished.



Source: Walt Meier, US National Snow and Ice Data Center

Mysteriously, a large patch of open water appeared in the same region last month — the biggest spotted in four decades. Gallaher says that scientists cannot accurately compare the patch from 2017 to those seen in the 1970s, because the break in the satellite record makes it hard to calibrate Nimbus-5 observations against later ones.

“That’s why it's so critical that you have overlap” from one sea-ice satellite to the next, he says.

NSIDC analysts continued using NASA sea-ice data until 1987, when they switched to information collected by the Defense Meteorological Satellite Program (DMSP). The military uses the microwave information to detect ocean wind speeds to feed into weather models, among other uses, but the data happen to be nearly perfect for sensing sea ice, says Walt Meier, a sea-ice specialist with the NSIDC. The centre has been using DMSP data ever since.

Today, the centre uses data from three DMSP satellites that are more than 8, 11 and 14 years old — and designed to last five. A newer satellite, known as F-19, was launched in 2014 but experienced sensor problems in 2016. It became inoperable this month after tumbling out of control. The final probe in the series, the unlaunched F-20, was dismantled last year after Congress stopped funding the programme.

“Everyone kept saying we got F-20, but then it became obvious 20 wouldn’t go up,” says Gallaher. “The science community was caught kind of flat-footed.”

Tenuous times

The US military is developing another set of weather satellites to replace the DMSP series, but the one carrying a microwave sensor will not launch before 2022. That means that when the current three ageing satellites die, the United States will be without a reliable, long-term source of sea-ice data. “Every day it’s more and more risk,” says Meier. “If one of those goes it will get to be nail-biting time, and certainly if two of them go.”

For now, the centre is preparing for those scenarios by incorporating data from Japan’s AMSR2 microwave sensor into its sea-ice record. Another, more politically fraught option is to pull in data from the China Meteorological Administration’s Fengyun satellite series. Their data are already being incorporated into European weather-prediction modelling, and they carry passive-microwave sensors that are appropriate for studying sea ice. Since 2011 Congress has banned NASA scientists from working with Chinese scientists — but not necessarily from using Chinese data.

One final possibility is finding a way to launch the passive-microwave sensor that scientists at the US Naval Research Laboratory salvaged from the dismantled DMSP satellite. The sensor currently sits at the Aerospace Corporation in El Segundo, California, where researchers are trying to find a way to get it into orbit. “It’s a beautiful instrument,” says Donald Boucher, a principal scientist and engineer with Aerospace. “It must fly.”

But the military might ultimately opt to launch the sensor on something such as the International Space Station, which travels over the Earth’s low and middle latitudes. That would fulfil US troops' weather-prediction needs, but would not provide the polar orbit needed to study sea ice. Other planned military or commercial satellites might be able to provide some information about sea-ice cover, but not with the level of detail and continuity that researchers desire.

“It’s kind of frightening that you can have a record as rich and continuous as what this is, and just not a real good way of continuing it,” says Molly Hardman, a remote-sensing specialist at the NSIDC. “It’s depressing.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22907

Comments

Comments

There are currently no comments.

3D map of mouse neurons reveals complex connections

Reconstructions of single cells highlight how far they can reach into the brain.

27 October 2017

3D map of mouse neurons reveals complex connections

Janelia Research Campus, MouseLight project team

The 70 million neurons in the mouse brain look like a tangled mess, but researchers are beginning to unravel the individual threads that carry messages across the organ. A 3D brain map released on 27 October, called MouseLight, allows researchers to trace the paths of single neurons and could eventually reveal how the mind assembles information.

The map contains 300 neurons and researchers plan to add another 700 in the next year. “A thousand is just beginning to scratch the surface,” says Nelson Spruston, a neuroscientist at the Howard Hughes Medical Institute (HHMI) Janelia Research Campus in Ashburn, Virginia.

To create the maps, Spruston and HHMI neuroscientist Jayaram Chandrashekar injected mouse brains with viruses that infect only a few cells at a time, prompting them to produce fluorescent proteins[1]. The team made the organs transparent using a sugar-alcohol treatment to obtain an unobstructed view of the glowing neurons, and then scanned each brain with a high-resolution microscope. Computer programs created 3D models of the glowing neurons and their projections, called axons, which can be half a metre long and branch like a tree.

MouseLight has already revealed new information, including the surprisingly extensive number of brain regions that a single axon can reach. For instance, four neurons associated with taste stretch into the region that controls movement and another area related to touch. Chandrashekar says the group is now working on identifying which genes each neuron expresses, which will help to pin down their function.

“This is a tremendous project,” says Hongkui Zeng, a molecular biologist at the Allen Institute for Brain Science in Seattle, Washington, who plans to collaborate with the Janelia group on MouseLight. The Janelia technique is similar to one that Zeng and her colleagues developed using a line of mice genetically engineered so that a certain drug activates glowing proteins in a handful of their neurons.

MouseLight is just one of several methods being used to reconstruct individual neurons, says Rafael Yuste, a neurobiologist at Columbia University in New York City. Accurately labelling neurons with markers such as fluorescence, he says, will probably be the key challenge in the eventual goal of creating a “census” of different cell types in the brain.

But to achieve that goal, Zeng says, researchers may need to reconstruct hundreds of thousands of neurons. “Now it’s a numbers game.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22908

Comments

Commenting is currently unavailable.

US March for Science group faces growing pains

A group of volunteers claims that the organization that spearheaded global protests in April has been unduly secretive about its management practices.

27 October 2017 Corrected:

1. 27 October 2017

Aaron P. Bernstein/Reuters

Participants in the March for Science in Washington, DC, on 22 April gather at the Washington Monument.

The US group that sparked the global March for Science movement is facing complaints about its management practices as it files for non-profit status and signals its intent to continue as “a movement to advance science and its role in public life”.

On 23 October, a group of current and former volunteers posted an open letter to the central March for Science organization in New York City, alleging that it is secretive, insensitive to the concerns of its volunteers, and unwilling to share power or information with organizers of its many affiliated ‘satellite’ groups around the world. The volunteers also claim that the organization sidelined and stonewalled experienced activists who wanted the movement to focus on how science can be used in ways that perpetuate racism, sexism and other forms of discrimination.

In a statement to *Nature*, the March for Science said that it welcomed the “concrete feedback and suggestions”. But volunteers have already walked away from the group, and at least one major satellite group, in New York, has severed ties. The turmoil comes at a time of renewed political activism by US scientists, much of it in protest against the policies of US President Donald Trump.

Aaron Huertas, the former communications director for March for Science and an author of the letter, says that the organization is acting in a hierarchical fashion, and not as the grassroots movement that many volunteers wanted. He adds that experienced activists in the group, many of whom focussed on issues of social justice, were the first to raise the alarm about lack of transparency — and with good reason. “Transparency prevents marginalized people from having their work and labour undervalued or thrown away,” Huertas says.

He and his letter co-signatories are concerned that the group has not published a detailed accounting of its finances, including the US$1.3 million it raised between 1 February and 30 April. They are uncomfortable with the group’s decision to ask some volunteers and board members to sign non-disclosure or confidentiality agreements, and to hire one of the group’s original co-chairs, Caroline Weinberg, as its paid interim director without advertising the job.

Weinberg says that the board hired her in August as the part-time interim executive director at a salary of $67,000 per year, with no benefits. She adds that a public search for a permanent director will begin in December, and that the March for Science will release more detailed financial information “at the end of this week or early next.” In the meantime, the disclosure on 24 October that Weinberg and her two co-chairs received some money for their services is also coming under scrutiny.

Terry Kush, the March for Science’s chief operating officer, revealed the payments in a memo to the March for Science's satellite groups. “In May and June, 12 national team members were paid for their work those months, including the former co-chairs,” Kush wrote. She added: “We’d like to reaffirm our commitment to increasing transparency within the org and the larger grassroots movement.”

The group's three original co-chairs — Weinberg, Jonathan Berman and Valorie Aquino — resigned their positions in late April and signed a confidential agreement with the organization in late August, Weinberg says. She adds that while she "cannot comment on the clauses therein", that does not prevent her from being open about "the march, our work, accounting, governance, or legal structures”. Aquino and Weinberg also signed what Weinberg calls "standard" confidentiality agreements with the board.

In a 25 October post on Twitter, former co-chair Jonathan Berman confirmed that he had been paid $6,500. “I didn't feel great about it at the time, and I'm still not sure accepting it was the right thing to do,” he wrote.

Huertas calls these payments “secret”, and argues that not disclosing the information publicly undermined the effectives of the March for Science group. Weinberg says that the payments were made in July, but “not publicly released” until now only because they took place in the middle of the fiscal year.

“The accusation that we are in this to enrich ourselves and make money is deeply offensive and something I am sadly not surprised to see aimed at women in leadership as it devalues our work and commitment to the cause,” Weinberg says. “Most people do not have the luxury of volunteering full time in perpetuity, and need — and deserve — to be paid for this work.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22909

Corrections

Corrected:

The original version of this story incorrectly stated Terry Kush's gender. It has been corrected.

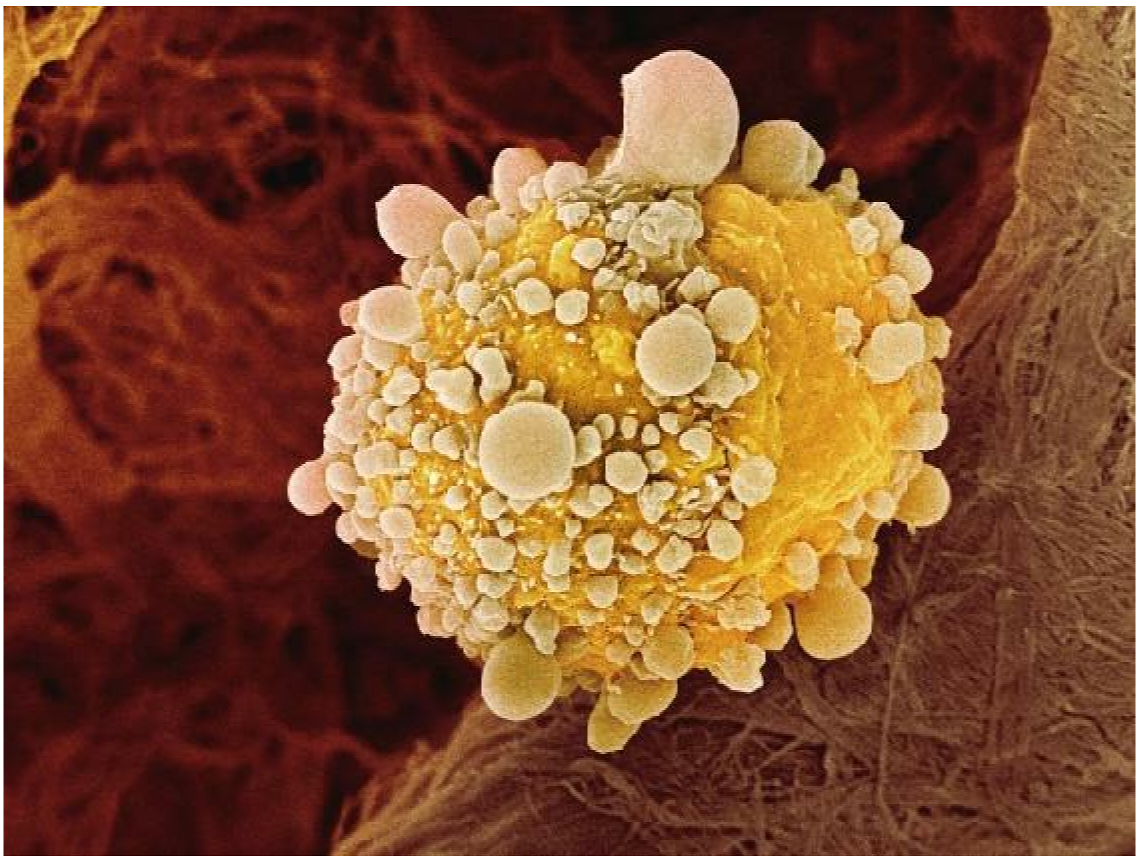
Comments

Commenting is currently unavailable.

Genomic studies track early hints of cancer

Pilot projects aim to pinpoint how benign tumours turn into lung, breast, prostate and pancreatic cancers.

27 October 2017



Steve Gschmeissner/SPL

Researchers are trying to stop tumour cells from turning malignant like this pancreatic cancer cell.

After years of studying advanced cancers, researchers are now training their

DNA sequencers on precancerous growths to learn more about how they develop into the full-blown disease.

A three-year pilot project funded this month by the US National Cancer Institute (NCI) as part of the National Cancer Moonshot Initiative, will take this approach with lung, breast, prostate and pancreatic cancer. Investigators hope to create a 'pre-cancer genome atlas' by sequencing DNA from precancerous growths, in addition to sequencing RNA from individual tumour cells and identifying the immune cells that have infiltrated the lesions.

Another project — a four-year US$5-million effort funded by the charities Stand Up To Cancer, the American Lung Association and LUNGevity announced on 26 October — will bolster the study in lung cancer by sequencing DNA from precancerous growths in the airway. Doctors sometimes monitor such lesions, taking periodic biopsies to determine if and when they become malignant. One component of this project will track the genetic changes in these biopsies over time.

The aim is to find ways to intervene in cancer earlier, when it may be easier to rein in the disease. “There’s a tremendous sense that the rate-limiting step for new approaches for either preventing cancers or detecting them early, is the fundamental lack of knowledge about the earliest molecular events,” says pulmonologist Avrum Spira at Boston University in Massachusetts, a leader on both projects. “We just don’t understand what’s going on very early.”

Making maps

The desire to map those earliest events has been growing, fuelled in part by frustration with the limited success of therapies in patients with advanced cancers. Meanwhile, technological advances in DNA sequencing have made it possible for researchers to glean useful data from tiny tissue samples — a crucial development because physicians tend to take small biopsies of precancerous growths, and there is often little tissue left after the pathologists have analysed them.

However, even with advances in sequencing, sceptics have questioned whether those minuscule amounts of tissue would suffice, says Spira. The Moonshot-funded project is set to last for three years, but Spira and his colleagues have been asked to report back in 12 months so that the NCI can decide whether the approach is feasible and warrants expansion, Spira says. “This is the beginning of a much bigger initiative,” he says.

It’s a short timeline, but the team has a head start, Spira says. Several institutions have already been collecting these small tissue samples in biobanks, so investigators can begin their analyses immediately. This will be particularly important for pancreatic cancer, a relatively rare condition that is often caught only when it has become advanced and difficult to treat, he says.

But it is worth the extra effort to study pancreatic cancer, which is among the most lethal ones, says Elizabeth Jaffee, who studies the disease at Johns Hopkins University in Baltimore, Maryland. Many pancreatic tumours seem to be driven by mutations in the same genes — and that commonality may make the disease more predictable, and therefore easier to detect and target at an early stage.

“You can look at it as, ‘Let’s pick the easiest ones’, but will that have the biggest impact?” Jaffee says. “Or let’s pick some of the harder ones and maybe we can, longer term, have this plan of just preventing them entirely.”

If successful, the projects could herald a change in how researchers approach cancer prevention, says Spira. “The field has been stagnant and people are frustrated,” he says. “People want to really transform that space, and the feeling is that the atlas is the next thing to do to change that.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22911

Comments

Commenting is currently unavailable.

Plans rejected for East Antarctic marine park

Negotiations to conserve unique ecosystems fail for the sixth year running.

27 October 2017

Hobart, Australia

Colin Monteath/Minden/Getty

The proposed East Antarctic marine park would protect species including cold-water corals, krill and Adélie penguins (*Pygoscelis adeliae*).

A huge area off the coast of East Antarctica rich in cold-water corals and penguin foraging grounds will remain unprotected for at least another year. Conservation advocates had hoped that the region, covering one million square kilometres, would become the continent’s newest marine protected area (MPA). But the international body that oversees Antarctic waters failed to reach agreement before the end of its annual meeting on 27 October in Hobart, Australia.

At last year’s meeting, after years of unsuccessful talks, the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) agreed to create the world’s largest marine park, the Ross Sea MPA. Buoyed by that success, representatives from Australia, France and the wider European Union had hoped that East Antarctica would follow this year. But for the sixth year in a row, CCAMLR was unable to agree on the details.

Conservationists did have some good news, however, with a decision to extend protection for waters exposed when a massive iceberg split from the Larsen C ice shelf this year; a new proposal for a marine protected area in the waters around the Antarctic Peninsula; and the approval of a research and monitoring plan for the Ross Sea MPA.

After the move to protect the Ross Sea, “it is disappointing that CCAMLR could not agree to protect more of the vast and biologically diverse Southern Ocean”, said Andrea Kavanagh, director of Antarctic and Southern Ocean work at the Pew Charitable Trusts in Washington DC, in a statement issued after the meeting.

“People aren’t feeling great,” Chris Johnson, senior manager of the Antarctic programme for global wildlife charity WWF, told *Nature* just after the meeting’s conclusion close to midnight. “This was a polarizing year. But these things take a long time to get consensus.”

Fighting over fishing

The proposal to protect three large blocks of ocean and sea floor along East Antarctica has been endorsed by the commission’s scientific committee three times. But opposition from China and Russia has blocked the proposal each year.

Both have current or historical fishing interests in the region. China began fishing in the area last year and trawlers from the Soviet Union once plied East Antarctic waters; Russia has expressed interest in returning. Under CCAMLR rules, all 25 commission members — 24 countries and the European Union — must agree for a proposal to be adopted.

Negotiations in recent years halved the size of the proposed reserve from 1.9 million square kilometres divided into seven areas to one million square kilometres divided into three and added a 30-year expiration date. On the other side of the ledger, the talks also yielded extra protections for underwater recesses in the ice along the coastline that harbour fish.

Fishing for krill, small crustaceans that are a fundamental part of the Antarctic marine food web, would be allowed in much of the reserve. But one area would be completely off limits, in part to provide a control for researchers studying the impacts of fishing on the region.

Neither China’s nor Russia’s delegates responded to requests for comment on the nature of their opposition to the latest proposal. But the high-level talks between parties including Russia, the United States and China that smoothed the way for the Ross Sea reserve were absent from this year’s meeting, according to several attendees interviewed by *Nature*.

Unique ecosystems

Although only two-thirds the size of the Ross Sea MPA, the East Antarctic reserve would protect unique ecosystems and features. Included within its boundaries are sites where Antarctic bottom water is formed; this very cold, dense, oxygen-rich slug of water drives global ocean circulation. Churning on the sea floor creates a range of important habitats on the ice shelf and slope that support marine food webs, a nursery for Antarctic silverfish (*Pleuragramma antarcticum*) and the foraging ranges of marine mammals and birds including Adélie penguins (*Pygoscelis adeliae*) and emperor penguins (*Aptenodytes forsteri*).

Antarctic marine reserves offer a rare opportunity to conserve and study largely untouched natural areas, says Keith Reid, science manager for CCAMLR in Hobart and a former research scientist with the British Antarctic Survey. By contrast, “MPAs in many parts of the world are implemented usually in response to something that’s gone wrong”. And although MPA status does little to ward off the effects of climate change, it can help “ensure the other activities don’t exacerbate the impacts”, he says.

Antarctic marine parks are part of a larger international effort to protect 10% of the world’s oceans in MPAs. Gillian Slocum, who represents the Australian Antarctic Division at CCAMLR, is optimistic that the negotiating challenges can be overcome: “We’re hoping CCAMLR can keep building on the momentum of creating the Ross MPA.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22913

Comments

Comments

There are currently no comments.

China announces plans to fast-track drug approval

Policies are expected to speed up access to medicines and boost the country’s pharmaceutical industry.

26 October 2017

Xue Jun/Xinhua via ZUMAPRESS

China is aiming to cut the amount of time people have to wait for new medicines.

China is overhauling its drug-approval system to let companies bring their treatments to market quicker and more easily. On 9 October, the Communist Party of China and the State Council, two of the country’s most authoritative

bodies, announced plans to reduce the backlog of medicines awaiting approval by the China Food and Drug Administration (CFDA). Policies will also be introduced to boost the productivity of Chinese drugmakers and spur innovation in health care.

Details of the plans are only just starting to emerge, but industry observers expect them to be in place by the end of 2017. One proposal, released for public comment on 20 October, states that companies will be allowed to use data from clinical trials conducted in other countries when applying for drug approval in China. Currently, companies have to perform extra trials in China to test a drug's efficacy. Under the new guidelines, they will instead need to provide data that show that a drug works in all human populations.

The changes will significantly reduce the time Chinese people have to wait for new medicines, and will save multinational companies time and money, says Angela Yan, senior director of science and regulatory affairs at the R&D-based; Pharmaceutical Association Committee in Beijing, which represents the interests of foreign companies in China**.** A vaccine against the human papillomavirus, for example, was approved in China only in 2016, a decade after it was given the green light in the United States. More than 20 years of efforts to reduce delays are now paying off, says Yan. "This is very positive."

Unblocking the pipeline

The shake-up is the latest in a series of measures to accelerate China's drug-regulation process and make it more rigorous, in line with international standards. In the past two years, the government has dramatically increased the number of application inspectors at the CFDA to reduce the backlog of medicines awaiting approval. It has also threatened to jail manufacturers or researchers caught submitting fraudulent applications.

And in June, China became a member of the International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use, which requires a nation's drug-approval agency to adhere to international standards and guidelines.

As well as reducing the administrative burden of drug registration, the government is eager to expand its pharmaceutical industry, given that China is the world's second largest drug market. Between 2001 and 2016, China approved just over 100 new drugs, whereas developed countries approved 433.

Far-reaching policies

Su Ling, director of the Institute of Drug Regulatory Science at Shenyang Pharmaceutical University and a venture partner for the investment fund Lilly Asia Ventures in Shanghai, says the government will introduce a range of policies that will have broad effects on the industry. "Overall they are in the right direction to become more aligned with international norms and to promote new drug R&D; and access," says Su. "This is really important."

Another policy, announced by the CFDA on 10 October, will end the restriction that prohibits pharmaceutical companies from starting phase I safety trials for a drug in China until its safety has been proved in another country. The ban was designed to protect Chinese people from exploitation by drug companies during early experiments.

Yan says loosening the restriction could plug crucial holes in China's drug-development pipeline, which has lost capacity to translate research from animals to humans. "Now they can do global phase I trials and learn and improve their capabilities," she says.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22888

Comments

Comments

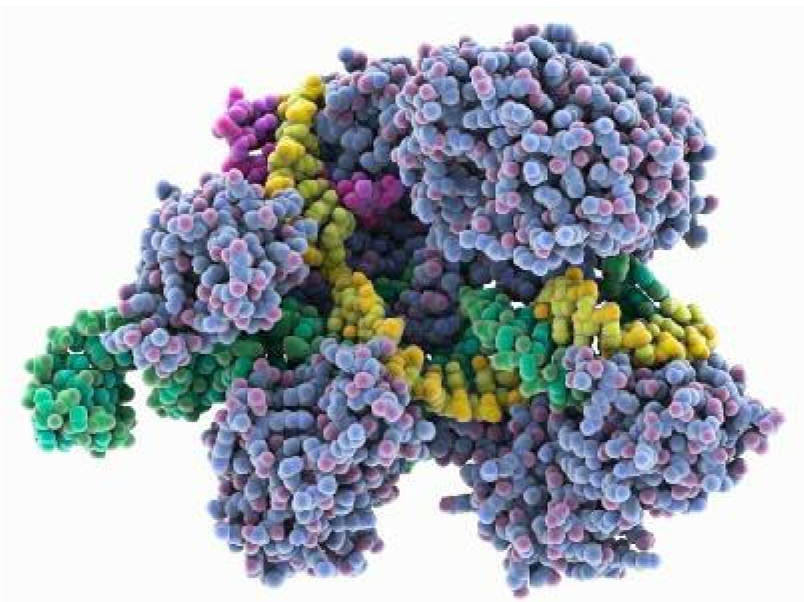
There are currently no comments.

| 章节菜单 | 主菜单 |

Bitter CRISPR patent war intensifies

Gene-editing pioneers prepare for next stage of intellectual-property disputes in the United States and Europe.

26 October 2017



Laguna Design/SPL

The CRISPR–Cas9 system acts as molecular scissors to precisely cut and edit genetic code.

The long-running battle over US patents for CRISPR–Cas9 gene editing continues. On 25 October, the Broad Institute of Cambridge, Massachusetts, filed a fresh set of arguments with the US government to defend a key patent.

That action helps to set the stage for a second round of oral arguments in the unusually vitriolic case, which observers expect to take place in early 2018.

A decision is anticipated to follow shortly thereafter.

In the filing, lawyers for the Broad and its collaborators argued that its opponent, a team that includes the University of California, Berkeley, has failed to provide new evidence that would undermine the legitimacy of the Broad's patent. The lawyers also used the University of California's own press releases as a sign that the case should be thrown out.

At stake are intellectual-property rights to the use of CRISPR–Cas9 gene-editing tools in eukaryotes, organisms such as plants and animals. This would include applications of the technique to treat human genetic diseases — an approach that has recently entered cancer clinical trials in China, and is potentially the most lucrative application of gene editing.

Although non-profit research institutes often reach settlements over such patent disputes, both sides in the CRISPR case have invested heavily in a prolonged patent fight, says Kevin Noonan, a partner at the law firm McDonnell Boehnen Hulbert & Berghoff in Chicago, Illinois. "They really went after each other so vigorously," he says. "You want to say, 'Hey, let's take a breath.'"

Novelty seeking

The fight began when the US patent office granted the Broad a patent covering the use of CRISPR–Cas9 in eukaryotic cells. The California team had filed its patent earlier, but the Broad opted for an expedited review that got its application granted first. The University of California then argued that the Broad's patent interfered with the granting of its own patent, and launched an official proceeding before a board of specialized patent judges.

Throughout that proceeding, the University of California team argued that its patent — which explicitly describes the use of CRISPR–Cas9 gene editing only in non-eukaryotes such as bacteria — rendered applications in eukaryotic cells "obvious" and therefore unpatentable. The Broad countered that the University of California's invention needed significant and non-obvious tweaks before it could be used in eukaryotes.

In February, the patent office sided with the Broad. The University of California team soon filed an appeal to the US Court of Appeals for the Federal Circuit, claiming that the patent board had made “fundamental errors of law” that would allow the Broad to unfairly claim rights to the most important and valuable applications of CRISPR–Cas9 gene editing.

Despite that argument, Noonan expects the court — which generally defers to the patent office — to uphold the patent board’s decision. “For Berkeley to prevail, the Federal Circuit is going to have to say, ‘Yeah, the board got it wrong,’” he says. “I think it’s unlikely that they’ll do that.”

Counter arguments

In the 25 October filing, lawyers for the Broad also pointed to press releases issued by the University of California in the wake of the patent board’s February decision. Those press releases argued that the University of California had come out ahead in the decision, because people who wanted to use CRISPR–Cas9 gene editing in any system — eukaryotic or not — would still need to license its patents. If so, the Broad argued, then the University of California was not harmed by the patent board’s decision and therefore lacks legal standing to appeal it.

Upholding that previous decision could spell trouble for the University of California, notes Jacob Sherkow, a legal scholar at New York Law School. The university’s patent would go back to the patent office for examination. But in May, the patent office issued another key CRISPR patent to Vilnius University in Lithuania. That application was filed earlier than the University of California’s, so patent law could dictate that it takes precedence. The California patent could be crowded out, Sherkow says: “This is a dramatic turn.”

The CRISPR patent landscape elsewhere is also uncertain. In Europe, the Broad has been granted ten patents but is in danger of losing as many as eight of them, notes Catherine Coombes, a patent attorney at intellectual-property specialists HGF in York, UK. In April, the European Patent Office issued a preliminary ruling that threw out the Broad’s earliest filing date for its first

patent, because the institute had later removed an inventor from the patent application.

If that decision — which will be discussed during oral arguments in mid-January — becomes final, it will push the Broad's patent date to a time after the institute's team published its findings in a scientific article[1]. And that would invalidate the patent application altogether.

Overall, there are more than 1,880 families of CRISPR patent, according to IPStudies, a consulting firm near Lausanne, Switzerland. More than 100 new families — each a group of related intellectual-property claims — are published each month.

With those numbers in mind, people looking to commercialize CRISPR–Cas9 gene editing will probably continue to face a daunting patent landscape, notes Coombes. "The situation is going to get a lot more complicated before it gets better."

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22892

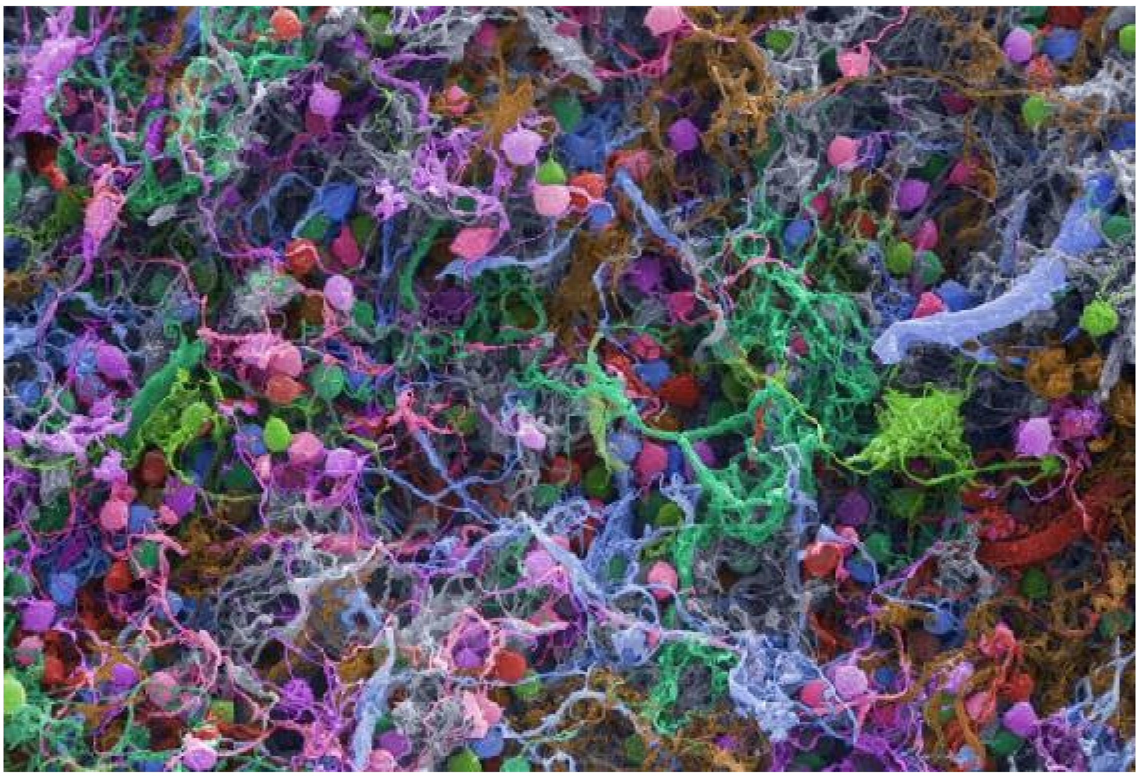
Comments

Commenting is currently unavailable.

First living human cells added to brain database

Measurements show how neurons behave in healthy living tissue.

25 October 2017



Ted Kinsman/SPL

Scanning electron micrograph of human brain cells.

Fresh human brain tissue is a vanishingly rare resource for neuroscientists. Now, data on small bits of live human brain tissue that normally get discarded during surgery are being added to a publicly available database that could help to unravel how cognition works. On 25 October, researchers at the

Allen Institute for Brain Science in Seattle, Washington, who compile neuroscience tools including large-scale databases and brain maps, announced that they had published their first data from living human brain cells.

Most human-brain studies use either images of functioning brains obtained by scanning volunteers or slices of dead organs from cadavers. The images and information now added to the database will let researchers analyse the molecular content of individual living cells, or neurons, and, ultimately, identify the biological basis of their behaviour. Until now, the database had contained information only about mouse brains.

Small studies using surgical human brain samples began very tentatively in the 1970s but the large amount of human data now published by the Allen Institute — the most extensive and systematic effort so far — has been welcomed as a major aid to identifying the uniqueness of the human brain.

Uniquely human

With their patients' consent, neurosurgeons in the Seattle region donated small pieces of brain that they would otherwise have discarded during surgery. The pieces are bits of the outer layer called the cerebral cortex that they needed to snip out to access diseased tissue deeper in the brain.

The cortex processes higher-level activities, including the deep introspection and abstract reasoning that is thought to be specifically human. "Finding out what the detailed differences are between the mouse and human brain will help us understand what makes us unique among species," says Christof Koch, president and chief scientific officer of the Allen Institute.

The first slew of human data includes the electrical properties of 300 different types of neuron from 36 people, along with 3D reconstructions of the spidery shapes of some of them, and computer models that simulate their electrical behaviour. It also includes gene-expression profiles of 16,000 individual cells from the brains of another 3 people. Scientists around the world may now compare these data with those from mice to generate hypotheses about where

key differences lie.

“This database is a major service to the scientific community,” says Huib Mansvelder, a neuroscientist at the Free University of Amsterdam and an early pioneer of research on fresh human brain cells. He and his colleagues have shown[1], for example, that human neurons have a lower capacitance than mouse neurons, which makes them quicker to start firing and quicker to transfer information. They also have more intricate shapes. “But the Allen’s industrial approach takes the endeavour to a whole new level,” he says.

Living tissue

The lumps of donated tissue are each about the size of a sugar lump — typically the same volume as an entire mouse brain. Cut into slices 300–350 micrometres thick, the cells remain alive and active for three days, giving scientists ample time to take measurements. Mouse neurons, by contrast, tend to degenerate within hours.

Only a few research centres worldwide study fresh human brain tissue, partly because until recently few brain surgeons had been inspired to work with it. But rapid developments in biological research tools have increased the scientific rewards for doing so.

The Allen Institute now plans to increase the number of human brain cells in its database and the amount of information available from each of them. It aims eventually to include full RNA profiles to indicate which genes are active in the tissue. The next phase will also analyse the connections between the cells. However, the work cannot be as comprehensive as studies of mouse brains, because only small pieces of living human brains can be removed, whereas the whole brains of mice can be examined.

Cell integrity

There is another concern about the human tissue. Although apparently healthy, the cells come from surgery to remove tumours or treat severe

epilepsy, which provokes concerns that their properties might have been altered by their pathological environment. However, Mansvelder has compared cortical tissue from people with cancer with that from people with epilepsy, and found them to be very similar. The Allen Institute has confirmed these results.

There is another advantage to using human cortical tissue. Neurosurgical teams collect vast information about the brain functions of their patients before and after operations. With appropriate anonymization, this can be correlated with cellular properties. At a meeting of the Federation of European Neuroscience Societies in Pécs, Hungary, on 20–23 September, Mansvelder presented data showing that IQ correlates with the threshold of firing of cells — the higher the IQ, the lower the threshold.

Mansvelder, along with fellow neuroscience pioneer Gábor Tamás of the University of Szeged in Hungary and groups from Israel and Sweden, will collaborate with the Allen Institute to develop the human-brain database further, thanks to a US$19.4-million grant from the US National Institutes of Health, announced on 23 October.

Journal name:
    Nature
DOI:
    doi:10.1038/nature.2017.22889

Comments

Comments

There are currently no comments.

Many junior scientists need to take a hard look at their job prospects

Permanent jobs in academia are scarce, and someone needs to let PhD students know.

25 October 2017

David Williams/Corbis/Getty

Most PhD students will have to look beyond academia for a career.

For his 2012 PhD thesis, the sociologist Chris Platts surveyed and interviewed more than 300 young footballers — aged 17 and 18 — at UK club academies who were hoping to pursue a career in the game. He told the newspaper *The Guardian* this month that just four of them currently have

gained a professional contract. That’s a drop-out rate of 99%.

For our Careers section this week, *Nature* surveyed more than 5,700 early-career scientists worldwide who are working on PhDs. Three-quarters of them, they told us, think it’s likely that they will pursue an academic career when they graduate, just like Platts — now a senior lecturer in sport development and sport business management at Sheffield Hallam University, UK. How many will succeed?

Statistics say these young researchers will have a better chance of pursuing their chosen job than the young footballers. But not by much. Global figures are hard to come by, but only three or four in every hundred PhD students in the United Kingdom will land a permanent staff position at a university. It’s only a little better in the United States.

Simply put, most PhD students need to make plans for a life outside academic science. And more universities and PhD supervisors must make this clear.

That might sound like an alarmist and negative attitude for the International Weekly Journal of Science. But it has been evident for years that international science is training many more PhD students than the academic system can support. Most of the keen and talented young scientists who responded to our survey will probably never get a foot in the door. Of those who do, a sizeable number are likely to drift from short-term contract to short-term contract until they become disillusioned and look elsewhere.

As *Nature* has said before, it is good for PhD students and postdocs to pursue careers outside academia. Many will find similar challenges and rewards in industry. And it is surely of benefit to science and society at large that a sizeable number of well-educated and well-trained scientists spread to other sectors, and take with them healthy scepticism and respect for evidence. It is certainly better for young scientists to take a realistic view early in their career path, when they still have time to adjust their ambitions. So why do people in science still see this reality as a dirty secret?

Our survey, for example, shows that one-third of respondents do not have useful conversations about careers with their PhD supervisors. And non-

academic jobs are low on the agenda when future options are discussed. Almost one-third of the students disagreed or strongly disagreed with the statement that their supervisor has useful advice for non-academic careers. That’s about the same as was reported in *Nature*’s previous PhD survey, in 2015. If you supervise a PhD student or know someone who does, then please help to shrink that number by the time the next survey goes out, in 2019. Supervisors are busy people but they are often the face of the university and the academic system for students, and so the most obvious place to seek guidance. At the very least, they should be willing to point students towards the university careers service, which should also focus more on options outside academia. It’s not just undergraduates who benefit from a variety of possibilities. Indeed, postgraduates arguably need more attention and advice because so many people — including themselves — believe that they are now on a path to a professorship.

Another major point worth making from the 2017 survey is about mental health. More than one-quarter of the students who responded listed mental health as an area of concern, and 45% of those said they had sought help for anxiety or depression caused by their PhD. One-third of those got useful help from their institution (which of course means that two-thirds did not). Still, just 5% said no help was available there or elsewhere, which, given the general difficulty in accessing mental-health support in many countries, suggests that young people in the education system are perhaps better served than many outside it.

If the outlook for junior scientists in academia is mixed, then, luckily for science, most don’t seem to let it put them off. Indeed, it’s striking to note that nearly eight in ten of the young scientists surveyed said they were satisfied with their decision to start a PhD. That reflects well on the excellent opportunities, facilities and supervision that many receive. Just like the footballers, some will succeed, and they will find a career in academic science to be as thrilling, rewarding and satisfying as they hope. But someone needs to tell the rest what happens next.

Journal name:
Nature
Volume:

550,
Pages:
429
Date published:
(26 October 2017)
DOI:
doi:10.1038/550429a

Comments

Commenting is currently unavailable.

Data science can improve aid distribution

Online platforms can help to steer emergency response and ensure money is well spent.

25 October 2017

Delil Souleiman/AFP/Getty

Better data tools could help coordinate aid and relief efforts.

Over the past decade, non-profit organizations have sent millions of small stoves to families in the developing world. These appliances are intended to stop people from cooking over open flames indoors — an activity linked to four million deaths per year, attributable to household air pollution.

But economists and public-health researchers have published studies that question the benefits of this effort. One randomized controlled trial (RCT), reported in 2012 and involving 15,000 households in rural India, found no evidence of improved lung function in women in the first four years after they received a stove (see go.nature.com/2zjgwny).

The RCT suggests that these efforts might be revised. But as useful as RCTs are in development economics and global health, they have limits. Findings in one place might be wildly different in another. And in a crisis, first responders are typically too busy trying to provide shelter, health care and bare necessities to design and carry out a controlled set-up.

But humanitarian groups can still improve their efforts in the short and long term through evidence obtained with new technology. A *Nature* News Feature this week highlights software called the Dharma Platform, which enables workers on the front line of hurricanes, outbreaks or other crises to record, share and analyse useful data — for example, the spread of disease in rural villages. Dharma is being tested by Médecins Sans Frontières (or Doctors Without Borders), the World Health Organization and other groups combating crises in the Middle East. And it is just one of many new technologies that will make data faster to collect and easier to exchange.

The rush to provide food, shelter and health care can be as chaotic as the disaster itself. Hundreds of millions of dollars flood into the world’s largest agencies and non-governmental organizations, which often sub-contract delivery to dozens of smaller groups. In such a system, the best source of data is a person on the ground — often someone low in an organization’s chain of command. It’s this aid worker who listens as a mother describes how she’s received four sacks of rice, yet her babies have nothing to eat. This essential feedback is typically recorded on paper. If it makes it into a report, weeks or months will pass by the time it gets to headquarters, where managers then adjust the system.

Platforms such as Dharma that collate real-time data could quicken this response time by informing groups of what people need, and help to reassure donors that their money is being spent wisely. After an acute crisis, researchers can use data collected in the heat of the moment to answer big-picture questions. For example, how might assistance better prevent tragedies

that follow disasters, such as the cholera epidemic in the wake of Haiti’s 2010 earthquake, or blindness in survivors of Ebola? As long as data collection is organized, consistent and secure, researchers distanced from those delivering aid can evaluate projects objectively.

Requesting more data and analysing them coldly will make failures more evident. In turn, philanthropists, taxpayers and governments that donate money should evaluate each inefficiency sensibly, and not be unforgiving. For example, a tiny fraction of donated insecticide-treated bednets may be used as fishing nets — but that fact should not negate an intervention that has been shown to reduce cases of malaria caused by *Plasmodium falciparum* by up to 62% (C. Lengeler *Cochrane Database Syst. Rev.* http://doi.org/c4f9c7; 2004). Failures at all scales must be upheld as lessons in the continuing struggle to do what’s right — and not as arguments to abandon aid completely.

Journal name:
Nature
Volume:
550,
Pages:
430
Date published:
(26 October 2017)
DOI:
doi:10.1038/550430a

Comments

Comments

There are currently no comments.

A death sentence, Hawking's thesis and China's ambitions

The week in science: 20–26 October 2017.

25 October 2017

Events | Facilities | Politics | Space | Research | Business | Energy | Trend watch

EVENTS

Death sentence for Iranian scientist A judge in Tehran sentenced to death an Iranian researcher accused of “collaboration with a hostile government” on 21 October, according to the researcher’s wife and diplomatic sources in Italy. Ahmadreza Djalali, a disaster-medicine researcher who is affiliated with institutions in Sweden and Italy, was arrested in April 2016 while on an academic visit to Tehran and convicted of espionage following a trial in Iran’s revolutionary court. Close contacts of Djalali’s say he believes that he was arrested for refusing to spy for the Iranian intelligence service and was forced to make false confessions. They say Djalali has 20 days to appeal against the sentence.

Dirk Waem/AFP/Getty

A flyer photographed during a protest outside the Iranian embassy in Brussels for Ahmadreza Djalali.

Hawking's thesis The PhD thesis of physicist Stephen Hawking has been made freely available online for the first time. The University of Cambridge, UK, where Hawking completed his PhD in 1966, posted the work on 23 October to mark Open Access Week 2017. The physicist was 24 years old when he wrote up his thesis, entitled 'Properties of expanding universes'. Demand to view the document temporarily crashed Apollo, the open-access repository on which it was posted. Hawking said that he hoped to inspire people by making his work available.

FACILITIES

Hungary university The US-registered Central European University (CEU) in Budapest faces another year of uncertainty over whether it can continue to

operate in Hungary. In April, the Hungarian government amended its higher-education law to require that all foreign-accredited universities there had to operate as higher-education institutes in their countries of origin. The CEU took steps to comply with the law, but on 17 October the country's parliament voted to delay a decision that would allow the CEU to keep operating. See 'Efforts to save leading Hungarian university hit hurdle' for more.

POLITICS

Travel ban blocked Two federal judges temporarily blocked much of US President Donald Trump's latest iteration of a travel ban that affects eight countries — most of which are Muslim-majority nations — citing unconstitutional religious discrimination. The decisions, announced on 17 and 18 October, allow visa processing to resume as usual for all countries named in the ban, with the exception of Venezuela and North Korea. Eighty-four scientific societies and a university submitted a letter on 17 October contesting the most recent version of the ban, which Trump introduced in late September. The letter says that the ban weakens US science, and cites "serious implications for diplomatic, humanitarian, and national security interests" as motivation for the organizations' disapproval.

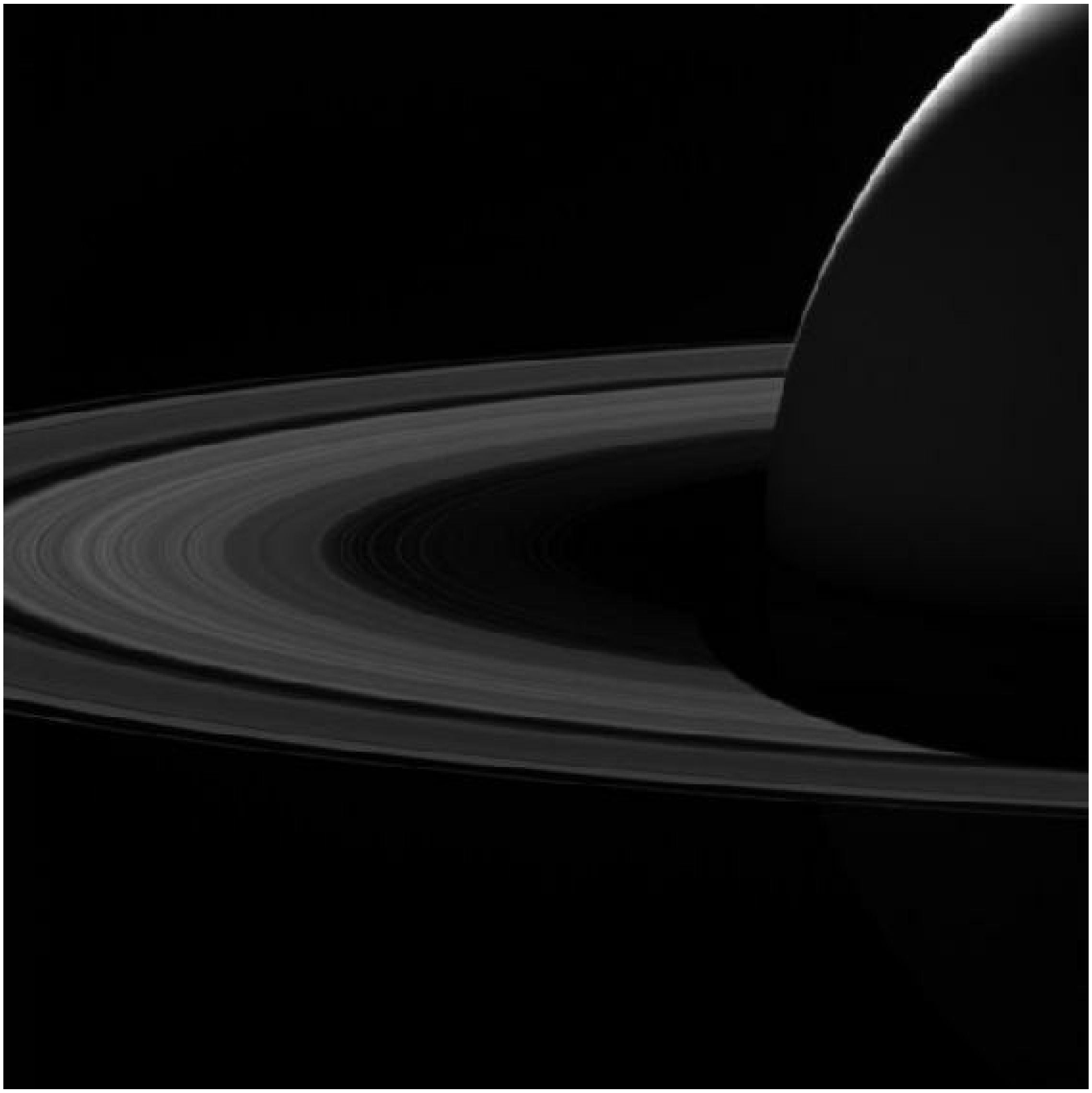
New Zealand leader Jacinda Ardern, New Zealand's newly elected prime minister, has promised to prioritize a number of science-related issues, including climate change and the environment. After a close-run election in which no party won an outright majority, it was announced on 19 October that Ardern would lead a coalition government made up of her own Labour Party and the New Zealand First party. During campaigning, both parties committed to boosting science funding, with New Zealand First saying it would increase investment in research and development (R&D;) to 2% of gross domestic product. The current figure is around 1.2%. The Labour Party plans to introduce tax breaks for companies that invest in R&D;, and to establish an independent climate commission to advise the government on reducing carbon emissions.

Chinese science China will become "a nation of innovators", according to a

speech by the country's president Xi Jinping on 18 October. Xi laid out the vision as he opened the 19th National Congress of the Chinese Communist Party, an event held every 5 years at which the party shuffles its leadership. It was also a chance for Xi to consolidate his power after five years of heading the party. His support for science and technological innovation, which he says is necessary to build the industrial system needed for "socialism with Chinese characteristics", has been welcomed by scientists. Xi also boasted of China's success on environmental issues, and promised to put the country at the forefront of global efforts to combat climate change.

SPACE

Saturn surprise New data from NASA's Cassini probe suggest that Saturn's majestic rings are showering tiny dust particles into the planet's upper atmosphere, where they form a complicated and unexpected chemical mix. The findings were presented on 17 October at a meeting of the American Astronomical Society's Division for Planetary Sciences in Provo, Utah. A mass spectrometer aboard Cassini detected the strange chemistry during the probe's final five months, as it looped between Saturn and its rings. Cassini's mission ended in September, when it burnt up on a controlled dive into Saturn.



NASA/JPL-Caltech/SSI

Telescope cut-back NASA will assess what it can strip off from the planned Wide Field Infrared Survey Telescope (WFIRST), its next major astrophysics mission for the 2020s, to keep the mission's cost below US$3.2 billion. On 19 October, following input from an independent panel of experts, NASA science chief Thomas Zurbuchen directed the agency to consider downsizing the capabilities of WFIRST's coronagraph, an instrument that studies exoplanets, and its wide-field camera. Even with these reductions, NASA says, WFIRST will still enable cutting-edge research into dark energy, exoplanets and other areas of astrophysics. The mission was the top priority

in the most recent US astrophysics decadal survey, but its cost has been creeping up. WFIRST’s current price tag is $3.6 billion.

Euclid delay Officials overseeing the European Space Agency’s (ESA’s) Euclid space telescope will assess whether they need to delay its scheduled 2020 launch because of a problem with infrared detectors developed by NASA. The detectors’ electronics have been failing during tests at cold temperatures, NASA astrophysics head Paul Hertz told an advisory panel on 18 October. Fixing the problem could take 12–18 months. NASA is providing 16 detectors for Euclid, which will study dark energy and dark matter. ESA is trying to minimize the impact of the NASA delay by reshuffling its schedule for integrating parts into the telescope.

RESEARCH

Nuclear-decay hunt On 23 October, physicists in Italy inaugurated a search for a type of nuclear decay that could explain why the Universe seems to contain almost no antimatter. The Cryogenic Underground Observatory for Rare Events (CUORE) at the Gran Sasso underground laboratories in the Apennine Mountains is one of several experiments worldwide that are looking for neutrinoless double-beta decay, a hypothetical reaction that would reveal whether neutrinos are their own antiparticles. In early cosmic history, this reaction could have led to matter becoming prevalent over antimatter. CUORE looks for the reaction in 760 kilograms of tellurium dioxide crystals kept at 10 millikelvin and shielded in part with lead recovered from a Roman shipwreck.

BUSINESS

CRISPR patents Key US patents on a gene-editing tool called CRISPR–Cas9 can be bundled together and licensed for agricultural applications, thanks to an 18 October agreement. The patents are held by the Broad Institute of MIT and Harvard in Cambridge, Massachusetts, and DuPont Pioneer, an agricultural biotechnology company in Johnston, Iowa, which had licensed the patents from the University of California, Berkeley, and

other institutions. Although the Berkeley team is embroiled in a fight with the Broad Institute over CRISPR–Cas9 patents, the new agreement will allow companies to obtain a non-exclusive licence for the patents from the Broad and DuPont. The CRISPR–Cas9 intellectual property will be free for universities and non-profit organizations.

ENERGY

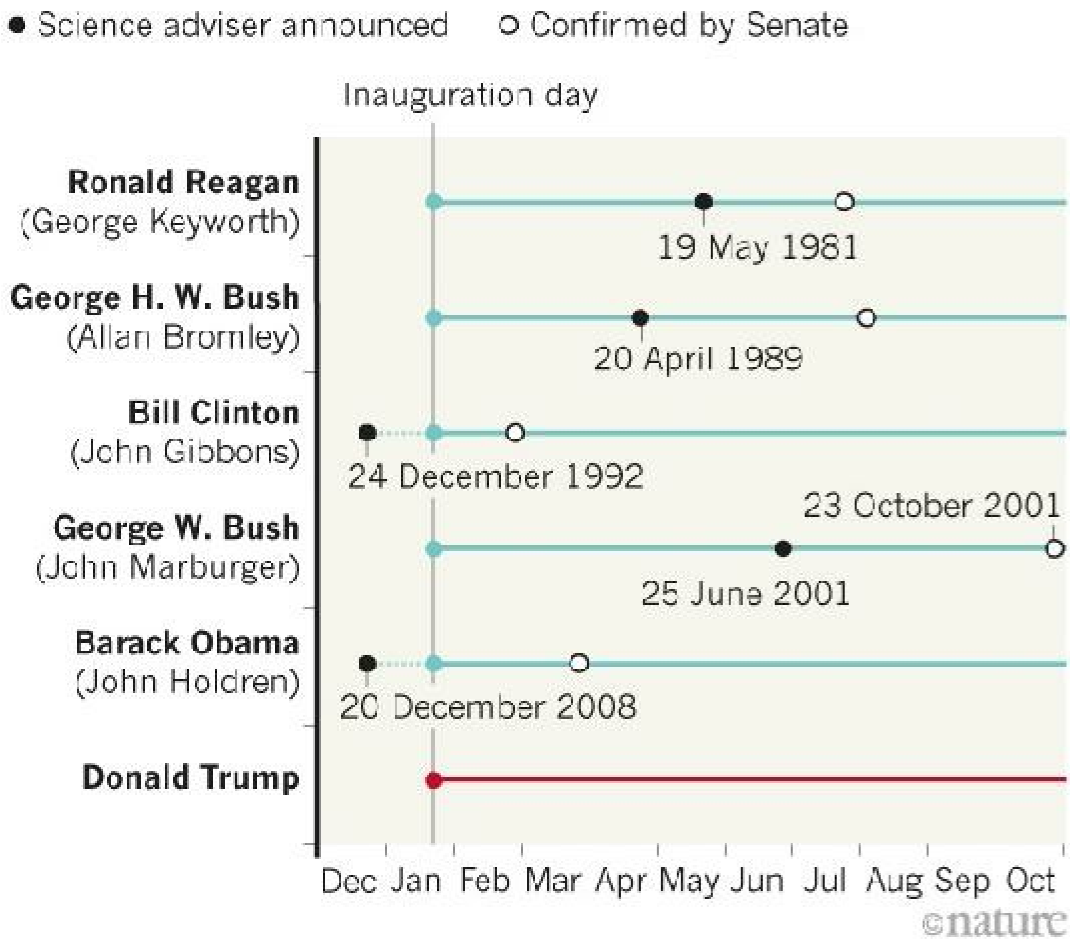
Korean reactors South Korea will resume building two nuclear power plants following the recommendation of a citizens' jury. Although President Moon Jae-in had pledged to cancel construction of the plants when he was elected earlier this year, he agreed to a three-month public debate after his party took power. On 20 October, the government announced that it would accept the jury's decision. Composed of 471 citizens, the jury also recommended that nuclear power eventually be phased out. Moon, who has shut down one old reactor, vowed to continue to pivot the nation towards renewable energy and natural gas. An earthquake last year in the country's southern region has raised fears of possible damage to its nuclear reactors.

TREND WATCH

Donald Trump has now gone longer without a science adviser in place than any first-term US president since at least 1976. On 23 October, Trump broke the record set by former president George W. Bush, whose science adviser was confirmed by the Senate on 23 October 2001 — 276 days after Bush took office, and 120 days after he announced his pick. Trump has yet to name an adviser. By contrast, Barack Obama took the least time of any first-term president in naming his science adviser.

HELP WANTED

Donald Trump has now gone longer without a science adviser than any first-term US president since at least 1976. By contrast, his predecessor Barack Obama took the least amount of time in announcing his science adviser pick (in brackets), naming John Holdren one month before Inauguration Day.



Journal name:
Nature
Volume:
550,
Pages:
434–435
Date published:
(26 October 2017)

DOI:
doi:10.1038/550434a

Comments

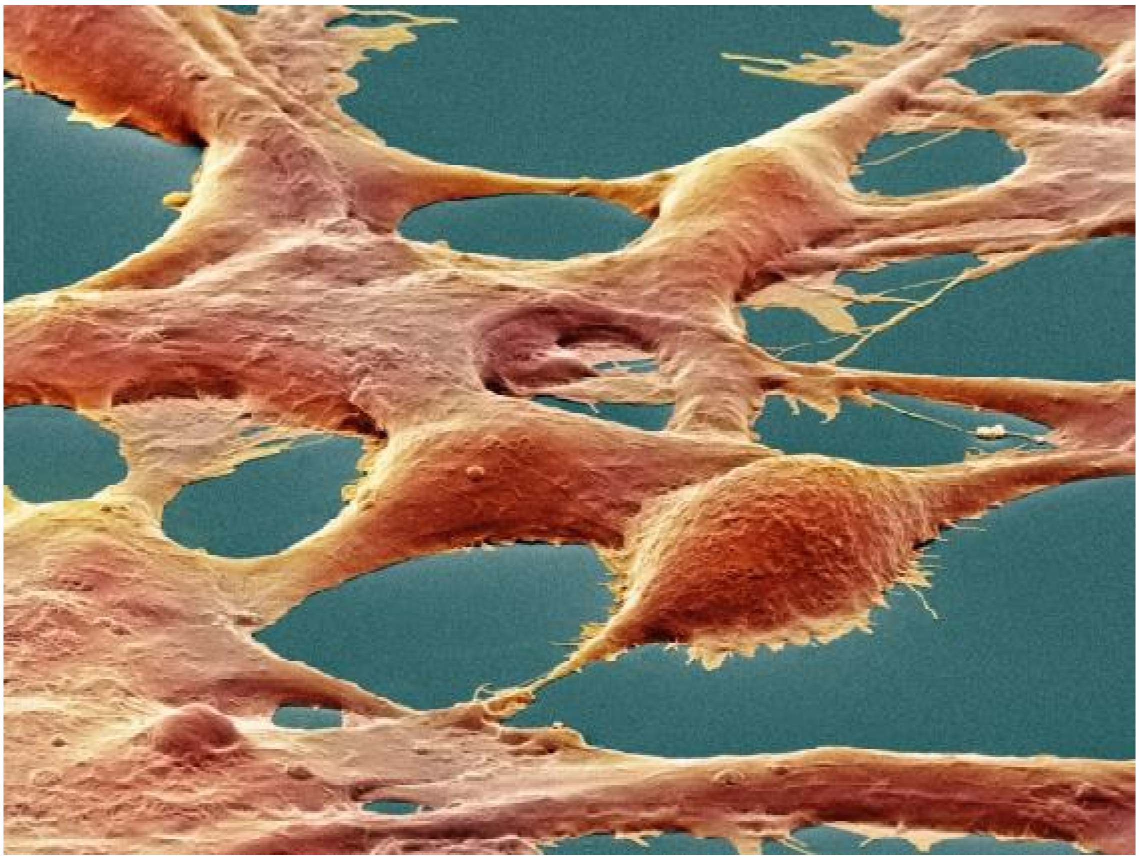
Comments

There are currently no comments.

CRISPR hacks enable pinpoint repairs to genome

Precision tools expand the number of ‘base editors’ available for manipulating DNA and RNA.

25 October 2017



David McCarthy/SPL

Using human embryonic kidney cells, researchers have come up with a way tc edit specific letters in the genome.

The toolbox for editing genes expanded this week, as two research groups

announced techniques that enable researchers to make targeted alterations to DNA and RNA. Unlike the original CRISPR gene-editing system — a relatively unpredictable and blunt form of molecular scissors that cut sizeable sections of DNA — the new systems rewrite individual letters, or genetic bases. The ability to alter single bases means that researchers can now attempt to correct more than half of all human genetic diseases[1, 2].

The tools, developed by separate teams at the Broad Institute of MIT and Harvard in Cambridge, Massachusetts, are adaptations of the CRISPR system. Whereas most past attempts to use CRISPR-based methods to fix individual bases have been crude affairs — akin to using a machete to remove a wart — the new techniques are more like "precision chemical surgery", says David Liu, a chemical biologist at the Broad Institute who led one of the studies.

Last year, his group reported[3] the first 'base editing' method for converting one target DNA letter into another without needing to cleave the genome's double helix. It has since been used around the world to correct genes in fungi, plants, fish and mice, and even in human embryos harbouring a defective gene that can cause a blood disorder. But that base editor could achieve only two kinds of chemical conversions: a cytosine (C) into a thymine (T) or a guanine (G) into an adenine (A).

The new base editor — described in a paper published on 25 October in *Nature*[1] — works in the other direction, converting T to C or A to G. It can therefore undo the most common types of 'point mutation', which involve single aberrant bases.

In human embryonic kidney cells and bone-cancer cells, the technique made the desired corrections with about 50% efficiency and almost no detectable by-products. By comparison, a more conventional CRISPR-based method, in which scientists insert a strand of DNA containing the desired base change, fixed the same single-base differences with less than 5% efficiency and often caused undesired insertions or deletions of large chunks of DNA.

"This is a major breakthrough in the field of genome editing," says Jin-Soo Kim, a molecular geneticist at Seoul National University.

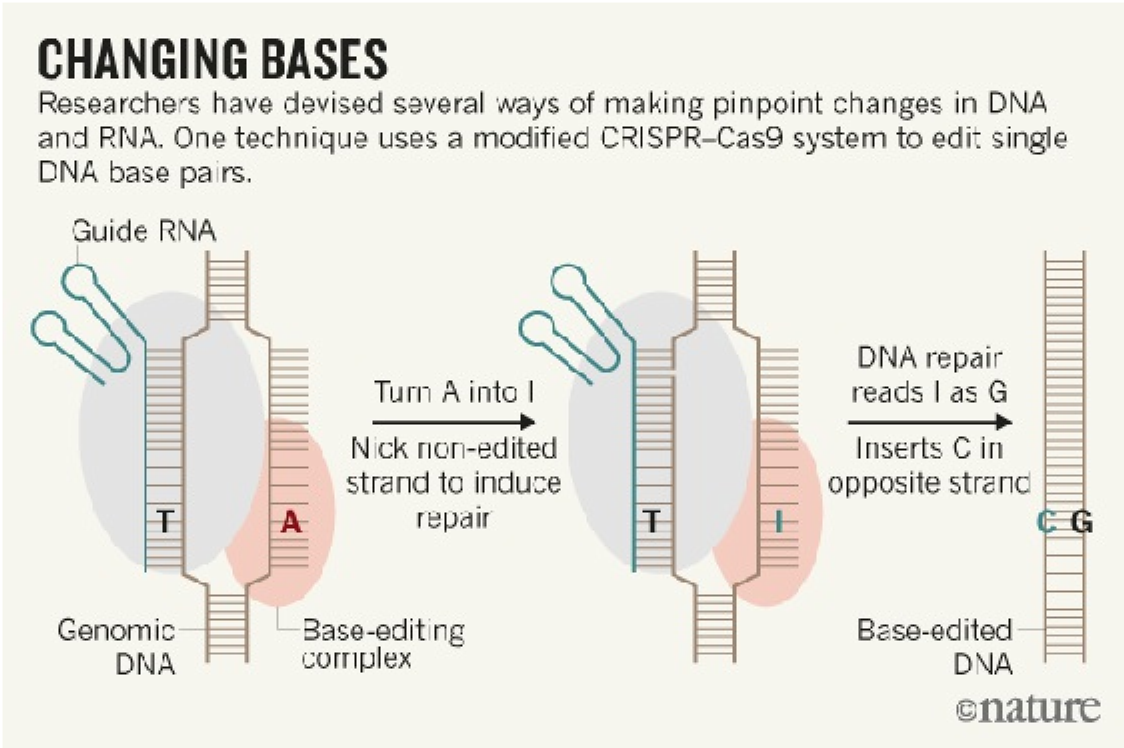
Tricks of the trade

Another method, described in a study published on 25 October in *Science*[2] and led by Broad Institute bioengineer Feng Zhang, performs a similar conversion, but for RNA instead of DNA. It turns an A into inosine (I), which is read as a G by the cell's protein-building machinery. This allows for a temporary correction of a disease-causing mutation without permanent alteration to the genome — a potentially safer option when it comes to gene-fixing therapeutics, although the treatment would need to be administered repeatedly. It would also mean that researchers could alter a treatment as they gain a better understanding of the disease. "If you use RNA therapy," Zhang says, "you can upgrade."

His team's RNA editor is based on a naturally occurring enzyme that rearranges the atoms in A to resemble I instead. The researchers fused the enzyme to a disabled version of the CRISPR system — one involving an RNA-targeted enzyme called Cas13, instead of the usual DNA-binding Cas9. With the help of a sequence-specific guide RNA molecule, they successfully corrected disease-causing mutations 23–35% of the time, with low incidences of off-target activity.

In the base-editing method pioneered by Liu's team last year, the researchers engineered a naturally occurring enzyme and tethered it to a dud Cas9, which allowed them to convert C to T. But there is no equivalent enzyme found in nature for the opposite conversion in DNA. So the researchers started with an RNA-editing enzyme similar to the one Zhang's group used.

The team guided the evolution of bacterial cells through seven generations, and used some protein engineering in the lab, to produce an enzyme that would recognize and manipulate DNA. The enzyme was able to rearrange atoms in adenine to change it into an inosine, which the cell reads as a guanine. The system then tricked the cell into inserting a cytosine into the unmodified DNA strand (see 'Changing bases').



SOURCE: REF. 1

Gutsy move

“It represents a heroic effort,” says Dana Carroll, a genome-engineering researcher at the University of Utah in Salt Lake City, noting that the directed-evolution approach was something of a shot in the dark. “I wouldn’t have had the guts to try what they did,” Carroll says. “My hat’s off to David Liu.”

The ability to make four types of single-base conversion — A to G, G to A, C to T and T to C — “will be extremely valuable for precise therapeutic and agronomic editing”, says Caixia Gao, a plant geneticist at the Chinese Academy of Sciences’ Institute of Genetics and Developmental Biology in Beijing.

It could also prove useful in drug discovery and for DNA-based data storage, says Marcello Maresca, a gene-editing researcher at AstraZeneca in

Gothenburg, Sweden.

The development of any other base editors will require enzymes that do not occur in nature, even for conversions in RNA. But that kind of obstacle has not stopped Liu before. “We’ll keep trying until the community has developed all possible base editors,” he says.

Journal name:
Nature
Volume:
550,
Pages:
439–440
Date published:
(26 October 2017)
DOI:
doi:10.1038/550439a

Comments

Comments

There are currently no comments.

Out of the Syrian crisis, a data revolution takes shape

Aid organizations have been piloting a nimble approach to cut through the fog of war.

25 October 2017

Neil Brandvold for Nature

A doctor and technicians record health data on a Syrian refugee in Jordan.

Shadows shroud Issam Salim's face as he recounts the operations he's performed. Yesterday, he tended to fractures, mangled limbs and intestinal injuries caused by an explosion from an unknown source. “The situation was very tense,” he says. Today, there have been no war-wounded patients, so he

saw people with bladder stones and hernias instead. Salim is deputy director of a hospital in southern Syria, and he's talking to an Iraqi surgeon, Ghassan Aziz, through a flickering Skype video call.

Aziz is not far away — just two hours south by car, in Jordan's capital, Amman. It is from here that the organization Aziz works for, Médecins Sans Frontières (MSF), has been providing medical aid to clinics in southern Syria during a conflict that has become one of the world's worst ongoing humanitarian crises. But Aziz and his colleagues dare not get much closer. After 13 MSF staff members were kidnapped in January 2014, the organization, also known as Doctors without Borders, pulled its international staff out of the country.

Text messages and calls such as the one with Salim provide a glimpse of what is going on, but it is hardly enough to let MSF staff predict what Syrian doctors and nurses will need most to help their communities. An increase in severe burns might mean that C-4 plastic explosives are in heavy rotation, for example, and therefore medics will require extra antibiotics, intravenous lines and surgical equipment, because they won't have time to sterilize between operations. Or an increase in kidney failures could mean that people with diabetes have lost access to regular care. But the fog of war makes tracking such trends next to impossible.

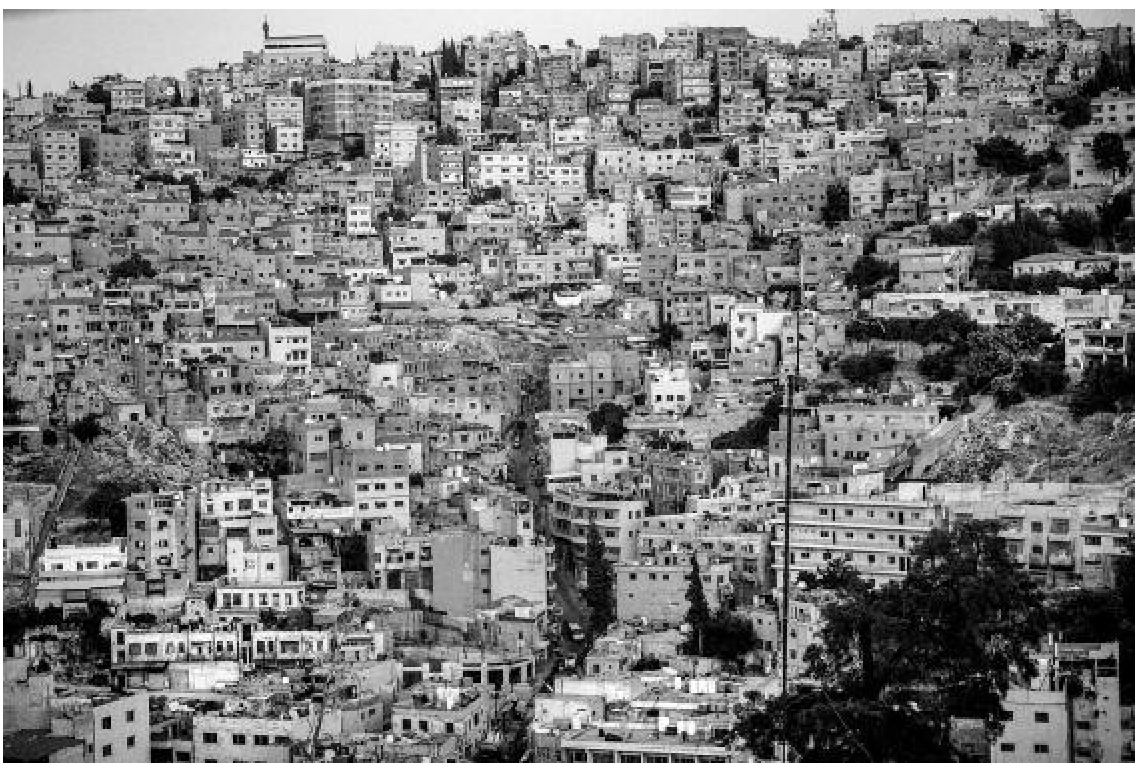
Whenever war, hurricanes or other disasters ravage part of the globe, one of the biggest problems for aid organizations is a lack of reliable data. People die because front-line responders don't have the information they need to act efficiently. Doctors and epidemiologists plod along with paper surveys and rigid databases in crisis situations, watching with envy as tech companies expertly mine big data for comparatively mundane purposes.

Three years ago, one frustrated first-responder decided to do something about it. The result is an innovative piece of software called the Dharma Platform, which almost anyone can use to rapidly collect information and share, analyse and visualize it so that they can act quickly. And although public-health veterans tend to be sceptical of technological fixes, Dharma is winning fans. MSF and other organizations now use it in 22 countries. And so far, the Rise Fund, a 'global impact fund' whose board boasts U2 lead singer Bono, has invested US$14.3 million in the company behind it.

“I think Dharma is special because it has been developed by people who have worked in these chaotic situations,” says Jeremy Farrar, director of biomedical-funding charity the Wellcome Trust in London, “and it's been road-tested and improved in the midst of reality.”

Now, the ultimate trial is in Syria: Salim, whose name has been changed in this story to protect him, started entering patient records into the Dharma Platform in March, and he is looking at health trends even as he shares his data securely with MSF staff in Amman.

It's too soon to say that Dharma has transformed his hospital. And some aid organizations and governments may be reluctant to adopt it. But Aziz, who has deployed Dharma in Iraq, Syria, Jordan and Turkey, is confident that it will usher in a wave of platforms that accelerate evidence-based responses in emergencies, or even in health care generally. “This is like the first version of the iPhone or Yahoo! Messenger,” he says. “Maybe something better will come along, but this is the direction we're going in.”



Neil Brandvold for Nature

Overlooking Amman, where Médecins Sans Frontières remotely supports clinics in southern Syria.

Born of frustration

Jesse Berns dreamt up Dharma after years of first-hand experience with the injured and ill, first as a helicopter paramedic, and then as a field epidemiologist embedded in some of the world's worst disaster zones. “I've worked in pretty much every conflict since 2006,” she says. She became disheartened by the inability to base decisions on data. In 2013, for example, she was surveying the health condition of refugees at the Iraq–Syria border with the World Health Organization. She entered her own hand-written data into an Excel spreadsheet, merged the information with other data, analysed it and generated a report. But the process took five months, and at that point, the results were too old to act on.

In 2015, she worked with MSF during the Ebola crisis in West Africa as the group tried to find a way to track and transmit data on the vital signs of dying patients without a Wi-Fi connection. Berns watched as incredible sums of money were spent. But the outbreak was over before a solution materialized.

She felt broken. “I got burned out after seeing colossal wastes of money and time,” she says. “I'd come home and have Uber and Slack, but in the field I had paper and Excel and it was just the ultimate shitshow for data.”

Berns complained to her friend Michael Roytman, a data scientist working in Chicago, Illinois, and California's Silicon Valley. Roytman suggested that the two join forces and create software to allow an emergency responder to fill the gap in a flash, without having to ask Excel experts, information-technology departments or consultants for help. The platform also had to work offline, store data securely in the cloud and be able to pass information through Bluetooth connections in case bombs, power failures or computer viruses interrupted service. So the pair started a company based in Washington DC to build what was needed in the field.

When they are asked to describe Dharma, Berns and Roytman struggle

because there aren't yet many things like it. “It's not a database,” says Roytman. “It's a platform or framework that lets people with no technical background create the tool they need.”

An early iteration of Dharma caught the attention of Pablo Marco, the head of MSF's Middle East operations, based in Amman, in 2015. His team had been struggling with the complexities of health in the region, which presented challenges MSF was unaccustomed to. For refugees in Africa, he says, the approach is generally straightforward because needs are fairly uniform: provide clean water, food, shelter, antibiotics and vaccines. “We have a checklist,” Marco says, “so we can act fast, fast, fast,” But refugees from Iraq and Syria have a range of different requirements. They might be managing depression, hypertension or diabetes instead of malnutrition. And their needs are in flux as they move and lose assets, and as access to medicine comes and goes.

Marco wanted to see whether new technology could provide faster feedback. So he asked Berns to meet Aziz, who was preparing to survey some 200,000 Iraqis who had fled south from the Islamist terrorist group ISIS in Mosul. Having completed his medical residency in Baghdad amid sectarian violence in 2007, Aziz understood the depth of the challenge before him. Acute traumas would be obvious, but not festering chronic maladies. He readied himself for the undertaking: “You need to train a large number of people to go out to households and fill out paper forms. Then it takes tonnes of time to transfer those forms into Excel, then transfer the data to an analyst and three months go by before they send back findings.”

Aziz, a programme manager at MSF's Center for the Advancement of Humanitarian Medicine in Amman, resembles a Silicon Valley techie with his backpack and worn T-shirt, but he has no computer-science background. Sceptical, but willing to give Dharma a try, he downloaded it onto a tablet and built a form with 145 questions. The survey was designed to move fast, asking only questions made relevant by previous responses. Each person would answer a total of about 25. Women of child-bearing age, for example, were asked whether they were pregnant, and children were asked if they had had diarrhoea or asthma attacks in the past two weeks. Iraqi medical students asking the questions sped through the surveys.

By day 5, the students had collected information from 6,455 people. Then Aziz did something he never could have done before. He merged the information from their devices onto his own and he began to interrogate the data, simply by typing in questions: for example, who identifies as head of household (husband, wife, son-in-law, and so on), and what are the chronic illnesses among these household heads? The answers came back instantly, in graph form.

“Even though I had been up since 5 a.m. that day, I stayed awake until 4 a.m. since it was so interesting,” he says. In one view, a pie chart revealed that people of various ages and backgrounds were complaining of skin irritation. Within minutes, it was obvious that the burrowing mites that cause scabies had infested mosques, motels and flats in which refugees were living. Aziz shared the data with MSF and in less than six weeks the organization was treating people with scabies and their contacts, and spraying shelters to eradicate the pests. A follow-up survey showed that the rate of scabies had dropped from 72% to 23%. Without Dharma, Aziz says, it would have taken several months to realize that something so easily fixed needed attention.

He was sold, and went on to use Dharma to survey refugee health in Turkey and Syria. All the while, he kept in touch with Berns, who tweaked the product in response to feedback. The same evolution occurred as the World Health Organization applied Dharma in Iraq, and as the Paris-based aid agency Médecins du Monde piloted it in Lebanon to assess the mental health of Syrian refugees. Preliminary data from that test suggest that refugee women with children have a lower incidence of suicidal thoughts than those without. Now the group is exploring the connection in a larger survey.

As Dharma's use has spread, public-health experts have taken notice. In April, Farrar told Larry Brilliant to check it out. Brilliant is an epidemiologist and former Google executive who now chairs the Skoll Global Threats Fund, a group in San Francisco, California, that identifies solutions to problems imperilling humanity. He was flabbergasted by how simple it was to use. “I am pitched lots and lots of systems that mechanize emergency and public-health responses, but they take so damn long to learn,” he says. “That is not true for Dharma.” In July, he joined the company's board.

Broken records

In Syria, MSF has been anxious to get access to patients' medical records, which would provide a long-term view of how people are faring and what support Syrian hospitals need. But that has been next to impossible because hospitals have been targeted by the Syrian regime and terrorist groups. Since March 2011, the non-profit group Physicians for Human Rights in New York City has documented 826 deaths of health-care workers in Syria from targeted bombs, assassinations and torture — more than 90% by the government.

Although MSF officially withdrew from the country in 2014, it had avoided some dangerous regions since 2011. One afternoon in 2012, Khalid Ahmad, a tropical-medicine doctor with the charity, got an idea about how the group could provide aid in areas that it was unable to reach itself. He was at an MSF office in Turkey, just across the northern Syrian border, when a young Syrian couple approached him. They showed him videos on their phones of people mangled under rubble. “They were finding the wounded and bringing them to clandestine hospitals,” Ahmad says. “They weren't even doctors, but they were organized, and I was so touched by their commitment.” He gave the couple first-aid kits and training on how to stop bleeding and move the wounded. Then he set out to find doctors said to be operating out of basements, in living rooms and under trees. Underground practices were “mushrooming up everywhere”, he recalls.

In 2015, MSF forged a connection with a hospital serving a large population in southern Syria — the one where Salim now works. At first, MSF asked hospital employees to enter patient data into an electronic database that the organization has long deployed around the world. But the Syrians didn't use it. They did not work for MSF, and they had little to gain from entering data into an unfamiliar system. Trying to get meaningful analyses out of it would take training and time, which the overwhelmed hospital staff didn't have. Plus, MSF's internal system is rigid. Requests for changes have to go through technology departments in European cities, a fact that stood out as a bottleneck.

Early this year, Aziz got the green light to try Dharma at the hospital. He

designed questionnaires on the platform that mimicked the format of the hand-written record books that hospital staff were accustomed to keeping. Two tablets with the program arrived at the hospital on 1 March, and every day since then, hospital staff have transferred data from hard copies into the devices. Anyone with access to the system can use it to search for trends.

For example, in April, Aziz noticed an unusually high number of infections among women who came for post-natal visits. Looking more closely, he saw that these women had not given birth at the hospital, so their infections probably came from stitches administered by midwives after slight rips during birth. “That means the midwife is doing this without sterile tools or in non-sterile conditions,” he says. “By knowing this, we can start to think about how to fix it.”

As of 15 October, the hospital has shared details from 29,469 patient visits. It's an exponential boost in information. “This is the only eye we have,” says Anja Braune, project coordinator for MSF's south Syria operation. “This is the only way we can try to forecast the coming period.” Still, Braune says that Dharma has not suddenly solved an extraordinarily difficult situation. In 2016 alone, MSF-supported facilities in the country were bombed or shelled on 71 separate occasions.

Data diaspora

But the data gap in the Syrian crisis extends outside the country's borders. Since 2011, about 5.3 million Syrians have fled the country, 92% of them to Turkey, Lebanon and Jordan (see 'Driven to data'). Although they are no longer in imminent danger, many continue to deteriorate from chronic health conditions, despite medical care. To understand how to help them, doctors need information.

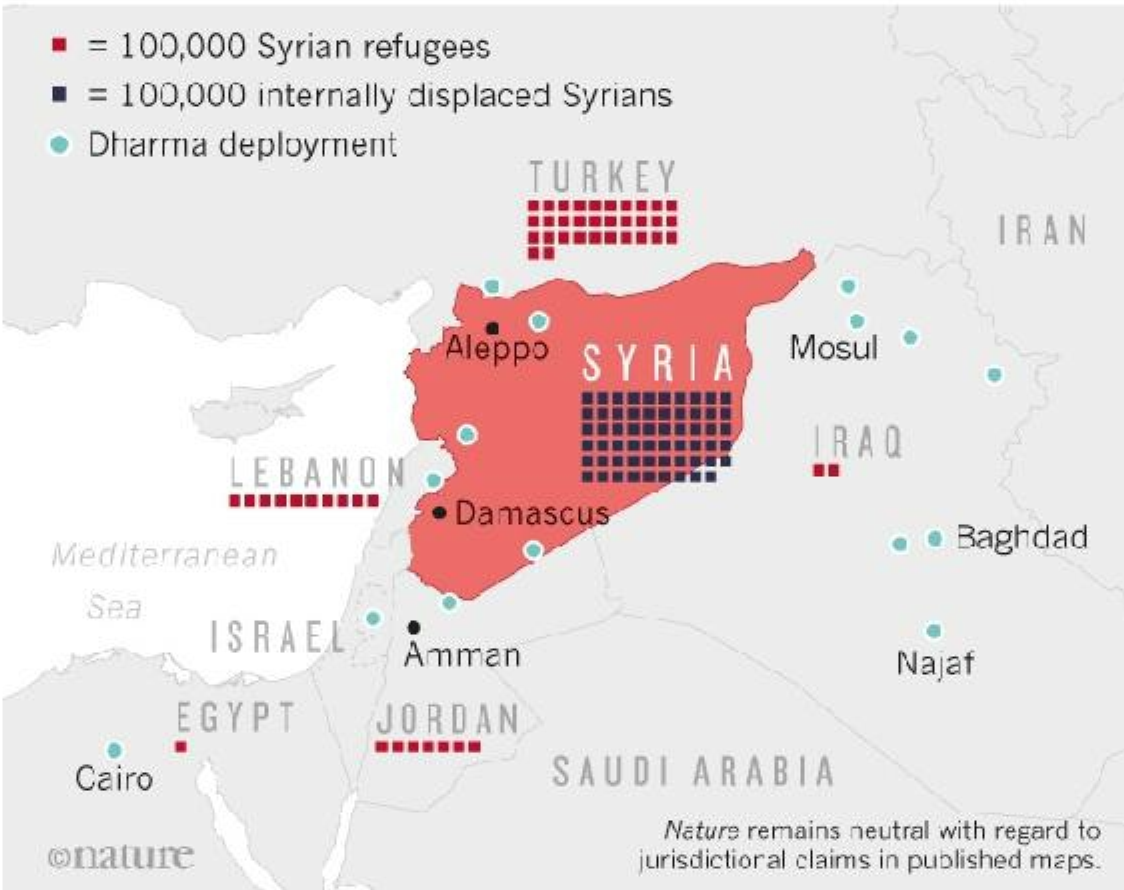
One sweltering morning in July, Mohammed Manasrah carries a device loaded with Dharma to the houses of his bed-bound patients in Ar Ramtha — a northern district of Jordan where roughly 68,000 Syrian refugees have settled in concrete flats. Manasrah is a physician at an MSF hospital in Ar Ramtha specializing in non-communicable disease. Forms created on Dharma

can be easily amended, and Manasrah inserts variables that might help him discover patterns. “I want to see if some medication we are giving them correlates with depression or if that's tied to refugee status,” he says. “I want to see if we can convince women who cannot walk in the street to exercise in their homes, and to see if this leads to better medical outcomes.” Some answers may lie in patient records maintained by the hospital, but analysing the information requires more expertise and time than he has. On Dharma, he could search for correlations in minutes.

Doctors and other crisis responders have never had access to technology like this before: something that lets them design the tool they need for a job, and that puts analytics at their fingertips. The hope is that this will make them want to participate further and collect more information. That kind of buy-in is important, says Matthew Gee, a data scientist at the University of Chicago. “Whether you are a clinician trying to treat an illness or an academic wanting to understand the propagation of an infection, you rely on the data collector,” Gee says. The same data that help crisis responders react day-to-day can later be used by academics doing long-term research.

DRIVEN TO DATA

More than 5 million people have fled Syria since 2011, mainly to neighbouring countries. Another nearly 6 million have been displaced within Syria. Aid organizations are using the Dharma Platform at more than a dozen spots throughout the region to track health and to support medical care.



Source: UNHCR

Dharma makes it technically easier to share data, too. If a sudden disaster occurs, information obtained on the platform can (pending permission) be passed on to researchers more easily than before. Berns and Roytman have designed the platform to adhere to the security and formatting standards that many scientific-review boards and government agencies recommend. That's a key reason that Dharma is being piloted by scientists monitoring Middle East respiratory syndrome, or MERS, as part of the International Severe Acute

Respiratory and Emerging Infection Consortium. In this way, researchers who arrive at an outbreak much later than first-responders can make use of information gathered at its unpredictable start.

Still, Dharma could fail, like most start-ups. At the moment, many aid groups and governments prefer open-source tools, such as Open Data Kit, says Dykki Settle, director of digital health at PATH, a global-health organization based in Seattle, Washington. Settle explains that cost is not the reason: although open source means that the raw software is free, consultants still charge fees to maintain and modify it, or to link it with other systems for storage or analytics.

Rather, open source has some of the appeal of a vintage car: tinkering is an expectation. Someone who can program computers can alter the code, and weave one component with another. But as with vintage cars, that's unlikely to be the most reliable approach in a crisis. “In an emergency, you may not have the time and money to invest in the extra labour that open source requires,” Settle says.

Berns argues that Dharma is just as useful for long-term health management as for emergencies. And although its code is not accessible, she says, the ease of customization has allowed humanitarian groups to assess data ranging from medical needs to housing damage in Hurricane Harvey. These attributes have caught the attention of powerful players in global health. The US Centers for Disease Control and Prevention (CDC) is planning to pilot Dharma and several other new or updated systems for data management in emergencies. Richard Garfield, an epidemiologist involved with the effort, says that the agency plans to publish a sort of “consumer report” listing the pros and cons of each. New technology and analytics, he hopes, will force aid agencies to base their actions on evidence. “Everyone gets by with good intentions, and that's a serious frustration for those of us who are really concerned about improving people's lives,” Garfield says.

Neil Brandvold for Nature

A Dharma representative shows staff how to use the platform at a Médecins Sans Frontières clinic in Ar Ramtha, Jordan.

With or without Dharma, technological barriers to information exchange are falling. Still, data sharing may remain an aspirational ideal. Organizations often keep information to themselves to save face when their programmes don't deliver; researchers keep it private because they want credit; and many governments like to control access. In this respect, says Farrar, “the technical side is not the challenge; it is a political one”.

Despite being surrounded by war, Salim pushes for data sharing as well. He would like scientists and doctors around the world to learn the details of his cases. “Many websites talk about the war in Syria, but it's very general,” he says. “We need more specialized people talking about our situation so that it can improve — because the situation is bad.” For example, he says, what types of nerve damage are caused by chemical weapons and how do you treat those affected?

Salim admits that he often considers fleeing Syria, but feels responsible

because he knows too well all he leaves behind. “When it's the worst,” he says, “I weigh the risks and the benefits of the services I provide.” And then he decides to stay. At the very least, the world could pay attention.

Journal name:
Nature
Volume:
550,
Pages:
444–447
Date published:
(26 October 2017)
DOI:
doi:10.1038/550444a

Comments

Comments

There are currently no comments.

French scientists in uproar over changes to medical-research clusters

Biomedical-research agency accused of attempting to undermine autonomy of university–hospital groups.

24 October 2017

IRCAD

The Research Institute Against Digestive Cancer is part of a university–hospital research cluster (IHU) in Strasbourg, France.

A group of French scientists is due to meet government officials on 27 October in a bid to resolve a row that has left many of the country's leading biomedical researchers furious.

Scientists were shocked earlier this month when the government

unexpectedly postponed a call for applications to create a new crop of medical-research clusters just days before the closing date, and said that it would slash the budget earmarked for the project.

Government ministers said that they were delaying the project because they wanted to change the way these autonomous clusters are governed. But scientists contacted by *Nature* say they suspect that behind the decision is an effort by INSERM, France’s biomedical-research agency, to exert control over the institutes.

The idea of creating the clusters, known as Instituts Hospitalo-Universitaires (IHUs), was introduced in 2009 to boost translational medical research, bringing together universities, teaching hospitals, research agencies and industry.

Based on public–private partnerships, they enjoy much autonomy and are mostly free from government and research-agency bureaucracy. The first six IHUs — in Paris, Bordeaux, Marseilles and Strasbourg — were approved in 2010 and received total funding of €850 million (US$1 billion). The clusters have been widely hailed as a successful model, and a second call for applications — open to any group of institutions that wanted to apply — was due to close on 12 October.

But in a press release on 2 October, the government announced that the deadline for the call would be postponed to an unspecified date. It also said that only two new IHUs would be funded, instead of the three initially planned, and that the total budget would be halved to €100 million. Nineteen applications had been made.

In letters sent to the government last week, and to President Emmanuel Macron on 23 October, 14 applicants said they were “appalled” or “bewildered” by the sudden and drastic changes to the funding and to the terms of the selection process. The health minister and higher-education ministers have invited applicants to discuss the issue this week.

Furious reaction

“None of the changes were discussed with us,” says Richard Frackowiak, who was chair of the international panel that would have assessed the IHU applications, but who resigned from the post on 6 October in protest. “The IHUs are the biggest French medical-research success of the past 10 years.”

The delay “is incomprehensible”, says Jacques Marescaux, a surgeon and chairman of the IHU Institute of Image-Guided Surgery of Strasbourg. The clusters are admired worldwide for their flexibility in being able to raise funds rapidly, and to recruit well-paid, top-flight researchers, says Marescaux. “The model has already been copied in Taiwan and Brazil.”

Despite the clusters' autonomy, INSERM seems to have weighed in on the latest call. In a 9 September letter to the IHU applicants, seen by *Nature*, the agency recommends that the candidate clusters alter their proposed structures to a ‘contract’ or ‘consortium’ model. This would give the agency a direct say in IHU affairs. The ministers’ desire to change the governance models seems to directly reflect INSERM’s recommendations, which were not solicited, say applicants. INSERM did not respond to a request for comment from *Nature*’s news team.

The change of strategy suggests that INSERM wants to get its hands on all the clusters, says Didier Raoult, who heads the infectious-diseases IHU in Marseilles. The institutes largely — or, in some cases, completely — escape the control of the research agencies, he adds, as do the patents that come out of them. “To quarrel with leading French and other medical researchers is very bad news for France and its image in the scientific community.”

A joint report by two French inspectorate agencies — of social affairs, and of education and research — was completed before the latest call was opened, and said that the IHUs were “promising”. The institutes had filed 183 patents and spun out 28 start-up companies. Although the report called for improved IHU governance, including closer researcher involvement, “it said the autonomous foundations should be maintained and strengthened”, notes Philippe Froguel, who is leading an IHU application and is an endocrinology researcher at Lille University Hospital.

Froguel is concerned that at the upcoming meeting, applicants will simply be again told what has been already decided. But he hopes that it will provide an

opportunity for negotiation and some clarity: “They will have to give us a new date for the tender and be more precise about the question of governance, which will be positive,” he says.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22877

Comments

Comments

There are currently no comments.

Wait for Trump's science adviser breaks modern-era record

Top White House science job stays empty more than nine months after president took office.

24 October 2017 Corrected:

1. 24 October 2017

Kevin Lamarque/Reuters

US President Donald Trump still hasn't chosen a White House science adviser

Donald Trump has now gone longer without a science adviser in place than any recent first-term US president — by any measure.

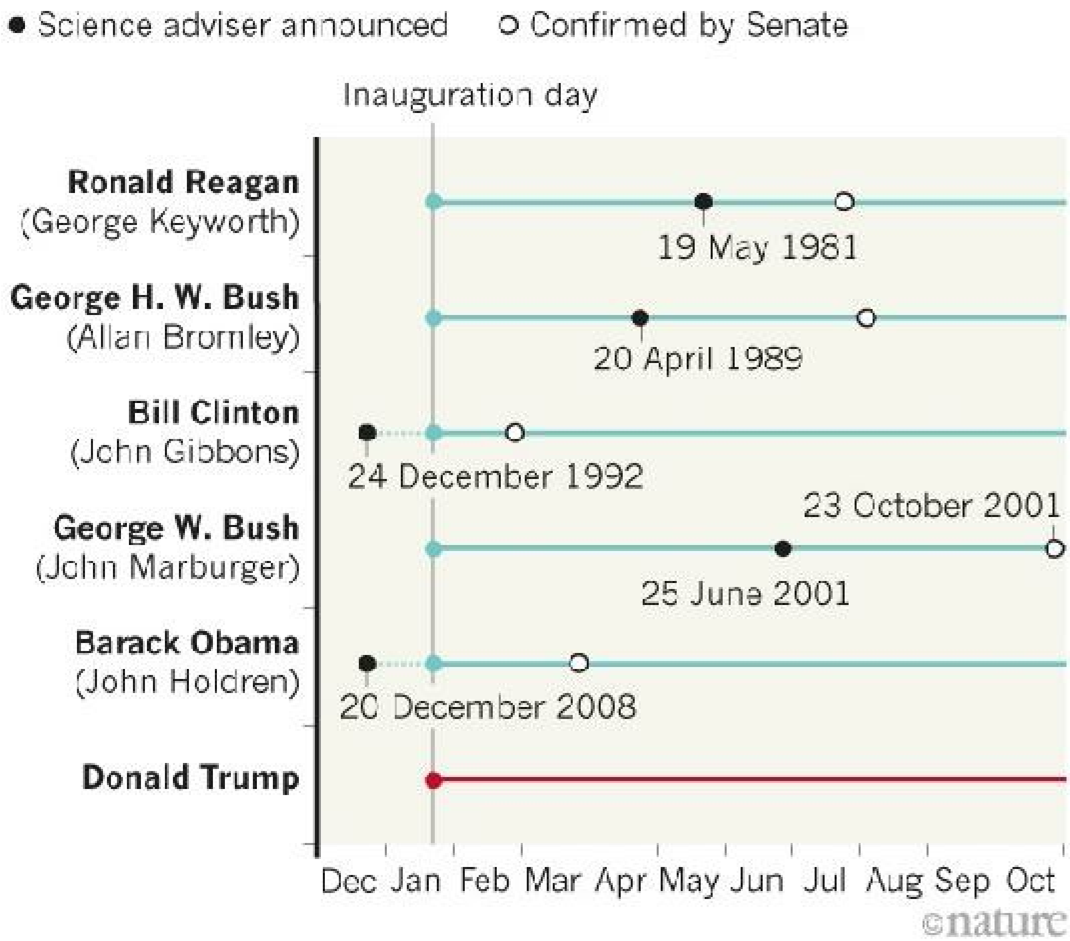
On 23 October, Trump broke the record set by former President George W. Bush. Bush's science adviser, physicist John Marburger, was confirmed by the Senate on 23 October 2001. That was 276 days after Bush took office, and 120 days after he announced that Marburger was his pick for the job.

Trump has also waited longer than any president since at least 1976, when the White House Office of Science and Technology Policy was created, to name his choice for the science-adviser job (see 'Help wanted'). Although rumours have surfaced periodically about scientists who may be in the president's sights, the White House has not made any official announcement.

By contrast, Trump's predecessor Barack Obama took the least time of any first-term president since 1976 in naming his science adviser. Obama revealed his choice of physicist John Holdren on 20 December 2008 — just 47 days after he won the presidency, and exactly one month before he was sworn in. (Holdren was confirmed by the US Senate three months later, on 19 March 2009.)

HELP WANTED

Donald Trump has now gone longer without a science adviser than any first-term US president since at least 1976. By contrast, his predecessor Barack Obama took the least amount of time in announcing his science adviser pick (in brackets), naming John Holdren one month before Inauguration Day.



Journal name:

Nature

DOI:

doi:10.1038/nature.2017.22878

Corrections

Corrected:

> An earlier version of the graphic gave the wrong year for the date that John Marburger was confirmed by the Senate as the science adviser.

Comments

Commenting is currently unavailable.

Reclassify waste to shift the nuclear landscape

The US Department of Energy should classify and dispose of nuclear rubbish according to risk.

24 October 2017

Brian Vander Brug/Los Angeles Times/Getty

Reclassification of nuclear waste could make disposal simpler and cheaper.

The United States has a single deep geological repository for nuclear waste. Since 1999, the Waste Isolation Pilot Plant (WIPP), 655 metres down in a massive salt formation near Carlsbad, New Mexico, has received 12,000-odd shipments of what it calls transuranic waste. This is clothing, tools and other

detritus from the nuclear-weapons programme that are contaminated by elements heavier than uranium. It’s more hazardous than low-level waste, which can be buried closer to the surface, but not as dangerous as high-level waste, for which a disposal site has yet to be found.

WIPP was closed for three years after radiation escaped from a ruptured drum in 2014. It was given the all-clear to reopen only in January; an enquiry determined that the drum had been packed improperly before shipment from the Los Alamos National Laboratory in northern New Mexico. Concerns remain about safety, as well as the long-term risk of human intrusion into a facility that will remain dangerous for thousands of years after its eventual closure. But by and large, WIPP has functioned as designed, and it could do even more to help the US Department of Energy (DOE) address the fallout from the country’s nuclear-weapons programme.

Much high-level waste — produced during the reprocessing of spent nuclear fuel into plutonium — is highly radioactive and dangerous. But the evidence suggests that some of the waste that is labelled ‘high level’ technically qualifies as transuranic. This material is still barred from direct disposal at WIPP, purely because of how it was produced. But labels can be changed. If wastes that meet the transuranic criteria could be shipped to WIPP, it would save considerable time and effort as the DOE continues to struggle with the country’s radioactive legacy.

At present, the high-level waste is scheduled to be encased in glass logs for disposal in a separate repository at Yucca Mountain in Nevada. Despite decades of delays and controversies, there are signs of progress at the DOE’s flagship vitrification facility at the Hanford Site in Washington. But even if current plans hold, that facility will not begin processing high-level waste until 2032. Nor is it clear where the logs will actually go. Yucca Mountain was shut down by former president Barack Obama, only to be revived by President Donald Trump. Its long-term prospects are far from certain.

Reclassifying some high-level waste at Hanford, as well as at two facilities in Idaho and South Carolina, offers an alternative path for some of that waste, and one that would reduce an ongoing threat to workers and the environment. More than one-third of the 177 underground storage tanks at Hanford have leaked and contaminated groundwater.

The problem is inertia, compounded by fear, distrust and politics. The DOE is operating under a complex web of rules, regulations and legal agreements, and shifting course isn't easy. Although the agency has the authority to look through its nuclear-waste inventory and reclassify wastes that meet the WIPP transuranic criteria, it has resisted such a move because it fears that this would spark political uproar — and quite probably legal challenges.

Washington state, which has in place a court-ordered clean-up agreement for Hanford, has been particularly resistant to change. And New Mexico has tied the DOE's hands at WIPP by banning the disposal of tank wastes and any other materials managed as high-level waste — even if they meet the WIPP criteria. Watchdog groups, meanwhile, are concerned that nuclear-waste reclassification is simply a way of changing the rules and lowering the bar for public and environmental safety.

The proposal briefly bubbled up to the surface several years ago, but political attention shifted after the leak at WIPP. Now a coalition of local governments from communities across the nuclear-weapons industry is reviving the idea. In a white paper published last month, the Energy Communities Alliance urged a two-pronged approach involving the DOE as well as Congress, which could clarify the definition of high-level waste legislatively. The alliance estimated that the DOE could save at least US$40 billion over the lifetime of its clean-up programme — more than 15% of the estimated $257-billion price tag.

After spending some $11 billion on the as-yet-unfinished vitrification plant over the past two decades at Hanford, some may hesitate to change course. But as former DOE secretary Steven Chu said, the worst thing you can do in a multi-decade project such as nuclear-waste clean-up is to close the door to alternatives. In this case, the solution is simple enough: nuclear waste should be managed on the basis of the risk it poses and not the process that produced it.

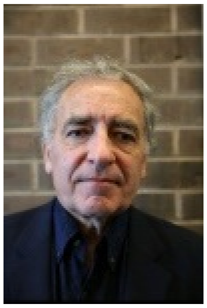
Journal name:
Nature
Volume:
550,
Pages:

429–430
Date published:
(26 October 2017)
DOI:
doi:10.1038/550429b

Comments

Comments

There are currently no comments.



Ted Lewis
III

Cancer biology still needs physicists

Considering game theory and the role of physical forces could lead to better treatments for cancer, says Robert Austin[1].

24 October 2017

Cancer is close to surpassing heart disease as the leading cause of death in the United States. The World Health Organization estimates that worldwide, new cases will rise by 70% in the next two decades. In concert, treatment costs are skyrocketing and could reach US$156 billion by 2020 in the United States alone, according to the US National Cancer Institute (NCI). A modest decline in US cancer mortality rates has been attributed to prevention, such as lower smoking rates, rather than better treatment. Yet, more than 150,000 papers on cancer have been published each year since 2013.

This month, application deadlines closed for several programmes in the US$1.8-billion Cancer Moonshot authorized by the US Congress in 2016. The extra funds to study cancer are badly needed, but we do not have a sufficient fundamental understanding of the disease for these investments to make a near-term difference in treatment.

Comparison of the cancer initiative to former US president John F. Kennedy’s lunar challenge is misleading. When, in 1961, Kennedy declared

the goal of landing on the Moon, we understood gravity well enough to be reasonably confident that if we built rockets powerful enough, we could do it. We could predict distant planetary orbits with startling precision. Getting an astronaut to a nearby satellite was an engineering feat. No new basic principles needed to be discovered.

This is not true for cancer. The deepest puzzle we must solve is how groups of cells behave, which networking theories developed in the physical sciences are well equipped to address. Cancer can move from a localized tumour to remote locations — a process called metastasis. Once that happens, individuals with cancer have a poor prognosis. Metastasis drives the costs of treatment skyward, but these therapies are, tragically, largely futile. Without a better way to explain and treat metastases, new clinical methods will do little to improve the situation.

To be sure, there has been progress. A growing appreciation of how the immune system keeps cancer in check has brought a new class of therapies. Patient-specific chemotherapy and more-precise radiotherapy have also led to advances. But cancer needs more big ideas — and those of scientists from other disciplines should be taken more seriously.

In 2008, I attended a series of workshops organized by the NCI in Bethesda, Maryland, to bring together physicists, engineers, mathematicians and computer scientists to look for new ways of tackling the disease. These led to the creation in 2009 of a dozen designated physical-sciences oncology centres; I led the Princeton Physical Sciences–Oncology Center, based in New Jersey, from 2009 to 2015.

Over that time, large cancer-genome sequencing projects revealed millions of cancer-related mutations. The numbers found in individual tumours and types of cancer range widely. Exactly what causes this variation is unclear. In any case, genetically targeted treatments generally buy affected individuals, at most, a few more months of life.

Since the centres launched, there has been greater recognition of the potential contributions of physical forces to cancer-cell responses, such as the number and location of metastases, or how cells stick together. Networking and game theories — mathematical analyses of social and economic interactions that

represent how humans do or don't cooperate to minimize costs and maximize gains — have also been adapted to model how cells behave during cancer growth and invasion. Particularly promising, in my view, are theories of the evolution of multicellularity, when cells had to develop mechanisms for living in communities — possibly at the cost of their own selfish, local goals of reproduction. I argue that these approaches have not yet had time to show their potential.

The cancer community has been unenthusiastic about the contributions of physical oncologists. When, several years ago, we proposed a special section on the physics of cancer for a high-profile journal, oncology referees were dismissive. One admitted: "I am not a big fan of the topic." Another reviewer rejected the proposal because genetics "is the Rosetta Stone with respect to treatment". Wrote another: "I did not recognize any of the proposed authors."

Too often, biologists see physicists as human calculators. The big ideas, they think, belong to them, with physicists filling in the details by performing quantitative analyses. To counter this attitude, the Francis Crick Institute in London, for instance, is actively searching for physicists with transformative ideas. We need to do more than hire 'quants' to crunch 'big data'.

To develop new conceptual approaches to cancer, scientists of all stripes must reach out. I have sometimes antagonized biologists by saying that their advice stifles creativity. But I am now working, along with medical physicist Robert Jeraj of the University of Wisconsin–Madison, to form groups within the American Physical Society that focus on oncology. These scientists have strong collaborations with biomedical researchers, but have historically been restricted to advancing imaging technologies — important, but far removed from bringing in ideas about the origins and progression of disease. I also serve on the editorial board of two journals designed as outlets for this sort of work. *Convergent Science Physical Oncology* was launched in 2015, by the Institute of Physics in Bristol, UK, and *Cancer Convergence* (published by Springer Nature, which also publishes *Nature*) will publish its first articles in the next few months.

We need to expand our questions — or risk remaining Earth-bound.

Journal name:

Nature
Volume:
550,
Pages:
431
Date published:
(26 October 2017)
DOI:
doi:10.1038/550431a

Comments

Commenting is currently unavailable.

India gears up for second Moon mission

The Chandrayaan-2 orbiter, lander and rover will track how lunar dust might scupper settlement.

24 October 2017

Xinhua/Alamy

India’s Chandrayaan-2 moon mission is scheduled to launch next March from the spaceport of Sriharikota.

In a large shed near the headquarters of the Indian Space Research Organisation (ISRO) in Bangalore, a six-wheeled rover rumbles over dark grey rubble in a landscape designed to mimic the Moon’s rocky surface. This test and others scheduled for the next few weeks are crucial steps in India’s

quest to launch a second mission to the Moon next March.

The country's much anticipated Chandrayaan-2 comes almost a decade after India began its first journey to the Moon, in 2008. "It is logically an extension of the Chandrayaan-1 mission," says Mylswamy Annadurai, director of the project at ISRO. The spacecraft comprises an orbiter that will travel around the Moon, a lander that will touch down in a as-yet undecided location near the Moon's south pole and a rover.

India's maiden Moon trip was a significant achievement for its space programme, but ended prematurely when ISRO lost contact with the orbiter ten months into the planned two-year mission. However, an instrument on a probe that reached the Moon's surface did gather enough data for scientists to confirm the presence of traces of water.

Chandrayaan-2 will attempt more ambitious technical manoeuvres that will put Indian space technology to the test. For the first time, ISRO will attempt to give a craft a controlled, or soft, landing. The agency has had to develop advanced systems that can guide the lander to a touch down and successfully deploy the rover.

Lunar conditions

Lunar missions are also being planned by China, Japan and other countries, among others. Like these, India's explorations are partly driven by the need to improve understanding of the Moon's environment in the event that governments or private entities decide to establish a human settlement there. One poorly understood phenomenon is floating lunar dust. Without an atmosphere like Earth's, the surface of the Moon is buffeted by solar wind and ultraviolet radiation, creating a layer of charged ions called a plasma sheath in which dust particles can levitate.

If humans colonize the Moon, this dust will be a significant challenge, says planetary scientist Penny King of the Australian National University (ANU) in Canberra. It gets into everything, from astronauts' suits to machinery and equipment, where it causes damage, she says. "Understanding how it moves

around is pretty critical.” ISRO says the Chandrayaan-2 orbiter and lander will carry a first of its kind instrument, called the Radio Anatomy of Moon Bound Hypersensitive ionosphere and Atmosphere (RAMBHA), to measure the density of the near-surface plasma and how it changes over time.

Evolving environment

The rest of the spacecraft’s suite of instruments will collect data to help scientists study other aspects of the Moon’s present environment and how it has evolved. Chandrayaan-2’s lander will take the first on-site thermal measurements on the lunar surface near a polar region. The mission “is expected to further consolidate the findings from the first mission and add new ones with *in situ* analysis of the lunar surface and ionosphere,” says Annadurai, who is also director of ISRO’s Satellite Centre in Bangalore.

ISRO plans to execute its mission on shoestring budget of just 6.03 billion rupees (US$93 million), including the cost of the rocket and launch. Chandrayaan-2 will be carried into space on one of the agency’s three-stage rockets, a Geosynchronous Satellite Launch Vehicle Mark II, taking off from a spaceport on the island of Sriharikota in the Bay of Bengal. “A nice part of the Indian space programme is that they manage to do things so cheaply,” says ANU astrobiologist Charles Lineweaver. “If it succeeds, maybe everyone else will see that their mission didn’t really need that extra bell or whistle.”

In three to four weeks**,** ISRO will begin one of the final and most complex testing phases for Chandrayaan-2, integrating all of its components. With one Moon mission under its belt, ISRO is settling into its role as a moon-faring organisation. “Maybe we were extra anxious with the first child, as parents. But we relax a bit as more children come along,” he jokes.

Journal name:
Nature
Volume:
550,
Pages:

440
Date published:
(26 October 2017)
DOI:
doi:10.1038/nature.2017.22870

Comments

Commenting is currently unavailable.

To stay young, kill zombie cells

Killing off cells that refuse to die on their own has proved a powerful anti-ageing strategy in mice. Now it's about to be tested in humans.

24 October 2017 Corrected:

1. 25 October 2017

Illustration by Paweł Jońca

Jan van Deursen was baffled by the decrepit-looking transgenic mice he created in 2000. Instead of developing tumours as expected, the mice experienced a stranger malady. By the time they were three months old, their fur had grown thin and their eyes were glazed with cataracts. It took him years to work out why: the mice were ageing rapidly, their bodies clogged

with a strange type of cell that did not divide, but that wouldn't die[1].

That gave van Deursen and his colleagues at Mayo Clinic in Rochester, Minnesota, an idea: could killing off these 'zombie' cells in the mice delay their premature descent into old age? The answer was yes. In a 2011 study[2], the team found that eliminating these 'senescent' cells forestalled many of the ravages of age. The discovery set off a spate of similar findings. In the seven years since, dozens of experiments have confirmed that senescent cells accumulate in ageing organs, and that eliminating them can alleviate, or even prevent, certain illnesses (see 'Becoming undead'). This year alone, clearing the cells in mice has been shown to restore fitness, fur density and kidney function[3]. It has also improved lung disease[4] and even mended damaged cartilage[5]. And in a 2016 study, it seemed to extend the lifespan of normally ageing mice[6].

“Just by removing senescent cells, you could stimulate new tissue production,” says Jennifer Elisseeff, senior author of the cartilage paper and a biomedical engineer at Johns Hopkins University in Baltimore, Maryland. It jump-starts some of the tissue's natural repair mechanisms, she says.

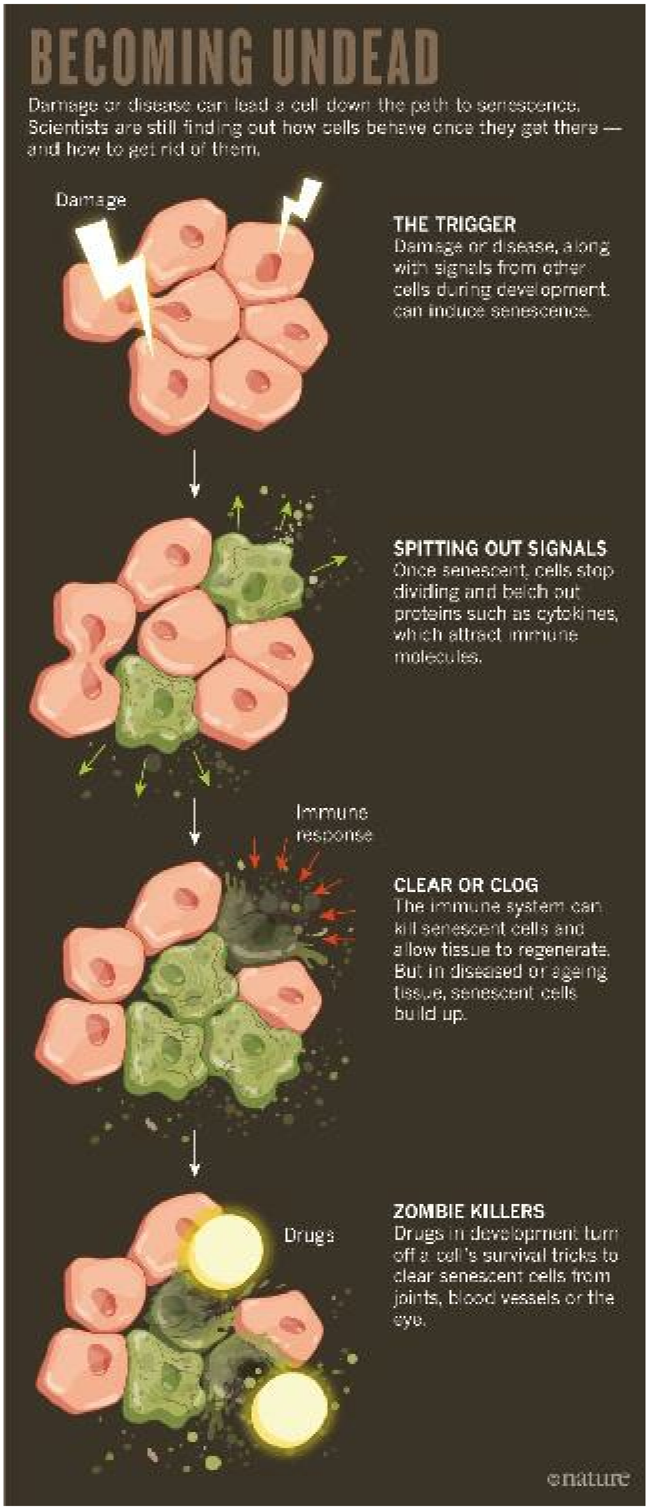
This anti-ageing phenomenon has been an unexpected twist in the study of senescent cells, a common, non-dividing cell type first described more than five decades ago. When a cell enters senescence — and almost all cells have the potential to do so — it stops producing copies of itself, begins to belch out hundreds of proteins, and cranks up anti-death pathways full blast. A senescent cell is in its twilight: not quite dead, but not dividing as it did at its peak.

Now biotechnology and pharmaceutical companies are keen to test drugs — known as senolytics — that kill senescent cells in the hope of rolling back, or at least forestalling, the ravages of age. Unity Biotechnology in San Francisco, California, co-founded by van Deursen, plans to conduct multiple clinical trials over the next two-and-a-half years, treating people with osteoarthritis, eye diseases and pulmonary diseases. At Mayo, gerontologist James Kirkland, who took part in the 2011 study, is cautiously beginning a handful of small, proof-of-concept trials that pit senolytic drugs against a range of age-related ailments. “I lose sleep at night because these things

always look good in mice or rats, but when you get to people you hit a brick wall," says Kirkland.

No other anti-ageing elixir has yet cleared that wall, and for a few good reasons. It's next to impossible to get funding for clinical trials that measure an increase in healthy lifespan. And even as a concept, ageing is slippery. The US Food and Drug Administration has not labelled it a condition in need of treatment.

Still, if any of the trials offer "a whiff of human efficacy", says Unity's president, Ned David, there will be a massive push to develop treatments and to better understand the fundamental process of ageing. Other researchers who study the process are watching closely. Senolytics are "absolutely ready" for clinical trials, says Nir Barzilai, director of the Institute for Aging Research at the Albert Einstein College of Medicine in New York City. "I think senolytics are drugs that could come soon and be effective in the elderly now, even in the next few years."



The dark side

When microbiologists Leonard Hayflick and Paul Moorhead coined the term senescence in 1961, they suggested that it represented ageing on a cellular level. But very little research was done on ageing at the time, and Hayflick recalls people calling him an idiot for making the observation. The idea was ignored for decades.

Although many cells do die on their own, all somatic cells (those other than reproductive ones) that divide have the ability to undergo senescence. But, for a long time, these twilight cells were simply a curiosity, says Manuel Serrano of the Institute for Research in Biomedicine in Barcelona, Spain, who has studied senescence for more than 25 years. “We were not sure if they were doing something important.” Despite self-disabling the ability to replicate, senescent cells stay metabolically active, often continuing to perform basic cellular functions.

By the mid-2000s, senescence was chiefly understood as a way of arresting the growth of damaged cells to suppress tumours. Today, researchers continue to study how senescence arises in development and disease. They know that when a cell becomes mutated or injured, it often stops dividing — to avoid passing that damage to daughter cells. Senescent cells have also been identified in the placenta and embryo, where they seem to guide the formation of temporary structures before being cleared out by other cells.

LISTEN

Hear Judy Campisi and Jan van Deursen discuss why they're excited to be researching senescence.

You may need a more recent browser or to install the latest version of the Adobe Flash Plugin.
Go to full podcast

But it wasn't long before researchers discovered what molecular biologist Judith Campisi calls the “dark side” of senescence. In 2008, three research groups, including Campisi's at the Buck Institute for Research on Aging in Novato, California, revealed that senescent cells excrete a glut of molecules

— including cytokines, growth factors and proteases — that affect the function of nearby cells and incite local inflammation[7, 8, 9]. Campisi's group described this activity as the cell's senescence-associated secretory phenotype, or SASP[7]. In recent unpublished work, her team identified hundreds of proteins involved in SASPs.

In young, healthy tissue, says Serrano, these secretions are probably part of a restorative process, by which damaged cells stimulate repair in nearby tissues and emit a distress signal prompting the immune system to eliminate them. Yet at some point, senescent cells begin to accumulate — a process linked to problems such as osteoarthritis, a chronic inflammation of the joints, and atherosclerosis, a hardening of the arteries. No one is quite sure when or why that happens. It has been suggested that, over time, the immune system stops responding to the cells.

Surprisingly, senescent cells turn out to be slightly different in each tissue. They secrete different cytokines, express different extracellular proteins and use different tactics to avoid death. That incredible variety has made it a challenge for labs to detect and visualize senescent cells. “There is nothing definitive about a senescent cell. Nothing. Period,” says Campisi.

In fact, even the defining feature of a senescent cell — that it does not divide — is not written in stone. After chemotherapy, for example, cells take up to two weeks to become senescent, before reverting at some later point to a proliferating, cancerous state, says Hayley McDaid, a pharmacologist at Albert Einstein College of Medicine. In support of that idea, a large collaboration of researchers found this year that removing senescent cells right after chemotherapy, in mouse models for skin and breast cancer, makes the cancer less likely to spread[10].

The lack of universal features makes it hard to take inventory of senescent cells. Researchers have to use a large panel of markers to search for them in tissue, making the work laborious and expensive, says van Deursen. A universal marker for senescence would make the job much easier — but researchers know of no specific protein to label, or process to identify. “My money would be on us never finding a senescent-specific marker,” Campisi adds. “I would bet a good bottle of wine on that.”

Earlier this year, however, one group did develop a way to count these cells in tissue. Valery Krizhanovsky and his colleagues at the Weizmann Institute of Science in Rehovot, Israel, stained tissues for molecular markers of senescence and imaged them to analyse the number of senescent cells in tumours and aged tissues from mice[11]. “There were quite a few more cells than I actually thought that we would find,” says Krizhanovsky. In young mice, no more than 1% of cells in any given organ were senescent. In two-year-old mice, however, up to 20% of cells were senescent in some organs.

But there's a silver lining to these elusive twilight cells: they might be hard to find, but they're easy to kill.

Out with the old

In November 2011, while on a three-hour flight, David read van Deursen and Kirkland's just-published paper about eliminating zombie cells. Then he read it again, and then a third time. The idea “was so simple and beautiful”, recalls David. “It was almost poetic.” When the flight landed, David, a serial biotech entrepreneur, immediately rang van Deursen, and within 72 hours had convinced him to meet to discuss forming an anti-ageing company.

Kirkland, together with collaborators at the Sanford Burnham Medical Research Institute in La Jolla, California, initially attempted a high-throughput screen to quickly identify a compound that would kill senescent cells. But they found it to be “a monumental task” to tell whether a drug was affecting dividing or non-dividing cells, Kirkland recalls. After several failed attempts, he took another tack.

Senescent cells depend on protective mechanisms to survive in their 'undead' state, so Kirkland, in collaboration with Laura Niedernhofer and others from the Scripps Research Institute in Jupiter, Florida, began seeking out those mechanisms. They identified six signalling pathways that prevent cell death, which senescent cells activate to survive[12, 13].

Then it was just a matter of finding compounds that would disrupt those pathways. In early 2015, the team identified the first senolytics: an FDA-

approved chemotherapy drug, dasatinib, which eliminates human fat-cell progenitors that have turned senescent; and a plant-derived health-food supplement, quercetin, which targets senescent human endothelial cells, among other cell types. The combination of the two — which work better together than apart — alleviates a range of age-related disorders in mice[14].

Ten months later, Daohong Zhou at the University of Arkansas for Medical Sciences in Little Rock and his colleagues identified a senolytic compound now known as navitoclax, which inhibits two proteins in the BCL-2 family that usually help the cells to survive[15]. Similar findings were reported within weeks by Kirkland's lab[16] and Krizhanovsky's lab[17].

By now, 14 senolytics have been described in the literature, including small molecules, antibodies and, in March this year, a peptide that activates a cell-death pathway and can restore lustrous hair and physical fitness to ageing mice[3].

So far, each senolytic kills a particular flavour of senescent cell. Targeting the different diseases of ageing, therefore, will require multiple types of senolytics. “That's what's going to make this difficult: each senescent cell might have a different way to protect itself, so we'll have to find combinations of drugs to wipe them all out,” says Niedernhofer. Unity maintains a large atlas documenting which senescent cells are associated with which disease; any weaknesses unique to given kinds of cell, and how to exploit those flaws; and the chemistry required to build the right drug for a particular tissue. There is no doubt that for different indications, different types of drug will need to be developed, says David. “In a perfect world, you wouldn't have to. But sadly, biology did not get that memo.”

For all the challenges, senolytic drugs have several attractive qualities. Senescent cells will probably need to be cleared only periodically — say, once a year — to prevent or delay disease. So the drug is around for only a short time. This type of 'hit and run' delivery could reduce the chance of side effects, and people could take the drugs during periods of good health. Unity plans to inject the compounds directly into diseased tissue, such as a knee joint in the case of osteoarthritis, or the back of the eye for someone with age-related macular degeneration.

And unlike cancer, in which a single remaining cell can spark a new tumour, there's no need to kill every senescent cell in a tissue: mouse studies suggest that dispatching most of them is enough to make a difference. Finally, senolytic drugs will clear only senescent cells that are already present — they won't prevent the formation of such cells in the future, which means that senescence can continue to perform its original tumour-suppressing role in the body.

Those perks haven't convinced everybody of the power of senolytics. Almost 60 years after his initial discovery, Hayflick now believes that ageing is an inexorable biophysical process that cannot be altered by eliminating senescent cells. “Efforts to interfere with the ageing process have been going on since recorded human history,” says Hayflick. “And we know of nothing — nothing — that has demonstrated to interfere with the ageing process.”

Fans of senolytics are much more optimistic, emboldened by recent results. Last year, van Deursen's lab went beyond its tests on super-aged mice and showed that killing off senescent cells in normally ageing mice delayed the deterioration of organs associated with ageing[6], including the kidney and heart. And — to the joy of anti-ageing enthusiasts everywhere — it extended the animals' median lifespan by about 25%.

Successful results from mouse studies have already lured seven or eight companies into the field, Kirkland estimates. At Mayo, one clinical trial has opened, pitting dasatinib and quercetin in combination against chronic kidney disease. Kirkland plans to try other senolytics against different age-related diseases. “We want to use more than one set of agents across the trials and look at more than one condition,” he says.

If eliminating senescent cells in humans does improve age-related illnesses, researchers will aim to create broader anti-ageing therapies, says David. In the meantime, researchers in the field insist that no one should take these drugs until proper safety tests in humans are complete. In rodents, senolytic compounds have been shown to delay wound healing, and there could be additional side effects. “It's just too dangerous,” says Kirkland.

Van Deursen says that continuing to answer basic biological questions is the field's best shot at success. “Only then will we be able to understand what

ageing really is, and how we can, in an intelligent way, interfere with it.”

Journal name:
Nature
Volume:
550,
Pages:
448–450
Date published:
(26 October 2017)
DOI:
doi:10.1038/550448a

Corrections

Corrected:

Reference 4 in this story originally omitted the journal name. This has now been added.

Comments

Commenting is currently unavailable.

Nature News

周三, 11 10月 2017

Nature News

[周三, 11 10月 2017]

- **Nature News**

Nature News

Nature is a weekly international journal publishing the finest peer-reviewed research in all fields of science and technology on the basis of its originality, importance, interdisciplinary interest, timeliness, accessibility, elegance and surprising conclusions. Nature also provides rapid, authoritative, insightful and arresting news and interpretation of topical and coming trends affecting science, scientists and the wider public.

- **Publishers threaten to remove millions of papers from ResearchGate** [周二, 10 10月 08:00]
  Take-down notices “imminent” as lawsuit is filed alleging widespread copyright infringement.
- **Trump EPA begins push to overturn Obama-era climate regulation** [周二, 10 10月 08:00]
  The agency's plan to reverse limits on greenhouse-gas emissions is likely to draw legal challenges.
- **Climate meetings pose serious test in the Trump era** [周二, 10 10月 08:00]
  Annual jamborees fail to ignite public passion but are crucial to progress on global-warming.
- **Developing nations need more than just money** [周二, 10 10月 08:00]
  Grants from big science funders can be hard to use without better administration and mutual understanding, says Rana Dajani.
- **How the United States plans to trap its biggest stash of nuclear-weapons waste in glass** [周二, 10 10月 08:00]
  After decades of delays, a challenging clean-up project is gaining ground.
- **Cancer-genome study challenges mouse 'avatars'** [周一, 09 10月 08:00]
  Grafting human cancer cells into mice alters tumour evolution.
- **LIGO's unsung heroes** [周一, 09 10月 08:00]
  Nature highlights just a few of the people who played a crucial part in the discovery of gravitational waves — but didn’t win the Nobel Prize.
- **Water-repellent coatings could make de-icing a breeze** [周一, 09 10月 08:00]
  Coatings that force ice to grow upwards from the surface could make it easier to remove.
- **Build on the outer space treaty** [周一, 09 10月 08:00]
  Fifty years on, the agreement is being pushed to its limits by changing geopolitics, technology and commercial interests, warns Joan Johnson-Freese.
- **Navajo Nation reconsiders ban on genetic research** [周五, 06 10月 08:00]
  Tribal leaders are developing a policy for genetic research and data sharing, potentially ending a

15-year moratorium.

- **The scientist who spots fake videos** [周五, 06 10月 08:00]
  Hany Farid discusses how to detect image manipulations — and the increasing sophistication of forgers.
- **Proton-size puzzle deepens** [周四, 05 10月 08:00]
  Measurement in ordinary hydrogen agrees with a surprising 2010 result on the element's exotic cousin — but gives a smaller value than virtually every other experiment.
- **Controversial pesticides found in honey samples from six continents** [周四, 05 10月 08:00]
  Neonicotinoids are at the centre of a long-running debate about whether they harm bees.
- **Antikythera shipwreck yields statue pieces and mystery bronze disc** [周三, 04 10月 08:00]
  Archaeologists think that at least seven life-sized sculptures are hidden nearby.
- **Cryo-electron microscopy wins chemistry Nobel** [周三, 04 10月 08:00]
  Jacques Dubochet, Joachim Frank and Richard Henderson share the prize for developing a technique to image biomolecules.
- **Crash in sea-turtle births stumps ecologists** [周三, 04 10月 08:00]
  Leading suspect — climate change — doesn't fully explain what is happening to leatherback turtles in the US Virgin Islands.
- **Scientists plead with Brazilian government to restore funding** [周三, 04 10月 08:00]
  If officials don't act soon, research institutions could start shutting down next year.
- **Supercomputer redesign of aeroplane wing mirrors bird anatomy** [周三, 04 10月 08:00]
  Bird-bone structures emerge from an evolution-like algorithm.
- **Elite Hungarian university may be saved** [周三, 04 10月 08:00]
  Hungary-New York agreement could allow Central European University to sidestep law change.
- **Science without walls is good for all** [周三, 04 10月 08:00]
  International mobility and collaboration are linked to stronger research.
- **Nobel prizes, giant telescope and buried treasure** [周三, 04 10月 08:00]
  The week in science: 29 September–5 October 2017.
- **Why fake islands might be a real boon for science** [周三, 04 10月 08:00]
  The seasteading movement is getting close to building its first prototype, an artificial archipelago where people will live, play and do research.
- **How fracking is upending the chemical industry** [周三, 04 10月 08:00]
  As shale-gas compounds flood the market, chemists are working out the best ways to convert them into the ingredients of modern life.

- **[Scientists have most impact when they're free to move]** [周三, 04 10月 08:00]
  An analysis of researchers' global mobility reveals that limiting the circulation of scholars will damage the scientific system, say Cassidy R. Sugimoto and colleagues.
- **[Open countries have strong science]** [周三, 04 10月 08:00]
  Caroline S. Wagner and Koen Jonkers find a clear correlation between a nation's scientific influence and the links it fosters with foreign researchers.
- **[Neuroscience: The mother lode of invention]** [周三, 04 10月 08:00]
  Dan Jones compares three studies on the origins and fruits of human creativity.
- **[Health: The war on germs]** [周三, 04 10月 08:00]
  Tilli Tansey hails a history of Joseph Lister's drive to vanquish post-operative infection and putrefaction.
- **[New in paperback]** [周三, 04 10月 08:00]
  Highlights of this season's releases
- **[Sustainability: China's path to ecotopia]** [周三, 04 10月 08:00]
  Xuemei Bai critiques a critique of the country's eco-city initiative.
- **[Ornithology: All eyes on the 10,000 species]** [周三, 04 10月 08:00]
  Stuart Pimm considers the obsessive, sometimes dark side to the joyous pursuit of watching birds.
- **[Theoretical physics: When the doer met the dreamer]** [周三, 04 10月 08:00]
  Graham Farmelo applauds a study on the productive friendship of two very different physicists.
- **[Technology: Into cyberia]** [周三, 04 10月 08:00]
  Li Gong weighs up three tomes on Silicon Valley's vast influence, for good or ill.
- **[Fossil fuels: Heed local impact of coal mining]** [周三, 04 10月 08:00]
- **[Hurricanes: rescue natural defences]** [周三, 04 10月 08:00]
- **[Hurricanes: enlist nature's protection]** [周三, 04 10月 08:00]
- **[World Heritage Site: UNESCO honour for Polish mining facility]** [周三, 04 10月 08:00]
- **[Food supply: Blockchain could boost food security]** [周三, 04 10月 08:00]
- **[Collaborative software development made easy]** [周三, 04 10月 08:00]
  Save time and protect critical code with 'continuous integration' services.
- **[A taste of Toolbox]** [周三, 04 10月 08:00]
  Nature 's technology editor, Jeffrey Perkel, started blogging about workplace technology in science in 2016. Here are some highlights.
- **[The daughter you've always wanted]** [周三, 04 10月 08:00]

Family matters.

- **[South Korea cracks down on dirty air]** [周二, 03 10月 08:00]
  Despite huge clean-up effort, scientists say country’s pollution problem could get worse over next five years.
- **[Xenon view, butterfly wings and a strange squid]** [周二, 03 10月 08:00]
  September’s sharpest science shots, selected by Nature ’s photo team.
- **[Europe’s Joint Research Centre, although improving, must think bigger]** [周二, 03 10月 08:00]
  External report criticizes lack of exploratory research.
- **[Make plans to eliminate cholera outbreaks]** [周二, 03 10月 08:00]
  Governments must stop denying the occurrence of cholera and unite in long-term prevention strategies, says Anita Zaidi.
- **[Ethics of Internet research trigger scrutiny]** [周二, 03 10月 08:00]
  Concern over the use of public data spurs guideline update.
- **[Gravitational wave detection wins physics Nobel]** [周二, 03 10月 08:00]
  Rainer Weiss, Barry Barish and Kip Thorne share the 2017 prize for their work at LIGO to detect ripples in space-time.

Publishers threaten to remove millions of papers from ResearchGate

Take-down notices “imminent” as lawsuit is filed alleging widespread copyright infringement.

10 October 2017 Updated:

1. 10 October 2017

Millions of articles might soon disappear from ResearchGate, the world’s largest scholarly social network. Last week, five publishers said they had formed a coalition that would start ordering ResearchGate to remove research articles from its site because they breach publishers' copyright. A spokesperson for the group said that up to 7 million papers could be affected,

and that a first batch of take-down notices, for around 100,000 articles, would be sent out “imminently”.

Meanwhile, coalition members Elsevier and the American Chemical Society have filed a lawsuit to try to prevent copyrighted material appearing on ResearchGate in future. The complaint, which has not been made public, was filed on 6 October in a regional court in Germany. (ResearchGate is based in Berlin). It makes a “symbolic request for damages” but its goal is to change the site’s behaviour, a spokesperson says.

ResearchGate may already have begun taking articles down, according to a 10 October statement by the coalition. The group said it had noticed that the site had removed "a significant number of copyrighted articles", although ResearchGate hadn't shared information about this with publishers. "At this point, not all violations have been addressed and ResearchGate will need to take additional steps to cease unauthorized distribution of research articles," the statement says.

The clash has been a long time coming. Researchers are increasingly posting paywalled research papers online, many of them on ResearchGate, a network often likened to Facebook for scientists. The site boasts more than 13 million members and has raised more than US$80 million in start-up funding from investors including Microsoft founder Bill Gates and the Wellcome Trust, the London-based biomedical-research funder.

Not only do academics upload articles to the site, but ResearchGate also scrapes material online and invites researchers to claim and upload these papers, says James Milne, a spokesperson for the five-publisher group, which calls itself the Coalition for Responsible Sharing. In February this year, information scientist Hamid Jamali at Charles Sturt University in Wagga Wagga, Australia, reported that he had examined 500 articles at random from ResearchGate, and found that 40% of them breached copyright[1].

Access issues

In September, the International Association of Scientific, Technical, and

Medical Publishers, a trade group based in Oxford, UK, sent a letter to ResearchGate suggesting that the network introduce an automated filtering system, through which uploaded articles would be shared publicly or privately depending on their copyright status. Publishers generally say that paywalled articles for which they own copyright can be shared only privately; scientists are allowed to upload preprints, and peer-reviewed but unedited manuscripts, online for general access.

“ResearchGate refused to engage with us on that,” says Milne. The Coalition for Responsible Sharing, which also includes publishers Wiley, Wolters Kluwer and Brill, says it is “now left with no other choice” but to issue take-down notices.

Litigation has been tried before: in 2013, Elsevier sent 3,000 notices under the US Digital Millennium Copyright Act to scholarly networks including Academia.edu, demanding that they take down papers that breached Elsevier’s copyright. Those notices were passed on to the networks’ academic users. But the new actions would be on a larger scale.

Terms and conditions

ResearchGate declined to comment on the coalition’s statement, but its terms of service ask users not to store information that infringes copyright. They also state that because the site neither previews nor automatically reviews information that users have stored on it, ResearchGate can’t know about — and isn’t liable for — any possible infringements. The site says it will quickly disable access to infringing material after being notified of a problem.

But repeatedly sending lots of take-down notices is not a long-term solution, Milne says — hence the lawsuit, which aims to clarify what responsibility ResearchGate has to prevent copyright breaches. Milne says Elsevier and the American Chemical Society are hoping that the German court will tell the social network that it has a duty to identify copyrighted material on its website, and remove it; that the site must check whether material it scrapes from the Internet is copyrighted before users are invited to ‘claim’ it and upload it; and that ResearchGate will also be told it cannot modify

copyrighted material.

“The expectation is that ResearchGate will be told by the courts to cease certain behaviours. This could take months or years,” says Milne.

Not all publishers have stopped discussions with ResearchGate. On 9 October, the company posted a joint statement with *Nature*’s publisher Springer Nature, saying that the two firms had been in “serious discussions for some time” about sharing journal articles online while protecting intellectual-property rights, and that they were “cautiously optimistic” that a solution could be found. (*Nature*’s news and comment team is editorially independent from its publisher.)

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22793

Updates

Updated:

Updated to include details of a 10 October statement by the coalition of five publishers, which said that ResearchGate had begun removing from public view some copyrighted articles.

Comments

Commenting is currently unavailable.

Trump EPA begins push to overturn Obama-era climate regulation

The agency's plan to reverse limits on greenhouse-gas emissions is likely to draw legal challenges.

10 October 2017

Jabin Botsford/The Washington Post/Getty

EPA administrator Scott Pruitt has questioned his agency's legal authority to regulate greenhouse-gas emissions.

The US Environmental Protection Agency (EPA) is moving to repeal former

President Barack Obama's landmark regulations to reduce greenhouse-gas emissions from power plants.

The plan, introduced on 10 October, is a step towards fulfilling President Donald Trump's promises to reverse Obama-era climate regulations and end the "war on coal". But any attempt to repeal the power-plant rule is certain to face lawsuits from environmental groups and many states that support Obama's climate policies.

"The Trump Administration's persistent and indefensible denial of climate change — and their continued assault on actions essential to stemming its increasing devastation — is reprehensible," said Eric Schneiderman, attorney general for the state of New York, in a prepared statement. "I will use every available legal tool to fight their dangerous agenda."

US emissions from electricity generation have been falling in recent years as energy utilities have shifted away from coal, and towards cheap natural gas and renewables. The Obama administration established the power-plant regulations to hasten that progress, and to help the United States meet its commitments under the 2015 Paris climate accord.

The power-plant rule would reduce greenhouse-gas emissions to 32% below 2005 levels by 2030 — but it is mired in legal challenges. In 2016, the Supreme Court blocked the regulations from taking effect. Legal challenges from 27 state governments are still pending, although a federal appeals court has put the case on hold while the Trump administration reviews the rule.

Trump has shown no fear of challenging environmentalists on climate issues: he has already announced plans to pull the United States out of 2015 Paris climate pact. But his administration's attempts to roll back various environmental regulations have faced legal setbacks. One of the latest rebukes came on 4 October, when a federal court rejected an effort by the Department of the Interior to delay implementing curbs on methane emissions from oil and gas operations on public lands.

A long fight

The power-plant rule that Trump's administration plans to challenge was made possible by the US Supreme Court's decision in 2007 that carbon dioxide and other greenhouse gases are pollutants under the terms of the Clean Air Act. Two years later, the EPA ruled that these gases are a threat to human health and the environment — a decision known as an 'endangerment finding'. That allowed the agency to draft regulations to limit greenhouse-gas output from various sources.

EPA administrator Scott Pruitt sued to overturn the endangerment finding in his former role as Oklahoma's attorney general, before Trump took office. More recently, as EPA's chief, he has questioned his own agency's authority to regulate CO_2. Environmentalists fear that he will attempt to repeal the endangerment finding, which would inevitably prompt a flurry of lawsuits.

The legal fight over the EPA's new plan to repeal the Obama power-plant regulations will almost certainly focus on whether the Clean Air Act allows the agency to require that utilities alter their energy portfolios to reduce emissions. The Obama administration set limits on emissions and then allowed states and utilities to decide how to meet those limits, with options that included expanding efforts to reduce energy consumption and developing new sources of renewable energy.

The Trump administration's proposal says that the EPA overstepped its legal authority when it finalized the Obama-era rules. The administration argues that the Clean Air Act limits the EPA to crafting regulations that can be implemented at power plants themselves. The proposal also says that the EPA is still considering whether and how to craft alternative regulations for power-plant emissions.

Jonathan Adler, who heads the Center for Business Law & Regulation at the Case Western Reserve University School of Law in Cleveland, Ohio, says the Trump administration can reasonably argue — as many states have — that the Clean Air Act was not designed to regulate greenhouse gases. Courts often give a certain amount of deference to federal agencies on regulatory matters, he says, but only if the agencies show that they have followed all legal and procedural requirements for finalizing new rules.

“Some of the same legal doctrines that helped the Obama administration

defend its regulatory decisions will now help the Trump administration defend its decisions going in the opposite direction," Adler says. "This will certainly be a test for whether this administration is capable of engaging in this sort of heavy lift."

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22813

Comments

Comments

There are currently no comments.

Climate meetings pose serious test in the Trump era

Annual jamborees fail to ignite public passion but are crucial to progress on global-warming.

10 October 2017

Adrien Morlent/AFP Photo/Getty

In the aftermath of the successful 2015 Paris climate conference, the public remained unengaged.

Climate change is a popular topic in Germany right now. Leading researchers are converging in Potsdam this week to take stock of the economic and societal impacts of global warming across sectors from health to agriculture.

In Berlin, experts are meeting to discuss the potential and risks of various geoengineering technologies intended to counteract the effects of climate change. And next month, at the climax of the climate-meeting season, thousands of delegates will flock to the United Nation's annual climate summit, this year in Bonn.

At the UN meeting, governments will discuss the next steps in implementing the global climate agreement that they reached in Paris almost two years ago. The landmark deal, which came into force last November, aims to limit global warming to 1.5 °C above pre-industrial temperatures. To achieve this ambitious (many say unrealistic) goal, the world's major economies might need to phase out emissions of heat-trapping greenhouse gases entirely within a few decades.

The Paris accord, although based on merely voluntary national contributions, was undoubtedly a rare triumph for international climate diplomacy. It was the most that was possible and the least that was needed. Alas, the excitement did not last long. The subsequent U-turn of the United States — President Donald Trump has resolved to leave the deal, deeming it half-baked, essentially unnecessary and intolerably unfair to the US economy — has dampened spirits. Even so, the rest of the world has pledged to stand firm. The first conference of the parties to the agreement in the Trump era must now work out how to proceed without the world's largest economy. In theory, the annual climate roller coaster is idling through one of the low-key phases in which success is measured by nothing going wrong. In practice, the Bonn meeting will serve as a litmus test of how the rest of the world plans to stand united and to keep the spirit of Paris alive.

Keynote speakers in Bonn (and presenters in Berlin and Potsdam) will no doubt reiterate the severity of the global-warming threat and the urgent need to act. Major meetings often galvanize debate among researchers, pundits and policy watchers. But beyond this predictable fuss in the expert world, do high-level climate meetings and policy events, and the media coverage they bring, help push the wider public to engage with the climate problem?

Not quite, it seems. Results of a survey of the German public, published this week in *Nature Climate Change*, suggest that extensive media coverage of the Paris climate summit had a soothing rather than a mobilizing effect (M.

Brüggemann *et al. Nature Clim. Change* http://dx.doi.org/10.1038/nclimate3409; 2017). Respondents who had taken notice of media reports (and many said they had not) had slightly more trust in the efficacy of global climate policy after the unusually successful meeting. However, fewer were in favour of their own country taking a leading role, and most said that they did not intend to change their behaviour. In essence, respondents were relieved that a political deal had finally materialized, but were disinclined to engage further with the issue.

The researchers who conducted the survey say that this is a missed opportunity. The annual UN meetings bring guaranteed media attention to a topic that many news editors are bored with, and so they are an opportunity to mobilize action. As such, the study authors go so far as to suggest that the lack of public engagement is a failure of journalism.

It might indeed seem worrying that despite the avalanche of information, climate change remains marginal to most people’s personal and political choices — Germany’s strong green movement notwithstanding. It might even seem like a bad case of civil indifference. Does it matter? There is an argument that climate action does not have to depend on media-stirred engagement from agitated citizens. People often choose to leave responsible decision-makers to deal with complex global problems that only concerted international effort can hope to solve, and this has brought progress on issues such as nuclear non-proliferation and the phase-out of ozone-depleting chemicals.

But climate change is a more complex issue, and one that cuts across many overlapping and sometimes contradictory concerns, from cultural and political issues to ethical and psychological ones. As such, organizations, businesses, scientists, policymakers and others who advocate action on global warming must continue to strive to take the public with them. As many experts have pointed out, that will take creativity and more than repeated references to the serious nature of the problem — in Bonn and elsewhere.

Journal name:
Nature
Volume:
550,

Pages:
158
Date published:
(12 October 2017)
DOI:
doi:10.1038/550158a

Comments

Comments

There are currently no comments.

A. Awad

Developing nations need more than just money

Grants from big science funders can be hard to use without better administration and mutual understanding, says Rana Dajani[1].

10 October 2017

As a molecular biologist based in Jordan, I’m used to colleagues from outside the Middle East and North Africa assuming that brain drain and a lack of funds are the chief obstacles to science in my region. That is not my experience. Like me, many scientists return home after studying in the United States or Europe, and successfully apply for grants, often from international philanthropies or funders.

The real problem is using the money. There is a disconnect between the funding systems that we can tap into and the institutions where we work. Granting agencies often fail to appreciate the constraints we’re operating under. Current practices by both funders and universities practically guarantee that our funds — already limited — are spent inefficiently. We need more investment in administrative systems and more flexibility, because science is unpredictable and creative.

I hear the same sorts of struggles again and again. For example, a researcher in the Middle East received a grant from a US institution to study vectors of disease. It included a line item to cover capturing insects in the desert. But the local university overseeing the funds would not disburse them to cover transport, because the team could not supply officially stamped receipts from a petrol station; services at remote locations in developing nations are rarely equipped to provide such documentation. The scientist has not applied for an international grant since.

Another colleague in the region received a grant budgeting for some human genetic analysis to be performed by a third party in the United States, because the necessary capacity doesn't exist in the Middle East. It took more than a year to get the funder, local university and third party to sign the agreements. But after the samples were shipped, university administrators said they could not process invoices because a bid to supply DNA-analysis services had not first been advertised in local newspapers. It took another year, many committees and much heartache to resolve the issue.

The situation is improving as more grants are awarded. For example, a newly appointed dean of scientific research at my university, Majd Mrayyan — herself a practicing scientist — has reduced the paperwork and minimized the levels of approval needed to begin projects. And the American University in Beirut has set up a department to handle funding logistics, staffed by people who understand the process. It has greatly increased the amount of funding that the university can receive.

Still, few university administrators in developing countries know much about science or how grants are typically handled. Postdoc and technician positions are rare across the Middle East and North Africa. When I hired a lab manager to handle administrative tasks such as ordering equipment, several people told me I was indulging in a luxury.

Institutions such as Harvard University in Cambridge, Massachussetts, where I am currently a visiting fellow, receive as much as 69% of awarded funds as indirect costs, which they put towards infrastructure and overhead — the costs of maintaining a system. By contrast, international grants to researchers in developing countries rarely cover infrastructure or capacity building; in some cases, philanthropists' charters explicitly prohibit them from putting

money into anything not directly related to a funded project.

Even when overhead funds are available, local universities are often wary of spending them on intangibles such as salaries or training. They prefer to use grants to buy instruments and equipment. In one typical occurrence, an award covered the purchase of a DNA sequencer, but not maintenance. The instrument was effectively rendered useless in three years.

How can we solve this? Through capacity and systems building. Funders need to find ways to ensure that recipients have the administrative staff and skills to use their money well, and to help build these foundations where they are lacking. Agencies should encourage the appointment of administrators who have research experience. They might even consider sponsoring training and exchange programmes for administrators.

People involved also need to sit around a table and talk about these issues in real time. When discussions happen — if they happen at all — it is through e-mail, and most communication occurs within groups rather than across them. People at institutions talk among themselves and then formally approach funders; those at funding agencies take the same approach. Each group misses out on nuance and connection with the other.

For every grant awarded, funders, university administrators and scientists should talk about the project together to identify needs and potential conflicts. They could then take the initiative to make changes, which builds ownership and creates useful precedents.

These discussions might reduce many roadblocks that keep scientists in the developing world from being able to use grants more efficiently. Core facilities that allow expensive equipment to be shared would cut down on redundancies and free up available funds. Provisions for maintaining equipment and paying and training technicians should be built into the budgets of both grants and institutions.

People from developed countries might feel noble when they give money to those in developing countries. What is really needed is more complicated — but it’s doable. For funders to have the most impact, they need to sit down with administrators and scientists in developing countries, listen to their

challenges and decide together what to do. That is the way to genuinely make a difference.

Journal name:
Nature
Volume:
550,
Pages:
159
Date published:
(12 October 2017)
DOI:
doi:10.1038/550159a

Comments

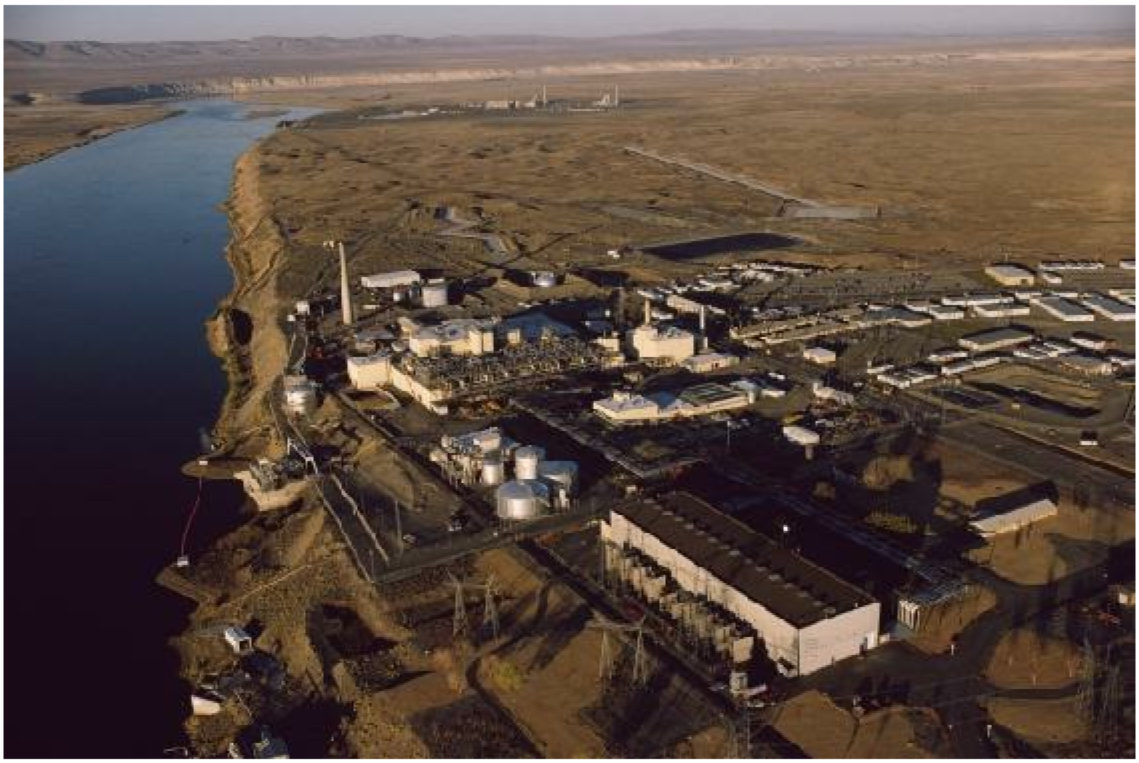
Comments

There are currently no comments.

How the United States plans to trap its biggest stash of nuclear-weapons waste in glass

After decades of delays, a challenging clean-up project is gaining ground.

10 October 2017



Karen Kasmauski/NGC

Waste from decades of nuclear-weapons production is buried at the Hanford Site in Washington state.

There's a building boom at the Hanford Site, a once-secret complex on the windswept plains of southeastern Washington state. Construction crews are

working to finish a 27-metre-tall concrete structure there by June. If all goes well, the facility will finally enable the US Department of Energy (DOE) to begin treating the toxic, radioactive waste that accumulated at the site for more than 40 years, starting during the Second World War.

Decades after the site stopped producing plutonium for nuclear weapons, the legacy of Hanford's activities is still causing trouble. Just this year, a tunnel holding railway carriages full of radioactive material collapsed. Separately, at least a dozen employees who were tearing down a contaminated building reportedly tested positive for plutonium inhalation. But the site's biggest challenge lies underground, in 177 carbon-steel tanks. Together, these buried containers hold more than 200 million litres of highly hazardous liquids and peanut-buttery sludge — enough to fill 80 Olympic-size swimming pools. More than one-third of the tanks have leaked, contaminating groundwater with radioactive and chemical waste.

In a 1989 legal agreement with the state of Washington and the US Environmental Protection Agency, the DOE committed to immobilizing the most dangerous waste in sturdy glass logs through a process called vitrification. Several years later, the agency agreed to vitrify other tank waste as well. All told, the process is expected to generate tens of thousands of logs, each weighing multiple tonnes. Those containing high-level waste would be shipped to a permanent storage facility; the rest could be stored on site. But the effort has been plagued by cost overruns, delays and safety concerns. Although the DOE has spent roughly US$20 billion on the tank problem since 1997, no waste has been vitrified.

Four years ago, the agency hit reset. Rather than making a single vitrification plant, it split the project in two. One plant — the building now under construction — would begin vitrifying the less-hazardous, 'low-activity' liquid in the tanks. A bigger, more-complex plant to process the high-level sludge would follow once researchers resolved some thorny safety questions.

On both fronts, there have been signs of progress. This year, the DOE reported that it had resolved crucial questions related to treating the high-level waste. And a laboratory needed for real-time analysis of the low-level waste is nearing completion. If work continues as planned, the site could crank out its first glass logs as early as 2022.

Hanford's critics, accustomed to missed deadlines and management scandals, remain sceptical. But even officials with the state of Washington, which has battled the DOE in court for nearly three decades over clean-up goals and deadlines, are hopeful that efforts are now on track. “There's reason for optimism,” says Suzanne Dahl, who oversees tank activities for the Washington Department of Ecology.

Scientists have been studying vitrification since the 1950s, and a number of countries have used the process to stabilize nuclear waste, including France, India, Russia and the United Kingdom. The United States vitrifies waste at the DOE's Savannah River Site in South Carolina. But the size and complexity of the problem is on a different scale at Hanford.

Established as part of the Manhattan Project during the Second World War, the Hanford Site delivered the plutonium that went into the first nuclear-weapon test and the bomb that was dropped on Nagasaki, Japan, in 1945. It went on to produce the bulk of the plutonium for the US nuclear arsenal. “Hanford is the whole history of nuclear development,” says Ian Pegg, a physicist at the Catholic University of America in Washington DC, who works with the DOE on vitrification experiments.

Toxic brews

The ever-shifting suite of technologies used at the site produced uniquely toxic brews that include radioactive caesium, strontium, americium and residual plutonium; salts; heavy metals; and myriad industrial chemicals. The containers also hold other surprises. People “threw everything imaginable into those tanks”, says Albert Kruger, a glass scientist with the DOE in Richland, Washington. His list includes contaminated gloves, planks of wood, rocks and tape measures.

Once such detritus is removed, vitrification calls for the waste to be combined with ingredients that include silica and boron, then heated to nearly 1,150 °C. The molten mixture is next cooled in stainless-steel canisters to create large cylinders of borosilicate glass — the same material used in oven-safe glassware.

The process is complicated by that fact that each tank contains a cocktail of chemicals and radionuclides that cannot be fully characterized until the waste is extracted. Some of those substances can weaken glass. Others, such as iodine, can't be readily trapped and must be removed. Hanford scientists will have to tailor glass recipes for each batch of waste — a bit like blending different vintages to produce a fine cognac. “Nobody will test the nose, and nobody will take a taste test, but it's an equivalent mechanism,” Kruger says.

Multiple contractors have worked on the Hanford project since 1989, including British Nuclear Fuels Limited, a UK-government-owned company that exported the technology it was using at the Sellafield nuclear-decommissioning complex. After price estimates rose, in 2000 the DOE hired construction and engineering giant Bechtel of San Francisco, California, as the primary contractor.

At that time, the Hanford plant was expected to cost $4.3 billion and to begin making logs in 2007. But as engineers began working through the safety and technical details, the project ballooned in price and complexity. By 2012, senior officials — including a former DOE employee and two contractors who later filed whistle-blower complaints after being fired — were raising concerns. One was that hydrogen, which is generated when heat and radiation split water molecules, would build up in tanks and pipes, creating a risk of explosion. Another was that mixing vessels meant to keep heavy particles moving would not be powerful enough. Over time, enough residual plutonium could settle out to create a dangerous chain reaction.

Then-DOE secretary Steven Chu assembled an expert panel to investigate. Ultimately, Bechtel was ordered to first construct a plant that would vitrify only liquid waste. The liquid represents 90% of the waste volume but just 10% of its radioactivity, and requires less processing than the high-level waste: it can be skimmed off, stripped of highly radioactive caesium and then sent directly to vitrification. “It makes sense,” says David Kosson, a chemical engineer at Vanderbilt University in Nashville, Tennessee, who was on Chu's expert panel. If you have got to pick one place to start, he says, “the low-activity waste is not a bad choice”.

Lingering questions

The high-level-waste facilities remain on hold, but the DOE and its contractors have spent years investigating the technical issues using computer models and prototypes. In February, the agency announced it had resolved issues related to hydrogen build-up and uncontrolled reactions. Scientists familiar with the effort says tests of a newly designed mixing vessel are nearing completion, apparently without any major hitches. The vessel is equipped with six 'pulse jet mixers' that pull waste in and out like turkey basters, to keep solids from settling.

Researchers are also making progress on the glass recipes. Kruger and external scientists have shown that certain compositions can accommodate more waste than previously estimated, and so potentially save on costs. The number of glass logs produced in the high-level waste facility could drop from 18,000 to as few as 7,000, Kruger says. The low-level plant may need to make just 70,000 logs or so, instead of 145,000.

But questions remain. A 2015 DOE report documented more than 500 vulnerabilities that could affect low-level plant operations — including some in the electrical and mechanical systems that would be used to handle radioactive materials. Tom Carpenter, executive director of the watchdog group Hanford Challenge, hopes the plant will work as advertised. But he is concerned that the DOE, its contractors and even the state of Washington are too eager to bring the facility online. “Everyone is desperate to show progress,” he says. “I get that, but you can't paper over the safety issues.” Senior DOE officials at Hanford declined to be interviewed for this story; a Bechtel spokesperson said the company has addressed the vast majority of concerns raised in the report and has submitted its responses to the DOE for verification.

Not everyone is convinced that vitrification is the way to go. The DOE is bound by legal agreements and nuclear-waste regulations to pursue the process, but from a technical standpoint there are better options, says Jim Conca, a consultant and former director of an independent research centre that supports the Waste Isolation Pilot Plant (WIPP) outside Carlsbad, New Mexico, the nation's only operating deep geological repository.

Hanford's high-level wastes are currently slated for disposal at Yucca Mountain, a long-stalled geological repository in Nevada. Water infiltration

is a concern there, so the waste must be encased in glass to help ensure that it remains stable over thousands of years. But Conca says that the tank sludge is safe enough to simply be dried out and sent to WIPP — if regulations could be changed to allow it. Similarly, low-activity waste could be mixed with grout to create concrete-like material, which would be cheaper and, many believe, just as safe. “Does all of that waste technically need to be vitrified for environmental safety? Probably not,” says Kosson. But in the end, Kosson believes that the DOE will press forward with the plan.

Chu remains confident that vitrification can work, but says the DOE should be receptive to new science and shift course as needed. More generally, he says, the country has a long way to go in resolving questions about how — and where — it will dispose of all its nuclear waste. “This is a significant problem, and there has to be a lot of good science in figuring out a better path forward,” he says. “Always keep your mind open.”

The price tag on Hanford's vitrification facilities now stands at $16.8 billion. Assuming that the latest timetable holds, the plant for high-level waste will open for business in the early 2030s, and operations will continue for decades. In the meantime, dangerous waste will remain underground, out of sight but not out of mind.

Journal name:
Nature
Volume:
550,
Pages:
172–173
Date published:
(12 October 2017)
DOI:
doi:10.1038/550172a

Comments

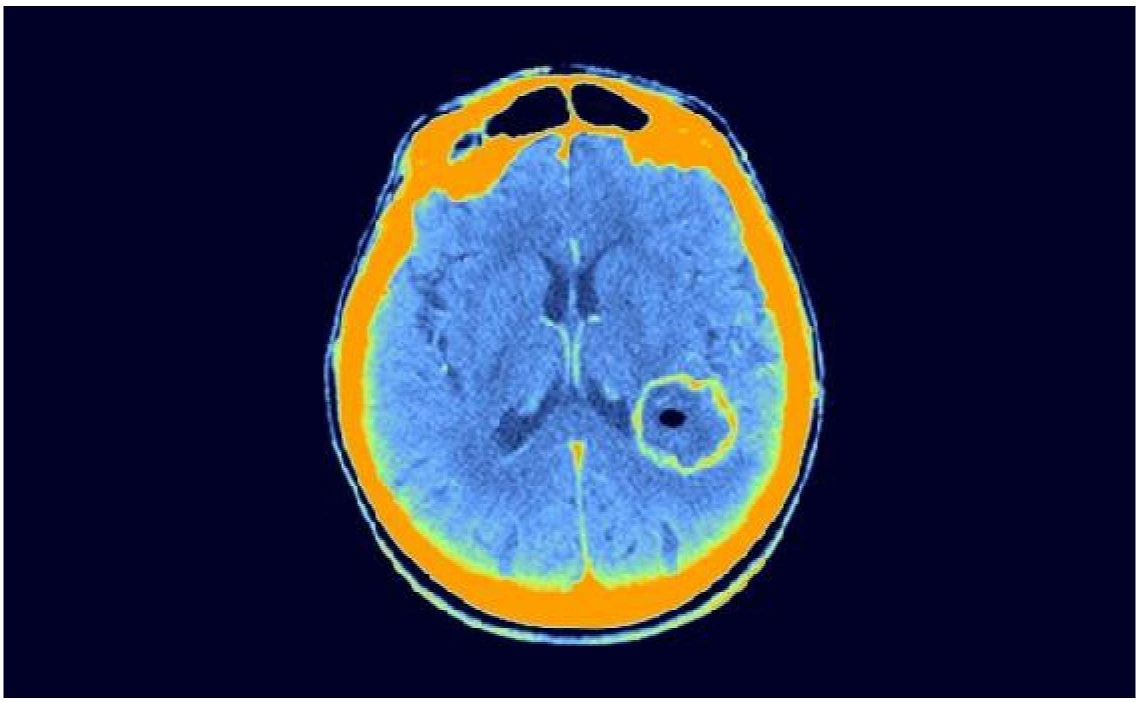
Comments

There are currently no comments.

Cancer-genome study challenges mouse 'avatars'

Grafting human cancer cells into mice alters tumour evolution.

09 October 2017



Centre Jean Perrin/ISM/SPL

A brain tumour called glioblastoma, shown here as the circular region in a patient's brain scan, is among the cancers that have been tested in mouse avatars.

An analysis of more than 1,000 mouse models of cancer has challenged their ability to predict patients' response to therapy.

The study, published today in *Nature Genetics*[1], catalogues the genetic

changes that occur in human tumours after they have been grafted into mouse hosts. Such models, called patient-derived xenografts (PDXs), are used in basic research and as ‘avatars’ for individual patients. Researchers use these avatar mice to test a bevy of chemotherapies against a person's tumour, in the hope of tailoring a treatment plan for the patient's specific cancer.

But fresh data from geneticists at the Broad Institute of MIT and Harvard in Cambridge, Massachusetts, suggest that transplanting human cancer cells into a mouse alters the cells' evolution, reshaping the tumour's genome in ways that could affect responses to chemotherapy.

“The assumption is that what grows out in the PDX is reflective of the bulk of the tumour in the patient,” says cancer geneticist Todd Golub, a lead author on the study. “But there’s quite dramatic resculpting of the tumour genome.”

No animal model is perfect, and researchers have long acknowledged that PDXs have their limitations. To avoid an immune assault on the foreign tumour, for example, PDXs are typically grafted into mice that lack a functioning immune system. This compromises scientists' ability to study how immune cells interact with the tumour — an area of increasing interest given the success of cancer therapies that unleash the immune system.

PDXs can also take months to generate, making them too slow to serve as avatars for those patients who need to make immediate decisions about their therapy.

Reasonable reproductions

But previous research had suggested that the PDXs were reasonably faithful reproductions of the human tumours they are meant to model, offering researchers a chance to explore the tumour’s interaction with its environment in ways that are not possible using cells grown in a Petri dish. The US National Cancer Institute has developed a library of more than 100 PDXs for distribution to researchers, and European scientists have launched EurOPDX, a consortium that boasts more than 1,500 models for more than 30 tumour

types. One company, Champions Oncology of Hackensack, New Jersey, creates and tests mouse avatars for individual patients and for pharmaceutical companies to use in research.

For the latest study, Golub and Broad Institute cancer geneticist Rameen Beroukhim, together with their colleagues, decided to examine how PDXs changed over time. The researchers studied data from tumour cells that were implanted into a mouse, allowed to grow into a tumour, and then harvested and re-implanted into a fresh mouse — sometimes for multiple cycles.

The researchers looked for alterations in the number of copies of a given gene in the cell. They did so for more than 1,000 PDX samples representing 24 cancer types, often extrapolating gene copy number from data on gene expression.

The analysis suggests that tumours implanted in mice change in ways that are not commonly seen in the human body. For example, human brain tumours called glioblastomas tend to gain extra copies of chromosome 7. But the mouse PDXs tend to lose those extra copies over time, says Beroukhim.

Some of these genetic changes were also associated with differences in how the PDXs responded to cancer drugs. For researchers studying many PDXs and looking for relationships between genetics and drug sensitivity, the finding does not spell disaster, says Golub. “That’s not to say that PDXs should be abandoned as a model — far from it,” he says. “But they’re not a panacea.”

Golub is more worried about using PDXs to predict outcomes in individual patients. “It raises some important questions around how to interpret the results of avatars,” he says.

But Champions Oncology founder David Sidransky, an oncologist at Johns Hopkins University School of Medicine in Baltimore, Maryland, points to his team's study of 92 patients, published in August. That showed an 87% association between the drug responses in a patient and their corresponding PDX[2].

The genetic analysis by Golub and his team could offer clues as to what goes

wrong in the other 15% of PDXs, Sidransky says.

The work is important, says David Tuveson, a cancer researcher at Cold Spring Harbor Laboratory in New York. But Tuveson also notes that PDX approaches are changing. Researchers are increasingly likely to graft a human tumour into the analogous location in the mouse avatar — for instance, by transplanting human pancreatic cancer cells into a mouse pancreas — rather than merely grafting them under the skin. This, he says, is thought to be an environment that is more similar to that of the original tumour.

Researchers are also turning to mice that have been ‘humanized’ in various ways, perhaps by introducing aspects of a human immune system or human versions of proteins that interact with the tumour.

As for those PDXs that have already been generated, researchers will continue to embrace them, says Carlos Caldas, a researcher at the Cancer Research UK Cambridge Institute at the University of Cambridge, UK.

Caldas notes that his own studies with breast cancer PDXs have not found such dramatic differences between PDXs and the tumours from which they were made. “We’re going to continue to see a lot of activity with these models — they are a great development, not a hindrance,” he says. “They are here to stay.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22782

Comments

Comments

There are currently no comments.

LIGO's unsung heroes

Nature highlights just a few of the people who played a crucial part in the discovery of gravitational waves — but didn’t win the Nobel Prize.

09 October 2017

Joe McNally/Getty

LIGO hunts gravitational waves with the help of two laser interferometers — and hundreds of people.

Every October, the announcements of the Nobel Prizes bring with them some controversy. This year’s physics prize — in recognition of the Laser Interferometer Gravitational-Wave Observatory (LIGO) in the United States — was less debated than most. The three winners — Kip Thorne and Barry Barish, both at the California Institute of Technology (Caltech) in Pasadena,

and Rainer Weiss at the Massachusetts Institute of Technology (MIT) in Cambridge — had attracted near-universal praise for their roles in the project’s success.

But the award has still put into stark relief the difficulty of singling out just a few individuals from the large collaborations of today’s 'Big Science'. The LIGO collaboration uses two giant laser interferometers to listen for deformations in space-time caused by some of the Universe’s most cataclysmic events. Physicists detected their first gravitational waves — interpreted as being produced by the collision of two black holes more than a billion years ago — in September 2015. The resulting paper, published in February 2016[1], has a mind-boggling 1,004 authors.

Some of those are members of the LIGO Laboratory, the Caltech–MIT consortium that manages LIGO’s two interferometers in Louisiana and Washington State. But the list also includes the larger LIGO Scientific Collaboration: researchers from 18 countries, some of which — such as Germany and the United Kingdom — have made crucial contributions to the detectors.

Yet more authors are from LIGO’s sister Virgo Collaboration, led by France and Italy, which built the Virgo interferometer near Pisa, Italy. The two experiments pool their data and analyse them together. Countless other people not named on the paper have also been involved in LIGO’s design, development, construction and operation since Weiss first detailed how to build a laser interferometer in 1972.

To honour the many unsung heroes of gravitational waves, *Nature* collected testimonials about just a few of them. Like the Nobel Prize, this list is inevitably very incomplete.

1. The pioneer: Joseph Weber

Researchers using two detectors in the United States shook the world when they announced their discovery of gravitational waves. The year was 1969, and the detectors were not LIGO but tonne-sized cylinders of aluminium built

by Joseph Weber, a physicist at the University of Maryland in College Park. His claim was later found to be invalid, but many physicists still credit Weber for having founded the field. “Joe Weber indeed started thinking about how to detect gravitational waves in about 1957,” Virginia Trimble, an astrophysicist and Weber’s widow, told *Nature* in an e-mail. At that time, many researchers were not even sure that gravitational waves existed. In the 1960s, Weber was also one of the first researchers to consider the possibility of using interferometers to detect them.

2. The German connection: Heinz Billing

The founder of Germany’s side of LIGO, Heinz Billing, a physicist at the Max Planck Institute for Astrophysics near Munich, first heard of Weiss’s pioneering interferometer designs in 1975, when he was asked to review Weiss’s request to the National Science Foundation to fund a prototype at MIT. Billing and his team liked it so much that they started building one themselves. “The Munich group quickly invented some of the most important ingredients that made the detectors possible,” says Karsten Danzmann, a director at the Max Planck Institute for Gravitational Physics in Hanover, Germany. Billing, in particular, came up with an idea to stabilize the laser that was later used in the UK–German GEO600 interferometer based near Hanover — and in LIGO itself. GEO600 is still a crucial testing and development centre for technologies introduced in the successive rounds of LIGO upgrades. “There is an awful lot of GEO in LIGO,” says Danzmann. Billing, who died on 4 January at the age of 102, was also a pioneer in magnetic data storage.

3. The laser expert: Alain Brillet

The 1980s were years of intense research and development for gravitational-wave detectors. Alain Brillet, an optical physicist with extensive experience in interferometers, then at the University of Paris-Sud in Orsay, France, saw an opportunity to contribute. “I decided to start with the optical part, the lasers and optics, because that was my specialty,” he says. Brillet went on to co-found Virgo. But many of his ideas — in particular, the type of laser that

would give the most stable signal — were implemented in LIGO and other interferometers as well, says MIT physicist David Shoemaker, who studied with Brillet in Orsay and is now LIGO’s spokesperson.

4. The facilitator: Richard Isaacson

Gravitational theorist Richard Isaacson went to Washington DC to work at the National Science Foundation (NSF) in 1973 for what he thought would be a brief stint as one of the programme directors. During the handover, his predecessor advised him to pay attention to an “interesting guy” called Rainer Weiss. Isaacson secured Weiss a small grant for his 1975 prototype, and later became LIGO’s chief advocate inside government. He was instrumental in the project's winning hundreds of millions of dollars in funding, despite the uncertain prospect of success. It was the first time that the NSF had managed a large project: US facilities such as particle accelerators were traditionally the remit of the Department of Energy, which had field offices staffed with dozens of experts. Isaacson did it by himself for more than ten years, and by the early 1990s he had paid a high personal cost. “Eventually, my health broke and my marriage went bad,” says Isaacson. By the time he retired in 2001, the construction of LIGO had been completed.

5. The first director: Rochus ‘Robbie’ Vogt

Before Barry Barish took the reins of LIGO, another director had left his mark on the collaboration: Rochus Vogt. The Caltech physicist, a veteran of the NASA Voyager mission, was put in charge in 1987. Until then, the project had been led by the ‘troika’ of visionary founders — Thorne, Weiss, and the physicist Ronald Drever, who started UK research on gravitational waves at the University of Glasgow before moving to Caltech — but managing large organizations was not their strength. “Thank God that was done,” Weiss recalled in a talk at NSF headquarters last year. “You don't manage it with three guys who are sort of a little bit flaky.” Vogt, who was once described as a taller and leaner Henry Kissinger, had a booming voice and forceful style that did not please everyone. But he was able to put together the first major request for NSF funding and, Thorne recalled in a 5

October press conference, “laid the foundations for moving LIGO forward to our construction”.

6. The theorist: Alessandra Buonanno

As Thorne realized early on, in the future field of gravitational-wave astronomy, it would not be enough to collect data; researchers would also need to know what signals to look for. But it is notoriously difficult to extract quantitative predictions from the equations of Einstein’s general relativity. Theoretical physicist Alessandra Buonanno had devised formulae for calculating the approximate orbits of spiralling objects and the gravitational waves they would generate in work she had done, in part with her PhD adviser Thibault Damour, at the Institute of Advanced Scientific Studies near Paris. The LIGO and Virgo collaborations use a database of hundreds of thousands of these waveforms for spotting gravitational waves in their data in real time. Buonanno is now a director at the Max Planck Institute for Gravitational Physics in Potsdam and a senior member of the LIGO Scientific Collaboration.

Journal name:
    Nature
DOI:
    doi:10.1038/nature.2017.22786

Comments

3 comments

1. *Pentcho Valev* • 2017-10-10 01:08 AM
    Gravitational waves (ripples in spacetime) don't exist because spacetime doesn't exist: Nima Arkani-Hamed (06:09): "Almost all of us believe that space-time doesn't really exist, space-time is doomed and has to be replaced by some more primitive building blocks." https://www.youtube.com/watch?v=U47kyV4TMnE Nobel Laureate David Gross observed, "Everyone in string theory

is convinced...that spacetime is doomed. But we don't know what it's replaced by." https://www.edge.org/response-detail/26563 What scientific idea is ready for retirement? Steve Giddings: "Spacetime. Physics has always been regarded as playing out on an underlying stage of space and time. Special relativity joined these into spacetime... [...] The apparent need to retire classical spacetime as a fundamental concept is profound..." https://www.edge.org/response-detail/25477 And spacetime doesn't exist because the underlying premise, Einstein's constant-speed-of-light postulate, is false: "Special relativity is based on the observation that the speed of light is always the same, independently of who measures it, or how fast the source of the light is moving with respect to the observer. Einstein demonstrated that as an immediate consequence, space and time can no longer be independent, but should rather be considered a new joint entity called "spacetime." http://community.bowdoin.edu/news/2015/04/professor-baumgarte-describes-100-years-of-gravity/ Is the speed of light "always the same, independently of who measures it"? Of course not - even Einstein knew that this is nonsense: John Stachel: "But this seems to be nonsense. How can it happen that the speed of light relative to an observer cannot be increased or decreased if that observer moves towards or away from a light beam? Einstein states that he wrestled with this problem over a lengthy period of time, to the point of despair." http://www.aip.org/history/exhibits/einstein/essay-einstein-relativity.htm In the quotation below, the statement "four pulses are received in the time it takes the source to emit three pulses" means that the speed of light is VARIABLE - the speed of the pulses relative to the receiver (observer) is greater than their speed relative to the source, in violation of Einstein's relativity: http://www.einstein-online.info/spotlights/doppler Albert Einstein Institute: "The frequency of a wave-like signal - such as sound or light - depends on the movement of the sender and of the receiver. This is known as the Doppler effect. [...] Here is an animation of the receiver moving towards the source: Stationary receiver: http://www.einstein-online.info/images/spotlights/doppler/doppler_static.gif Moving receiver: http://www.einstein-online.info/images/spotlights/doppler/doppler_detector_blue.gif By observing the two indicator lights, you can see for yourself that, once more, there is a blue-shift - the pulse frequency measured at the receiver is somewhat higher than the frequency with which the pulses are sent out. This time, the distances between subsequent pulses are not affected, but still there is a frequency shift: As the receiver moves towards each pulse, the time until pulse and receiver meet up is shortened. In this particular animation, which has the receiver moving towards the source at one third the speed of the pulses themselves, four pulses are received in the time it takes the source to emit three pulses." [END OF QUOTATION] Pentcho Valev

2. *Pentcho Valev* • 2017-10-09 02:33 PM

   "As Thorne realized early on, in the future field of gravitational-wave astronomy, it would not be enough to collect data; researchers would also need to know what signals to look for. But it is notoriously difficult to extract quantitative predictions from the equations of Einstein's general relativity. Theoretical physicist Alessandra Buonanno had devised formulae for calculating the approximate orbits of spiralling objects and the gravitational waves they would generate in work she had done, in part with her PhD adviser Thibault Damour, at the Institute of Advanced Scientific Studies near Paris. The LIGO and Virgo collaborations use a database of hundreds of thousands of these waveforms for spotting gravitational waves in their data in real time." Not true. Actually LIGO conspirators don't use theoretically calculated waveforms in detecting (more precisely, faking) gravitational wave signals: The Nobel Committee for Physics: "While these waveforms provide a reasonable match, further important improvements are obtained using numerical methods that are very computationally intensive [23]. The analytical methods are crucial to producing the big library of template waveforms used by LIGO. While the waveforms produced in this way are necessary for determining the detailed properties of the objects involved, as well as identifying weak signals, they were not essential for the very first detection of

GW150914. This was a model-independent detection of a gravitational-wave transient." https://www.nobelprize.org/nobel_prizes/physics/laureates/2017/adv physicsprize2017.pdf According to Rana Adhikari, professor of Physics at Caltech and a member of the LIGO team, LIGO conspirators have no preliminary knowledge about the signals. Adhikari declares: "the only thing that we really know is what we measure. And that's the mantra of the true empirical person": Rana Adhikari: "You split it in two and you send it in two separate directions, and then when the waves come back, they interfere with each other. And you look at differences in that interference to tell you the difference in how long it took for one beam to go one way, and the other beam to go the other way. The way I said it was really careful there because there's a lot of confusion about the idea of, these are waves and space is bending, and everything is shrinking, and how come the light's not shrinking, and so on. We don't really know. There's no real difference between the ideas of space and time warping. It could be space warping or time warping but the only thing that we really know is what we measure. And that's the mantra of the true empirical person. We sent out the light and the light comes back and interferes, and the pattern changes. And that tells us something about effectively the delay that the light's on. And it could be that the space-time curved so that the light took longer to get there. But you could also imagine that there was a change in the time in one path as opposed to the other instead of the space but it's a mixture of space and time. So it sort of depends on your viewpoint." https://blog.ycombinator.com/the-technical-challenges-of-measuring-gravitational-waves-rana-adhikari-of-ligo/ Pentcho Valev

3. *Pentcho Valev* • 2017-10-09 04:23 PM

   Another sword of Damocles hanging over LIGO conspirators (and over the Nobel committee as well). They had no idea what they were measuring (faking) and produced signal correlation but also noise correlation that they are unable to explain: James Creswell, Sebastian von Hausegger, Andrew D. Jackson, Hao Liu, Pavel Naselsky, June 27, 2017: "As a member of the LIGO collaboration, Ian Harry states that he "tried to reproduce the results quoted in 'On the time lags of the LIGO signals'", but that he "[could] not reproduce the correlations claimed in section 3". Subsequent discussions with Ian Harry have revealed that this failure was due to several errors in his code. After necessary corrections were made, his script reproduces our results. His published version was subsequently updated. [...] It would appear that the 7 ms time delay associated with the GW150914 signal is also an intrinsic property of the noise. The purpose in having two independent detectors is precisely to ensure that, after sufficient cleaning, the only genuine correlations between them will be due to gravitational wave effects. The results presented here suggest this level of cleaning has not yet been obtained and that the identification of the GW events needs to be re-evaluated with a more careful consideration of noise properties." http://www.nbi.ku.dk/gravitational-waves/gravitational-waves.html James Creswell, Sebastian von Hausegger, Andrew D. Jackson, Hao Liu, Pavel Naselsky, August 21, 2017: "In view of unsubstantiated claims of errors in our calculations, we appreciated the opportunity to go through our respective codes together - line by line when necessary - until agreement was reached. This check did not lead to revisions in the results of calculations reported in versions 1 and 2 of arXiv:1706.04191 or in the version of our paper published in JCAP. It did result in changes to the codes used by our visitors [LIGO conspirators]. [...] In light of the above, our view should be clear: We believe that LIGO has not yet attained acceptable standards of data cleaning. Since we regard proof of suitable cleaning as a mandatory prerequisite for any meaningful comparison with specific astrophysical models of GW events, we continue to regard LIGO's claims of GW discovery as interesting but premature." http://www.nbi.ku.dk/gravitational-waves/gravitational-waves-comment2.html Here is Sabine Hossenfelder's article: Sabine Hossenfelder: "Was It All Just Noise? Independent Analysis Casts Doubt On LIGO's Detections. A team of five researchers - James Creswell, Sebastian von Hausegger, Andrew D. Jackson, Hao Liu, and Pavel Naselsky - from the Niels Bohr Institute in Copenhagen, presented their own analysis of the openly available LIGO data. And, unlike the LIGO collaboration itself, they come to a disturbing conclusion: that these gravitational waves might not be signals at all, but rather patterns in the noise that have hoodwinked even the best scientists working on this puzzle. [...] A few weeks ago, Andrew Jackson presented his results in Munich. A member of the local physics faculty (who'd rather not be named) finds the results "quite disturbing" and hopes that the collaboration will take the criticism of the Danes to heart. "Until LIGO will provide clear scientific(!) explanation why these findings are wrong, I would say the result of the paper to some extent invalidates the reliability of the LIGO discovery." https://www.forbes.com/sites/startswithabang/2017/06/16/was-it-all-just-noise-independent-analysis-casts-doubt-on-ligos-detections/ In a world different from our post-truth world the disclosure of the noise correlation would mark the end of the LIGO project and the beginning of an interrogation. In the post-truth world the glory of the fraudsters can only increase - if the absurd noise correlation cannot topple them, nothing can! Immediate Nobel prize - should have been given to LIGO fraudsters a year ago! Pentcho Valev

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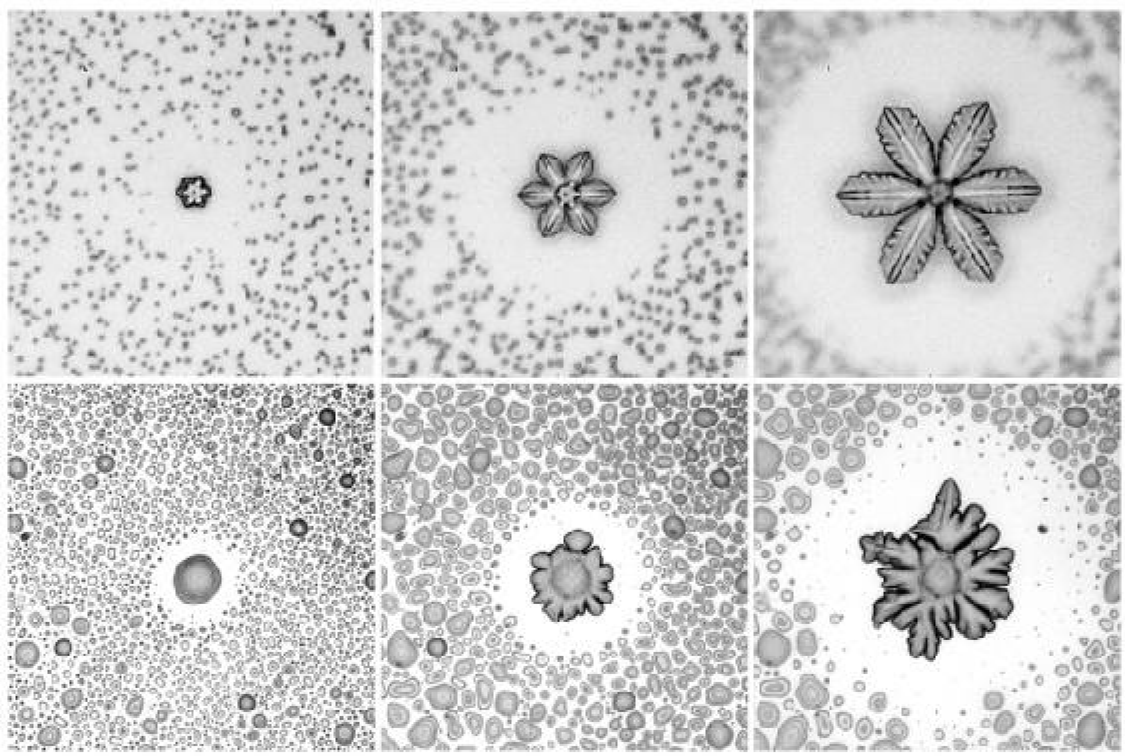
Water-repellent coatings could make de-icing a breeze

Coatings that force ice to grow upwards from the surface could make it easier to remove.

09 October 2017



Wang et al., DOI 10.1073/pnas.1712829114

Ice growth on hydrophillic (top layer) and hydrophobic surfaces

When water droplets suspended in the air freeze, they generate snowflakes — ice crystals with six-fold symmetry. But when ice grows along a solid surface, like frost growing on windows, it can take on an almost infinite range of different shapes.

These crystalline patterns are affected by whether a surface repels or absorbs water, says a team led by chemists Jie Liu of the Chinese Academy of Sciences Institute of Chemistry in Beijing and Chongqin Zhu of the University of Nebraska–Lincoln. The researchers showed that when a surface tends to repel water, ice crystals can be cultivated to grow away from the surface at an angle, resembling a clover with six leaves.

The work was published on 9 October in the *Proceedings of the National Academies of Science*[1].

Clover crystals

Using a high-speed camera attached to a microscope, the team captured imagery of ice forming on aluminium that had been covered with a hydrophobic, or water-repellent, coating. Water drops sprayed on the surface remained taut and spherical instead of spreading out.

The researchers triggered ice formation across the entire surface by spraying it with silver iodide nanoparticles, which acted as seeds for ice growth. As the ice developed, the crystals grew outwards and up from the nanoparticle, forming a symmetrical, six-leafed clover with only a single point of contact with the surface.

On hydrophilic, or absorbant, surfaces, water spread out quickly, and so did ice — forming a sunflower-shaped crystal in full contact with the surface.

And, when the team prepared a hybrid surface with both hydrophilic and hydrophobic parts, ice spreading on the hydrophilic side came to a halt at the boundary with the hydrophobic side.

The researchers also observed that the clover-like ice crystals growing away from a hydrophobic surface could be removed by wind more easily than crystals on a hydrophilic surface.

They suggest that this could be exploited to make surfaces such as car windscreens more resistant to icing by embedding nanoparticles inside them. “The key is to have these stable ice-nucleation sites,” says Jianjun Wang, a materials scientist at the Chinese Academy of Sciences Institute of Chemistry and a co-author of the paper.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22790

Comments

Comments

There are currently no comments.

Build on the outer space treaty

09 October 2017

Fifty years on, the agreement is being pushed to its limits by changing geopolitics, technology and commercial interests, warns Joan Johnson-Freese.

Reuters

The Long March-5 Y2 rocket takes off from Wenchang Satellite Launch Center in Wenchang, Hainan Province, China in July 2017.

On 10 October 1967, the Outer Space Treaty went into force. Agreed on during a golden age of cooperation between the then-dominant superpowers, the Soviet Union and the United States, the treaty deems space a domain to

be shared by all nations. It states: “The exploration and use of outer space, including the moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind.”

The treaty gave rise to a series of others that govern space today: the Rescue Agreement (1968), the Liability Convention (1972), the Registration Convention (1976) and the Moon Agreement (1984). Although the United States and Soviet Union declined to sign the Moon Agreement, to avoid having to share lunar resources and technologies, most issues were seemingly covered — liability for damage caused by space objects, the safety and rescue of spacecraft and astronauts, and the rules governing the exploitation of space resources and settling disputes.

A lot has changed since. Launch costs have plummeted — from US$20,000 to send one kilogram into orbit in the late twentieth and early twenty-first centuries to as little as $5,000 now. And more nations, people, businesses and organizations are seeking to establish themselves in space. 'NewSpace' entities — non-governmental actors, often with commercial interests and financed through personal wealth — are diversifying the space landscape, with motivations ranging from human settlement to economic development. SpaceX founder Elon Musk, for example, has said that becoming an interplanetary species is the only way for humanity to avoid an eventual extinction event on Earth, and that he wants to “die on Mars, just not on impact”. Planetary Resources, a US-based asteroid-mining company, states that its vision is to extend the economy into space.

Meanwhile, conventional interests of prestige, geostrategic influence and military missions in space have come to the fore. Access to space is considered a “vital national interest” by the United States[1], an area of revitalized national interest by Russia, and an aspiration of China, India[2] and a growing number of other countries. India and China's 'space race', crucial to each country's national prestige, is arguably fiercer than even the twentieth-century US–Soviet race.

In terms of military competition, the United States sees China's encroachment

on space as heightening the risk of a space war[3]. China's launch of a 'science mission' in May 2013 that nearly reached geosynchronous orbit (about 36,000 kilometres above Earth) caused quiet panic in the Pentagon and in US intelligence circles. The United States had considered that orbit a sanctuary, out of reach of foes, for some of its most strategically important spy satellites, such as those in the Keyhole series.

LISTEN

Earlier this year, the Nature Podcast marked half a century since the Outer Space Treaty was opened. Here, reporter Adam Levy looks at its relevance to our relationship with space today.

You may need a more recent browser or to install the latest version of the Adobe Flash Plugin.

Fifty years on, the Outer Space Treaty and its spin-offs are still appropriate. But interpretations of its provisions are, more than ever, being influenced by commercial interests and politics. Supplementary rules and norms are needed. In an era in which international cooperation on treaties is tenuous, informal agreements and resolutions must guide space-faring actors, protect the environment and prevent wars.

Competing interests

The United States is the largest player in terms of space spending, capabilities and assets in orbit. The government alone spends about $40 billion each year on space activities through the Department of Defense and NASA, with China and Russia next, at about $6 billion each. Japan, France, Germany, Italy, India, Canada and the United Kingdom together spend around $11 billion. As of 1 January, there were 1,459 satellites in orbit, of which 593 belong to the United States, 135 to Russia and 192 to China.

US strategic thinking will largely shape the direction of future global space policies. And the 2011 US National Security Space Strategy described the

official US view of space as “congested, contested, and competitive”. Active satellites and debris from old missions clutter the skies. More than 500,000 pieces of debris, ranging in size from a baseball to a school bus, are being tracked in Earth orbit. Millions of smaller but nonetheless dangerous pieces are not.

The number of countries, consortia and companies involved in space is growing. In 1959, when the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) was formed, there were 24 members. Today, there are 84. Although few countries can afford to develop their own launch capabilities, none wishes to be left out of the expanding information age facilitated by space technology. Data that were once available only to or through governments, such as remotely sensed data, are now available through private companies. Commercial communications satellites increasingly carry military traffic. In 2013, US troops operating in Africa began using a Chinese Apstar-7 satellite to carry data.

Almost 50 commercial and non-profit organizations are listed in the informal directory of the Space Frontier Foundation in Arlington, Virgina, which is committed to facilitating the human settlement of space. These companies are exploring ideas from satellite refuelling to mining asteroids for water and providing extraterrestrial human habitats, among other projects.

The main driver of change in US thinking about space security is the number of countries that are developing capabilities with potential military uses. Since the 1990–91 Gulf War, when the use of the Global Positioning System (GPS) allowed coalition troops and equipment to be moved across the desert without being detected, the US military has reaped the advantages of its advanced space-based technologies. Satellites are used for command, control, communications, reconnaissance and intelligence.

AL SEIB/Los Angeles Times/Getty

Sir Richard Branson presents Virgin Galactic SpaceShipTwo, part of the company's space-travel efforts.

Many countries desire similar capabilities and are developing a wide range of 'dual-use' space technologies, which are of value to both the civil and military sectors. China and Russia have their own versions of GPS. Missile-defence systems being built by the United States, China, Russia and India use targeting systems similar to those required for an anti-satellite weapon. Yet, so far, no country has crossed the Rubicon of explicitly and officially developing a space weapon.

Space security

Two debates have broken out among space-security analysts. First, are more rules needed for managing the space environment sustainably for all? Second, is space warfare inevitable or how should one deter it?

Space-resource ownership and traffic need to be managed. In 2015, the US Congress enacted legislation to protect the interests and investments of US companies, such as Planetary Resources, that seek to harvest the potentially vast mineral and water resources of the asteroid belt as early as the 2020s. The Spurring Private Aerospace Competitiveness and Entrepreneurship Act of 2015, or SPACE Act, entitles US citizens to “possess, own, transport, use and sell” extracted materials, subject to the obligations of the United States under the various treaties it has previously signed[4].

Some argue that this act violates Article II of the Outer Space Treaty. It states: “Outer space, including the moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means.” Even without making territorial claims, appropriation of resources could restrict access to resources for others and potentially encourage environmentally risky exploitation of the Moon, planets and asteroids.

Space-traffic management is the equivalent of air-traffic control. It is in no one's interest to have thousands of planes flying around unchecked, and so is the case with satellites. You need to know where they are and where they will be. Traffic-management systems must be able to notify parties of potential collisions and events, such as when a satellite 'goes rogue' and is beyond control, or suddenly comes back to life, as the LES-1 satellite did in 2016 after 46 years of silence.

Public organizations such as the US military's Joint Space Operations Center (JSpOC) and private bodies such as the Space Data Association are making progress on these issues, including coordination between the public and private sectors. The addition of a Commercial Integration Cell, where commercial operators are able to interact with their military counterparts, at JSpOC in 2015 was seen as a landmark in commercial–military cooperation. Nevertheless, some satellite owners, especially intelligence agencies, are reluctant to share too much information. That spurs the question of whether traffic rules for operation are needed, or even acceptable. Rules restrict actions, which neither companies nor governments welcome.

The United States has largely shunned multilateral rules for coordinating and limiting space operations beyond the provisions already in place through the

Outer Space Treaty. Three key arms-control provisions of the Outer Space Treaty reside in Article IV. First, parties should not place in orbit around Earth any objects carrying nuclear weapons or other weapons of mass destruction, install such weapons on celestial bodies or station them in outer space. Second, the Moon and other celestial bodies must be used exclusively for peaceful purposes. And third, it is forbidden to establish military bases, installations or fortifications, or to test any type of weapon or conduct military manoeuvres on celestial bodies.

However, military personnel's involvement in scientific research or other peaceful endeavours is not prohibited. Many early astronauts and cosmonauts were members of the military. Similarly permitted is the use of military equipment or facilities for peaceful purposes. But the dual-use nature of many space technologies means that civilian efforts often concurrently improve military capabilities. For example, developing tracking stations for human spaceflight missions also improves missile-tracking ability. The many definitions of peaceful — ranging from non-military to non-offensive — have allowed space to slip through the cracks of arms-control efforts since 1984.

Although weapons of mass destruction are banned in space, weapons in general are not. Releasing energy or kinetic force in space, through lasers and electromagnetic pulses, flak or collisions, can pollute the orbital environment for decades. From the 1962 US Starfish Prime test of nuclear weapons in space to the more recent anti-satellite weapons test carried out by China in 2007, the debris created can take decades to clear. The 2007 Chinese test generated some 3,000 pieces of space debris through some of the most populated low-Earth-orbit positions. As more satellites switch off and remnants break up, space becomes more difficult, expensive and dangerous to use. The International Space Station, for example, has had to manoeuvre several times to avoid colliding with space junk.

Since the contentious May 2013 Chinese launch, the United States has shifted its position on space warfare. Previously, its stance was strategic restraint, refraining from introducing offensive space capabilities in the hope of moderating the behaviour of friends and potential foes; since 2013 it has been preparing for war in space, whatever that might look like. US officials are

now actively exploring offensive and defensive space-based activities, with the only caveat being to avoid creating debris.

In 2008 and again in 2014, China and Russia submitted a joint proposal to the United Nations for a Treaty on Prevention of the Placement of Weapons in Outer Space and of the Threat or Use of Force Against Outer Space Objects, dubbed the PPWT. Each time, the United States rejected the proposal as “fundamentally flawed”. Among the reasons cited are that it is unverifiable — it is difficult to define a space weapon owing to the dual-use nature of most of the technology; it does not prohibit the development and stockpiling of space arms; and it does not consider ground-based space weapons, such as that demonstrated by the Chinese in 2007.

Rather than shift to aggressive policies, nations should instead show further restraint and cooperation.

The way forward

Space laws need to be updated for our time. Extending the Outer Space Treaty or writing a new one is unlikely to work, as US hesitancy to sign the PPWT shows. 'Soft law', driven by need, seems the best option for revising the rules for space operators.

Soft law comprises rules or guidelines that have legal significance but are not binding. It sets standards of conduct for agreeing parties, much like those that protect the environment and endangered species. 'Rules of the road' and best practices for space should be developed. These could take a similar form to the navigation guidelines set out in the 1972 Convention on International Regulations for Preventing Collisions at Sea, which govern when one vessel should give way to another, as well as other interactions.

Soft law works when it is in the interest of all parties to abide by it. If countries and companies want to maintain the space environment as a usable domain, then it is in their interests to accommodate a variety of operations. Space is more complex to manage than air, land or sea because of the distance, physics and technology involved. Just as in the cyber domain,

technology has preceded regulation, making it difficult to impose after the fact.

The first focus of an analogous set of space guidelines should be environmental protection and debris avoidance, areas that most spacefaring nations agree on. Governments are engaged in groups such as the 13-member Inter-Agency Space Debris Coordination Committee (IADC). The 84-member COPUOS works through two subsidiary bodies to develop best practices for sustaining the space environment, including mitigating debris. COPUOS working groups will begin meeting again in January 2018 to continue developing best practices, with new proposals to be presented to the committee in June 2018. Commercial perspectives should be included through national delegations and external observers.

Politicization of any guiding principles must be resisted, for example, by seeking consensus. The IADC Steering Committee releases information and materials to the public only when all parties agree, and it works through sub-committees operating from a technical rather than a political perspective. COPUOS discussions are progressing, albeit slowly.

Encouraging mutual understanding and building trust between nations is crucial to avoid conflict. It is impossible to verify exactly what is happening in space if a satellite ceases to function: has there been an intentional attack, an act of nature or a technical glitch? This problem of distance and the nature of dual-use technology create ripe circumstances for mishaps. Transparency and confidence-building measures developed in 2013 by the UN-sponsored Group of Governmental Experts are designed to help avoid misunderstanding and miscalculations and should be widely adopted.

A coordinated human spaceflight mission, in which different nations work together towards a common goal, could build the kind of space environment envisioned in the Outer Space Treaty. US–Russian cooperation on the International Space Station has shown that when terrestrial tensions get high, working together can maintain ties.

Coordination is easier than cooperation when there are technology-transfer concerns. Proposing a big mission and inviting other countries to join would give the US human spaceflight programme a direction, as well as serving

strategic purposes. A crewed fly-by mission of Venus and Mars, for example, has been on the table since the days of the Apollo missions and could yet be resurrected. An encouraging example is the 'space armada' of coordinated missions to study Halley's comet in 1986, involving the Soviet Union, European Space Agency and Japan.

With the expansion of national and commercial space activities, the Outer Space Treaty will be stretched to its limits. In that regard, it will be serving its intent — paving the way for the peaceful exploration and development of space.

Journal name:
Nature
Volume:
550,
Pages:
182–184
Date published:
(12 October 2017)
DOI:
doi:10.1038/550182a

Comments

Comments

There are currently no comments.

Navajo Nation reconsiders ban on genetic research

Tribal leaders are developing a policy for genetic research and data sharing, potentially ending a 15-year moratorium.

06 October 2017

Ricky Carioti/The Washington Post/Getty

Children play on the Navajo Nation's vast reservation in the southwestern United States.

When the Navajo Nation opens its first oncology centre next year in Tuba City, Arizona, clinicians there may be able to offer a service that has been banned on tribal lands for 15 years: analyzing the DNA of Navajo tribe

members to guide treatments and study the genetic roots of disease.

That's because the Navajo, the second-largest Native American group in the United States, are considering whether to lift their longstanding moratorium on genetic research. The tribal government banned DNA studies in 2002 to prevent the misuse of its members' genetic material. Although there is still some apprehension about the risk of allowing researchers access to Navajo DNA, the tribe's leaders increasingly see genetic research as a tool to improve medical care for the 174,000 residents of their sprawling reservation, which is roughly the size of Scotland.

As it now stands, Navajo people who live on the reservation must drive hundreds of kilometres to access specialized medical care off tribal lands, in large cities such as Phoenix, Arizona. “We spend millions of dollars outsourcing [care] for cancer and diabetes,” says Walter Phelps, a delegate to the Navajo Nation Council. As the tribe — a nation independent of the United States — tries to expand the health services it offers to its members, he says, “the moratorium could become a barrier when blood and tissue have to be collected”.

Phelps is working on the effort to create a policy by which the Navajo Nation would approve genetic-research projects and maintain control of DNA samples. The research-ethics board run by the tribal government’s department of health is working with tribal officials and traditional leaders and holding a series of public hearings to solicit opinions on the matter from tribe members. The group hopes to deliver a draft proposal by the end of October. Whatever the tribe decides could influence the hundreds of other Native American groups, who have tended to be wary of genetic studies because of a history of scientists conducting research without consent or adequate privacy controls.

The Navajo Nation's new oncology centre provides part of the impetus for revisiting the genetic-research ban. It will be the first such facility on Native American lands outside of Alaska. Allowing some genetic testing at the centre could help physicians to identify the most effective therapies for each patient, says Lynette Bonar, chief executive of the Tuba City Regional Health Care Corporation in Arizona, which will run the facility.

That would match the standard of care that many Navajo people with cancer

have received at medical facilities off the reservation. And creating a repository for such genetic material on Navajo land would enable research into the genetic and environmental factors underlying a broad range of diseases, not just cancer.

So far, Phelps says, the idea of allowing some genetic research has not drawn major opposition. Many tribe members consulted about lifting the moratorium have generally supported the idea after learning how physicians could use genetic data to diagnose disease and tailor treatments. And the number of Navajo tribe members who are geneticists and medical experts has grown since 2002, bolstering the tribe’s ability to evaluate proposed protocols and represent its own interests.

Fraught history

Still, some Navajo have lingering questions about whether the tribal government can protect the privacy of their genetic material and maintain control over its use. Such concerns helped to shape the current ban back in the early 2000s, when the Navajo Nation’s department of health conducted an outreach campaign about genetics and medical research. “In the absence of a research code and lack of expertise at the time, they decided it was not a good time to move forward with genetic research until they were able to develop a research policy,” says Nanibaa’ Garrison, a member of the Navajo Nation who is a geneticist and bioethicist at Seattle Children’s Hospital in Washington.

The tribe had reason to be cautious. “As Native Americans, we have a problem with trust because we have been violated so much,” says David Begay, a pharmaceutical scientist at the University of New Mexico in Albuquerque and a member of the Navajo Nation’s human-research review board. “In the past, our data have been misused."

Native Americans in the southwestern United States want to avoid repeating the experience of the region's Havasupai tribe. In 2004, the group sued Arizona State University in Tempe over alleged misuse of tribe members’ blood samples. The Havasupai said that the samples, which had been

collected for diabetes research, had later been used in studies of schizophrenia, migration and inbreeding without their consent. The university made a settlement with the tribe in 2010, paying US$700,000 and returning the blood samples.

Sara Hull, a bioethicist at the US National Human Genome Research Institute in Bethesda, Maryland, says the case helped to change how researchers engage with the people they study, by raising awareness of the complexities of dealing with vulnerable minority populations. For Native Americans, such thorny issues can include privacy. Science-funding agencies and journals often require researchers to put the genetic data they collect into public repositories, but the relatively small size of many Native American tribes can make it easy to identify individual members in a genetic data base. In recognition of this, the US National Institutes of Health sometimes works with researchers it funds to develop methods for sharing data on a minority group without compromising its privacy.

Garrison, who is helping the Navajo Nation develop its new policy, says that the plan is likely to include rules on what types of research will be allowed, who will have access to tribe members' genetic material and information, and who will provide oversight. It is also likely to require that the tribe maintain ownership of its members' DNA samples and data.

The policy that the Navajo Nation ultimately produces could serve as a template for other Native American groups considering how — or whether — to engage with genetic research, says Ellen Clayton, a bioethicist at Vanderbilt University in Nashville, Tennessee. She expects other tribes to watch the development of the Navajo Nation's new policy. "If they reach an agreement, I think it will be influential."

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22780

Comments

Commenting is currently unavailable.

The scientist who spots fake videos

Hany Farid discusses how to detect image manipulations — and the increasing sophistication of forgers.

06 October 2017

Eli Burakian/Dartmouth College

Hany Farid.

Hany Farid, a computer scientist at Dartmouth College in Hanover, New Hampshire, specialises in detecting manipulated images and videos. Farid, who provides his services to clients as varied as universities, media organizations, and law courts, says that image manipulation is becoming both more frequent and more sophisticated. He spoke to *Nature* about the arms race to stay ahead of the forgers.

Where do you start when trying to spot a fake image?

One simple but powerful technique is reverse image search. You give the image to a site such as Google Image Search or TinEye, and they show you all other instances of it. A project at Columbia University, in New York City, is taking this to the next level, and starting to find parts of images that have been repurposed from other images**.**

Generally, we think about which patterns, geometries, colours or structures are going to be disrupted when someone manipulates a photo. For example, when people add an object into a scene, we know that where they put the shadow is usually wrong. A viral video called Golden Eagle Snatches Kid from 2012 is one of my favourite examples. It took us only 15 minutes of analysis to show shadow inconsistencies: the eagle and baby were computer-generated.

What about if fake images make only slight tweaks?

There are a number of analyses we can do. In a colour picture, every pixel needs three values — corresponding to the amounts of red, green and blue at that point. But in most cameras, every pixel records just one colour, and the camera fills in the gaps by taking the average values of the pixels around it. This means that, for any given colour in an image, each missing pixel has a particular correlation with its neighbours, which will be destroyed if we add or airbrush something, and we can detect that**.**

Another technique is JPEG compression. Almost every image is stored in a JPEG file, which throws away some information to save on storage. There is a huge amount of variation in how each camera does that. If a JPEG is unpacked — opened in Photoshop — and then put back together, it is always repackaged slightly differently, and we can detect that. I wish you could just upload any image and we could tell you if it's real or not, but it's still a very

difficult process and requires expertise to understand different components.

Who uses your digital forensic services?

I do analysis for organisations such as the Associated Press, Reuters, and *The New York Times*. There are only a handful of academics worldwide who are specialists in this, so it doesn’t scale — and that means you can only do the analysis of really high-stakes images. But there are efforts under way to scale this up. Last year, the US Defense Advanced Research Projects Agency (DARPA) got into this game with a large project of which I’m part. Over the next five years they’re trying to create a system that will allow you to analyse hundreds of thousands of images a day. It’s a very ambitious programme.

I also do a lot of work in the courts. For example, here in the United States, child pornography is illegal, but computer-generated child pornography counts as 'protected speech' under the First Amendment. If someone’s arrested they might say that the offending image isn’t real, and I might have to prove that it is. I also get lots of e-mails from people about photo hoaxes — almost daily.

Do you apply your techniques to scientific papers?

I have worked on many cases of scientific misconduct, hired by universities conducting internal investigations. When I visited the US Office of Research Integrity recently, they asked me “how do we get our hands on automated tools?” The reality is we’re still not there. But creating something that uses some of the tools, such as clone detection, which looks to see whether parts of an image have been copied and pasted from elsewhere, would be possible as a semi-automated process looking at dozens, not millions, of images a day. It’s something my colleagues and I are thinking about, and it’s a small but not insignificant part of the DARPA programme.

How about fake videos?

Researchers are now able to splice together footage to create videos of famous people seeming to say things they never said — for instance, this video of President Obama. And they can create fake images or short videos using machine learning techniques: in particular, generative adversarial networks (GANs), which learn to generate fake content. These pit a network that generates fake content against a 'classifer' network that attempts to discriminate between real and fake content, so that the faking network rapidly improves.

I've seen the technology get good enough that I'm now very concerned. In 5 or 10 years, this is going to get really good. At some point we will reach a stage where we can generate realistic video, with audio, of a world leader, and that's going to be very disconcerting. I would say that the field of digital forensics is now behind in video.

How can you detect fake video?

JPEG compression has an analogous construct in video, which is a bit harder to detect because video uses a more sophisticated version. Another approach is to use machine learning for detection. But we're taking an approach similar to what we do with images — which is based on the observation that computer-generated content lacks the imperfections that are present in a recorded video. It's created in almost too perfect a world. So one of the things we look at is, are we not seeing the statistical and geometric patterns we'd expect to see in the physical world?

Another technique is based on some beautiful work by William Freeman and colleagues at the Massachusetts Institute of Technology in Cambridge, who showed how if you magnify really small changes in a video of a person, you can see subtle changes in the colours in their face that correspond to their pulse rate. We showed that you can use this to distinguish real people from computer-generated people.

Couldn’t machine learning algorithms learn to include these features?

Perhaps in principle. But in practice, these algorithms have limited time and training data, and there is little control over which features a neural network will pick up on to discriminate between real and fake videos. A GAN is only trying to fool the classifier it’s trained on. That’s no guarantee that it will learn all aspects of what makes an image or video real or fake, or that it will fool another classifier.

My adversary will have to implement all the forensic techniques that I use, so that the neural network can learn to circumvent these analyses: for example, by adding a pulse in. In that way, I’ve made their job a little harder.

It’s an arms race. As we are developing faster, folks are creating more sophisticated technology to augment audio, images and video. The way this is going to end is that you take the ability to create a perfect fake out of the hands of the amateur. You make it harder, so it takes more time and skill, and there’s a greater risk of getting caught.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22784

Comments

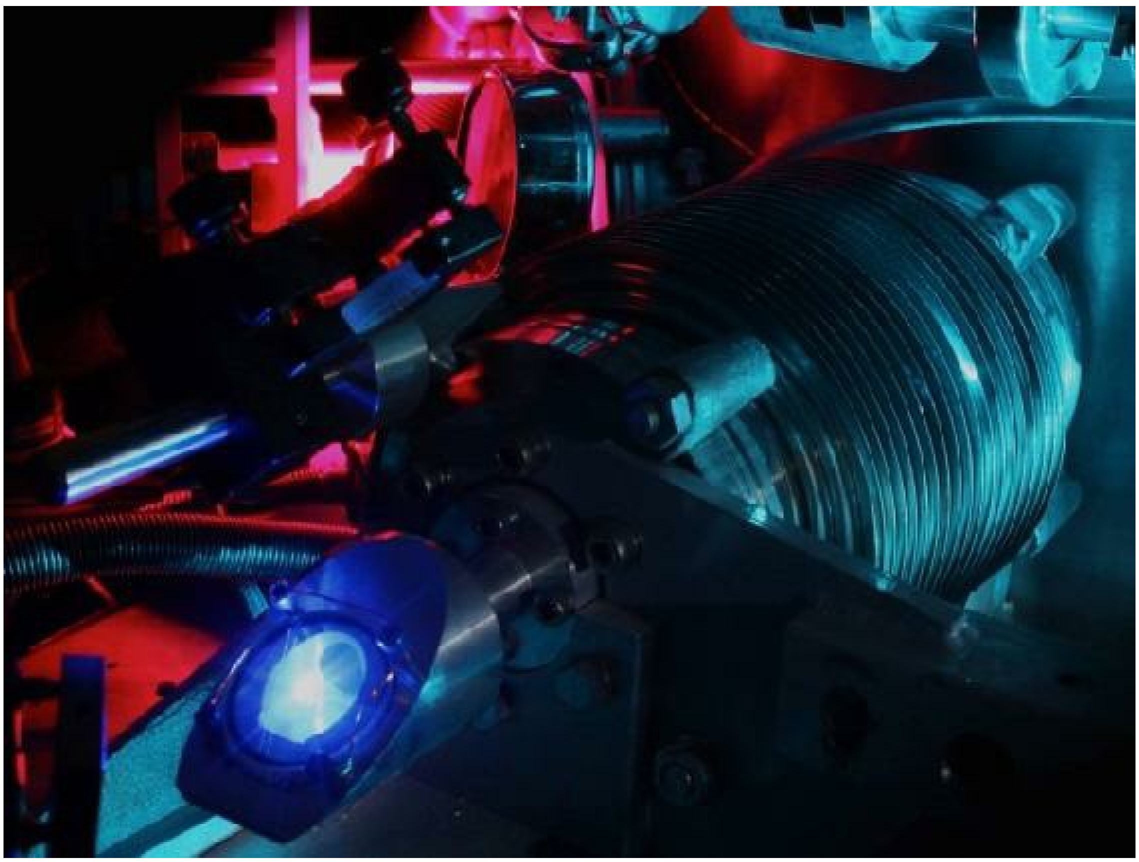
Comments

There are currently no comments.

Proton-size puzzle deepens

Measurement in ordinary hydrogen agrees with a surprising 2010 result on the element's exotic cousin — but gives a smaller value than virtually every other experiment.

05 October 2017



Axel Beyer

Researchers shone lasers at hydrogen atoms in a vacuum chamber to pinpoint the size of the protons inside.

The proton might truly be smaller than was thought. Experiments on an exotic form of hydrogen first found[1] a puzzling discrepancy with the

accepted size in 2010. Now, evidence from a German and Russian team points to a smaller value for the size of the proton with ordinary hydrogen, too.

The results, which appeared on 5 October in *Science*[2], could be the first step towards resolving a puzzle that has made physicists doubt their most precise measurements, and even their most cherished theories.

Still, “before any resolution, this new value has to be confirmed”, says Jan Bernauer, a physicist at the Massachusetts Institute of Technology in Cambridge. If other labs confirm it, he adds, “then we can find why the old experiments were wrong, hopefully”.

Method mix-up

For decades, physicists have estimated the size of the proton using one of two main techniques. Atomic physicists use spectroscopy to measure the energy levels of electrons orbiting an atomic nucleus — consisting of either the single proton in a hydrogen atom, or a bigger nucleus. The size of the nucleus affects those energies because electrons spend some time moving through the nucleus as they orbit it.

Meanwhile, nuclear physicists have used a similar technique to the one that enabled Ernest Rutherford to discover atomic nuclei in the first place. They hit the atoms with beams of fast-moving electrons and measure how the electrons bounce off.

As their precision improved, both methods roughly came to agree on a radius of about 0.8768 femtometres (millionths of a millionth of a millimetre).

But in 2010, a novel kind of experiment completed at the Paul Scherrer Institute in Villigen, Switzerland, disrupted the consensus. After a decade of unsuccessful attempts, a multinational collaboration led by Randolf Pohl, then at the Max Planck Institute of Quantum Optics (MPQ) in Garching, Germany, measured energy transitions not in ordinary hydrogen, but in lab-made ‘muonic’ hydrogen. These are atoms in which the electron has been replaced by a muon — a particle similar to an electron in most of its

properties, but 200 times more massive. The heavier particle spends more time inside the nucleus, which means that the proton’s size has a much larger effect on the muon’s energies — which, in turn, should lead to a much more precise estimate of the proton’s radius.

Pohl’s team found the proton to be 4% smaller than the accepted value. Some researchers speculated that perhaps some previously unknown physics could make muons act differently than electrons. This would have required a revision of the standard model of particle physics, which predicts that muons and electrons should be identical in every way except for their masses — and might have pointed to the existence of yet-to-be-discovered elementary particles.

Exciting technique

In the latest paper[2], Pohl, now at the Johannes Gutenberg University in Mainz, Germany, and his collaborators tickled hydrogen atoms — containing ordinary electrons — with two different lasers. The first one sent the atoms’ electrons into an excited state, and the second one put them into a higher-energy excitation. The team then detected the photons that the atoms released as their electrons fell back into lower-energy excitation states.

The team combined its data with an earlier, high-precision measurement to calculate the Rydberg constant, which expresses the energy that it takes to rip the electron off the hydrogen atom. Standard theory then enabled the researchers to calculate the radius of the proton from this constant. The value they found was consistent with the muonic-hydrogen measurement, and 5% smaller than the 'official' proton radius.

To ensure that they eliminated any spurious experimental effects, the team spent three years analysing its data, says Lothar Maisenbacher, a co-author of the paper and an atomic physicist at the MPQ.

Bernauer, who works on the electron–proton scattering technique, is impressed. “It’s a great experiment,” he says. “I think they really advanced their field with this.”

The care that they took is “very impressive”, and makes their measurement more reliable than many others, says Krzysztof Pachucki, a theoretical physicist at the University of Warsaw who is on the task group of the Committee on Data for Science and Technology (CODATA).

CODATA, the international agency that publishes the best-known values of the fundamental constants, is taking notice of the Mainz experiment. “We will take this result very seriously,” says Pachucki. The committee is due to revise the ‘official’ handbook of universal constants of nature next year. Because of this experiment, CODATA will "most probably” change its values for the proton radius and Rydberg constant, he says.

More evidence needed

But the German–Russian group is not quite ready to claim that the puzzle has been solved, Maisenbacher says. “We have not identified any conclusive reason why the other measurements should not be correct themselves,” he says. “We would like to see more experiments from other people.”

A number of teams around the world are doing just that. Bernauer is interested, for example, in the results of spectroscopy experiments being done at York University in Toronto, Canada. If their measurement is also small, “then I would start to believe that the old data has a problem”, Bernauer says. But that would still leave open the matter of the electron–proton scattering results.

In those experiments, researchers have conventionally used electrons that have a range of different energies. Estimating the size of the proton required extrapolating all the way to an ideal situation, in which electrons had zero energy.

Ashot Gasparian, a particle and nuclear physicist at North Carolina A&T; State University in Greensboro and his team have recently conducted an experiment at the Thomas Jefferson National Accelerator Facility in Newport News, Virginia. They injected cold hydrogen gas directly into their electron accelerator, rather than bombarding liquid hydrogen kept in a plastic box, as

was previously done. This technique enabled them to remove some experimental uncertainties and also to use electrons with lower energies than before. In principle, this could reveal whether and where the previous extrapolations went wrong. They are now analysing their data and hope to have results next year. “The ball is in our court,” says Gasparian.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22760

Comments

1 comment

1. *Raji Heyrovska* • 2017-10-10 11:52 AM
   I have just posted a simple relation connecting the CODATA 2014 proton radius with Bohr radius and fine structure constant at: http://viXra.org/abs/1710.0105 (abstract) and http://vixra.org/pdf/1710.0105v1.pdf (full text).

Controversial pesticides found in honey samples from six continents

Neonicotinoids are at the centre of a long-running debate about whether they harm bees.

05 October 2017

Fergus Gill/2020VISION/naturepl.com

Honey is a major source of food for honey bees.

Honey bees on every continent except Antarctica face significant exposure to neonicotinoid pesticides — chemicals that some studies suggest harm bees' health. Researchers who tested honey from nearly 200 sites worldwide found that 75% of their samples contained some level of the pesticides, according to

a report published on 6 October in *Science*[1].

The study is the first attempt to quantify the presence of neonicotinoids in honey on a global scale using standardized methods. Nearly half of the samples tested contained levels of neonicotinoids at least as high as those thought, on the basis of previous research, to impair bees' brain function and slow the growth of their colonies. The study also found that 45% of the samples contained two or more types of neonicotinoid.

"It's not a surprise, in a sense, that we find neonicotinoids in honey. Anybody could have guessed that," says lead author Edward Mitchell, a biologist at the University of Neuchâtel in Switzerland. "What's original is using the same protocol. We now have a worldwide map of the situation."

The research provides additional context for the long-running debate over whether and how neonicotinoids affect bees' health. Some studies have suggested that exposure to neonicotinoids lowers honey bees' nutritional status[2] and impairs their immunity[3]. And in June, a paper published in *Science* reported that neonicotinoids lower honey bees' chances of survival during the winter, and threaten the queen in particular, which can affect reproduction[4].

To assess the scale of honey bees' exposure to neonicotinoids around the world, the authors of the new study collected honey from 198 sites on six continents through a citizen-science project. Then they tested those samples to determine the concentrations of five of the most commonly used neonicotinoids. Honey collected in North America had the highest proportion of samples containing at least one neonicotinoid, at 86%, with Asia (80%) and Europe (79%) close behind.

The extent of the contamination, even in honey from remote places — including islands in the middle of the Pacific Ocean and off the coast of West Africa — is surprising, says Amro Zayed, an insect researcher at York University in Toronto, Canada. The findings suggest that bees the world over are exposed to neonicotinoids constantly over generations, he says, which is worrying because the insects depend so heavily on honey for food. "It's one thing to go out to a restaurant and get a bad meal, but if you have your fridge

at home contaminated with insecticides, that’s an entirely different method of exposure,” Zayed says.

Others say that the widespread presence of neonicotinoids in honey is to be expected, given how commonly the chemicals are used in staple crops such as canola and wheat, as well as in home gardens. “Yes, there is going to be long-term exposure, potentially, to neonics, but that doesn’t say anything about the risk,” says Chris Cutler, an entomologist at Dalhousie University in Halifax, Canada. “Just because it’s there doesn’t necessarily mean there’s a problem.”

Much of the debate about neocotinoids has focused on just this question: how problematic are the pesticides when bees are exposed to them at low levels, but over a long period of time? “One of the issues around assessing the impacts on bees has been the discussion of what a field-relevant level of exposure actually is,” says Nigel Raine, a pollinator-health researcher at the University of Guelph in Canada. “This contributes toward that discussion substantially.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22762

Comments

Comments

There are currently no comments.

Antikythera shipwreck yields statue pieces and mystery bronze disc

Archaeologists think that at least seven life-sized sculptures are hidden nearby.

04 October 2017

Brett Seymour/EUA/ARGO 2017

Archaeologist Brendan Foley discovers a bronze disc, at first thought to be part of the Antikythera mechanism.

Marine archaeologists investigating the ancient shipwreck that yielded the Antikythera mechanism — a complex, bronze, geared device that predicted eclipses and showed the movements of the Sun, Moon and planets in the sky

— have recovered a wealth of treasures, including bronze and marble statue pieces, a sarcophagus lid and a mysterious bronze disc decorated with a bull. The artefacts were trapped under boulders in a previously unexplored part of the site near the island of Antikythera, Greece, and the researchers think that large parts of at least seven statues are still buried nearby.

The discoveries are “extremely exciting”, says Kenneth Lapatin, curator of antiquities at the J. Paul Getty Museum in Los Angeles, California. Only a handful of bronze statues survive from the ancient world, and they have almost invariably been treated and altered by previous conservators, undergoing processes that destroyed much of the information scientists might have gleaned from them. “Technology has improved so much,” says Lapatin. “We can learn from these untreated finds.”

The first-century-BC cargo ship, discovered in 1900 by sponge divers, is famous for yielding a heavily encrusted and corroded geared device that used to predict eclipses and chart the skies. The sponge divers also retrieved many other priceless items, including luxury glassware, jewellery and a two-metre-tall bronze statue, dating from the fourth century BC, nicknamed the ‘Antikythera youth’.

Statue search

Courtesy of ARGO 2017

The bronze arm was one of the most significant recent findings.

The recovery of multiple ‘orphan’ statue pieces — limbs without matching heads or bodies, for example — suggested that several statues still lie buried here. So an international team of archaeologists and divers, co-led by Brendan Foley of the University of Lund in Sweden and Theotokis Theodoulou of the Greek Ephorate of Underwater Antiquities in Athens, is now re-excavating the 50-metre-deep wreck site to look for them.

The team has made a stream of discoveries since work began in 2014, including wine jars, giant anchors, gold jewellery and a human skeleton, which is now being analysed for DNA. But the statues have remained hidden until now.

On 4 October**,** the team announced that during a 16-day dive season the previous month, they found several major statue pieces, including two marble feet attached to a plinth, part of a bronze robe or toga, and a bronze male arm, with two fingers missing but otherwise beautifully preserved. A slim build and “turning hand” gesture suggest that the arm may belong to a philosopher,

says Theodoulou.

In 1900–01, the sponge divers salvaged orphan limbs from a minimum of six bronze statues. The newly discovered arm pushes that total to at least seven, says Theodoulou. The team is particularly excited because the statue pieces were found in an area undisturbed by any previous excavations, buried beneath large boulders dislodged from Antikythera’s steep cliffs over the course of 2,000 years by periodic earthquakes. “We think this means that everything is down there still,” says Foley.

The discovery of seven bronze statues, if they could be recovered, would significantly boost the world’s total from this time period, which stands not much greater than 50, Lapatin estimates. Few of those are complete. And although these ancient figures might look beautiful, they are hard to study because the aggressive treatments by generations of conservators have altered and damaged the bronze.

Technological advances

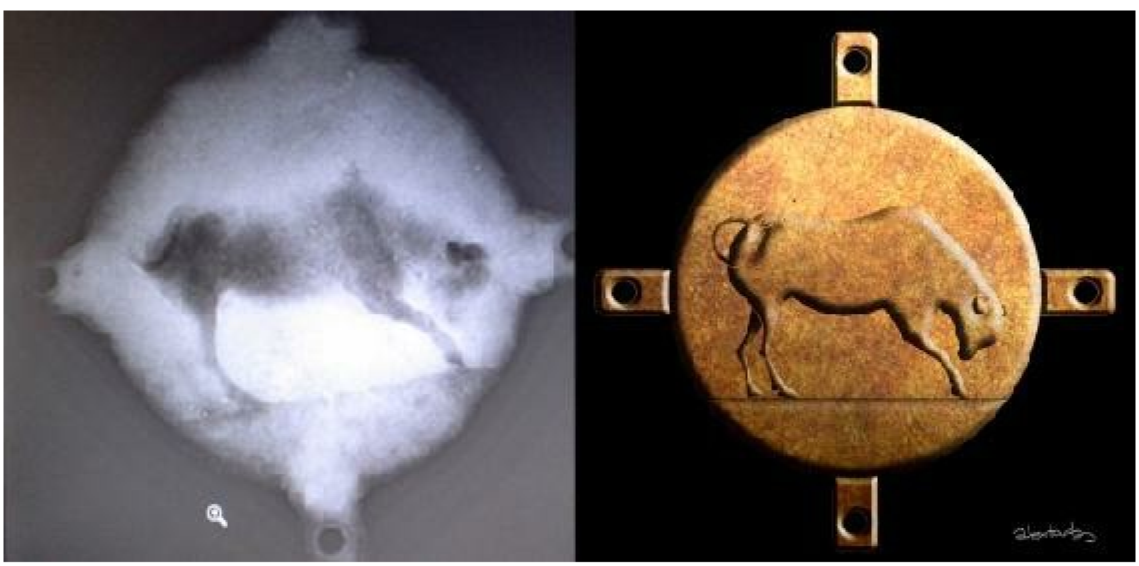
Fresh, untreated finds such as those from Antikythera will give researchers the opportunity to use modern techniques to study a significant aspect of ancient Greek life — for example, by looking at casting methods, which precise alloys were used and whether the statues were made for export or had been previously displayed. Meanwhile, any heads found might enable researchers to identify the people depicted, and to compare their likeness with any existing portraits, for example, marble statues or images etched on coins.

Brett Seymour/EUA/ARGO 2017

The bronze disc, which researchers at first thought might contain some of the lost gears of the Antikythera mechanism.

Foley and Theodoulou’s team also recovered an intriguing bronze disc or wheel, about eight centimetres across, attached to four metal arms with holes for pins. A layer of hardened sediment hides its internal structure, but it superficially resembles the Antikythera mechanism, and researchers had initially hoped that it might be part of that ancient device: perhaps the gearing that calculated the positions of the planets, which is missing from the find.

But preliminary X-ray imaging conducted in an Athens hospital on 25 September revealed a surprise: instead of gear wheels, the image of a bull appeared. The object might have been a decorative element, says Lapatin, perhaps attached to a box or a statue’s shield, or even — because of its sturdy construction — to the doomed ship. More-detailed radiography is planned for the next few weeks.



Left: EUA. Right: Alexander Tourtas.

The X-rays of the bronze disc, and artist's reconstruction of the bull.

Other discoveries this season include a sarcophagus lid made from fine, red marble, more human remains and wooden ship planks and frames that the researchers hope will reveal information about the vessel’s size and shape.

The team plans to return to Antikythera in May 2018, to break up the boulders and excavate beneath. “It’s going to be a major operation,” says Foley. “But we think it will be spectacular.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22735

Comments

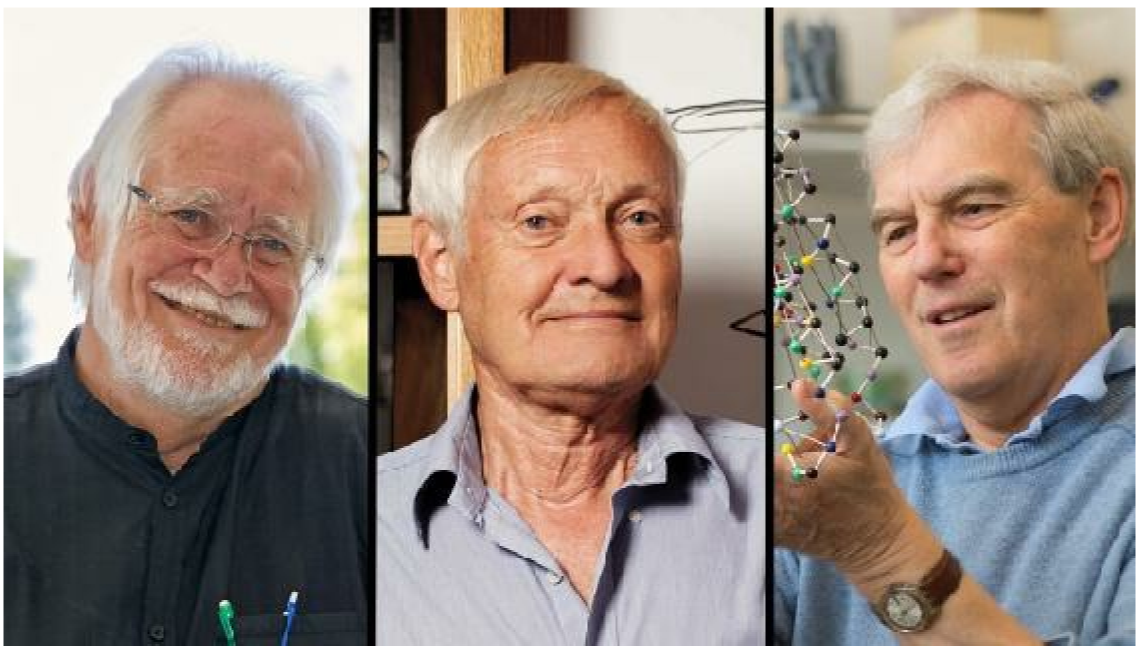
Commenting is currently unavailable.

Cryo-electron microscopy wins chemistry Nobel

Jacques Dubochet, Joachim Frank and Richard Henderson share the prize for developing a technique to image biomolecules.

04 October 2017 Corrected:

1. 05 October 2017



Left: Marietta Schupp/EMBL. Centre: Jorg Meyer. Right: LMB-MRC.

From left: Jacques Dubochet, Joachim Frank and Richard Henderson helped to develop cryo-electron microscopy.

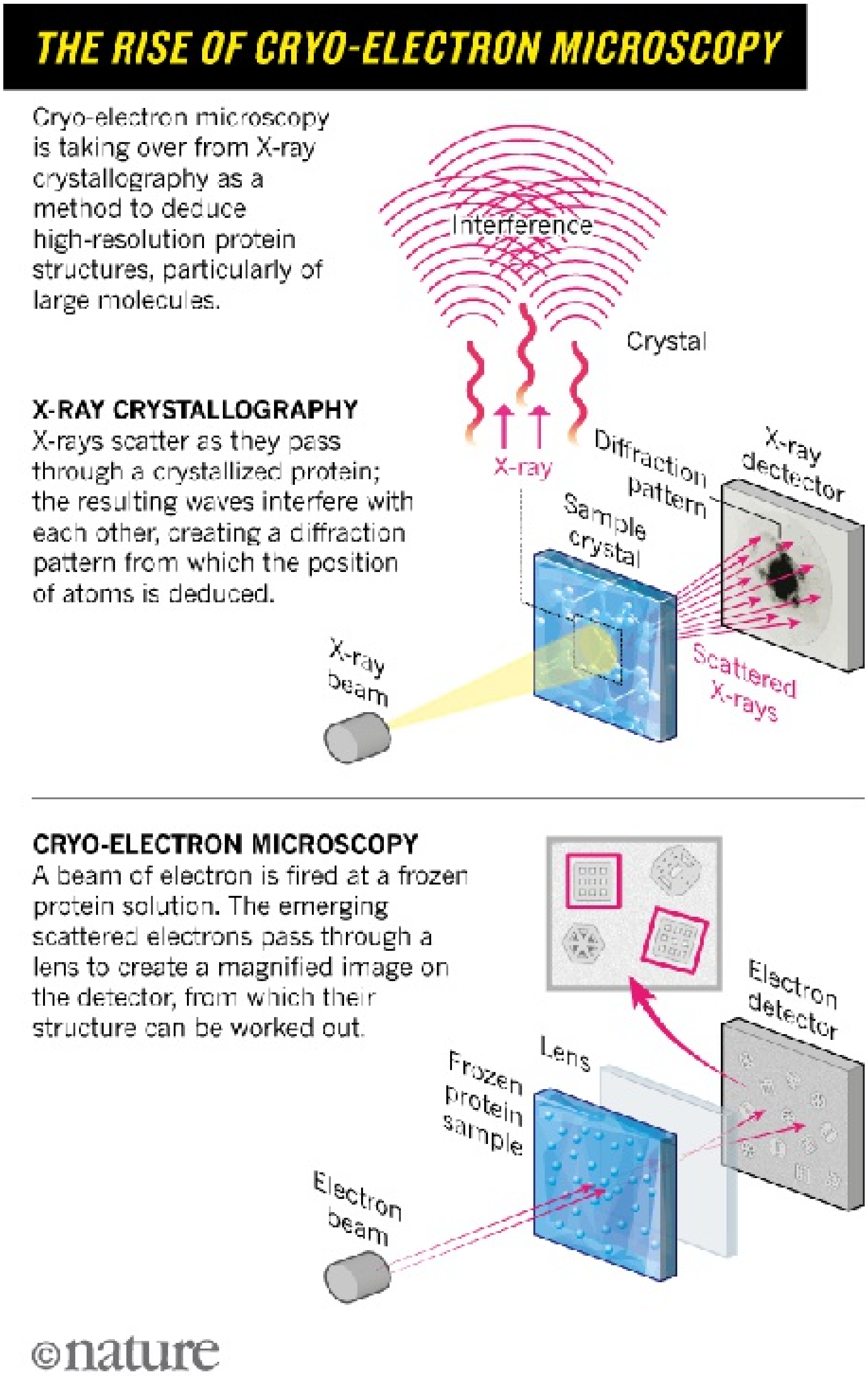
The 2017 Nobel Prize in Chemistry has been awarded for work that helps researchers see what biomolecules look like.

Jacques Dubochet, Joachim Frank and Richard Henderson were awarded the prize on 4 October for their work in developing cryo-electron microscopy (cryo-EM), a technique that fires beams of electrons at proteins that have been frozen in solution, to deduce the biomolecules' structure.

For decades, biologists have used X-ray crystallography — blasting X-rays at crystallized proteins — to image biomolecular structures. But labs are now racing to adopt the cryo-EM method, because it can take pictures of proteins that can't easily be formed into large crystals. The tool has "moved biochemistry into a new era", says the Royal Swedish Academy of Sciences, which awards the prize.

Imaging solutions

In the 1970s, Henderson, a molecular biologist who works at the MRC Laboratory of Molecular Biology in Cambridge, UK, and his colleague Nigel Unwin were trying to determine the shape of a protein called bacteriorhodopsin. The molecule, which uses light energy to move protons across a cell membrane, proved unsuitable for crystallography. So the researchers turned to electron microscopy (see 'The rise of cryo-electron microscopy') and, in 1975, produced their first 3D model of the protein[1].



During the same decade, Frank, a biophysicist who is now based at Columbia University in New York City, and his colleagues developed image-processing software to make sense of the fuzzy pictures that are produced when an

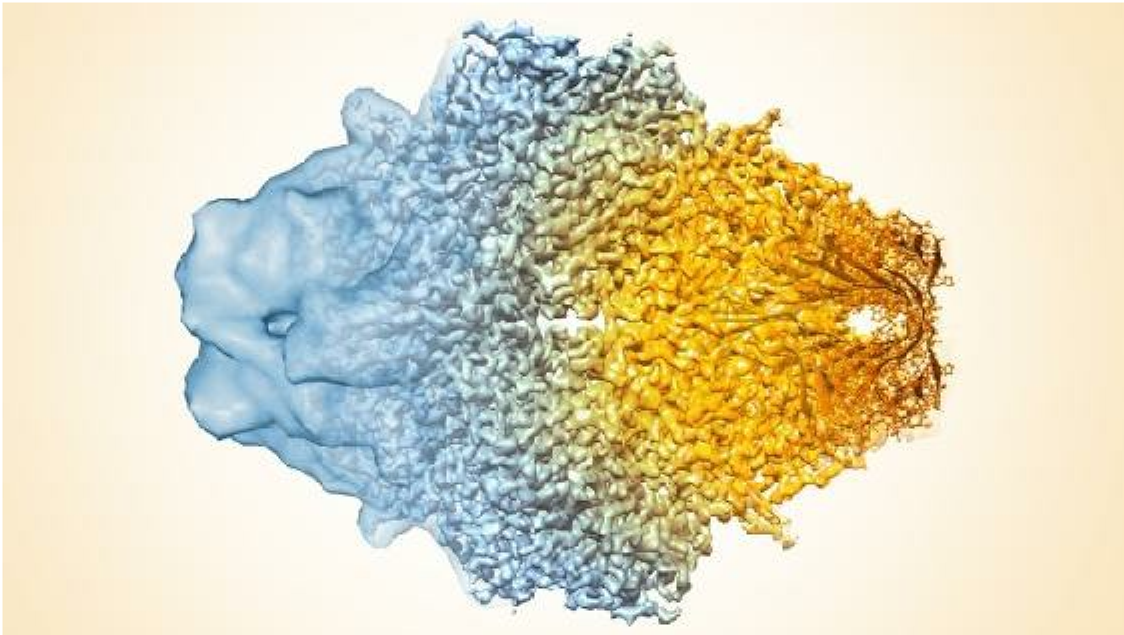
electron microscope is aimed at a protein, and to convert these two-dimensional blurs into 3D molecular structures.

In the early 1980s, a team led by Dubochet, who is now an honorary professor at the University of Lausanne in Switzerland, worked out how to prevent water-soluble biomolecules from drying out in the vacuum of an electron microscope, allowing the molecules to retain their natural shape during imaging. His team found a way to flash-freeze solutions of proteins using liquid ethane, keeping the molecules relatively still when they were pummelled with electrons. This allowed researchers to use electron microscopes to determine the structures of proteins at much higher resolution than before.

These and other improvements enabled Henderson to create the first atomic-resolution images of a protein using cryo-EM in 1990[2].

Resolution revolution

Although the research recognized by the Nobel Committee was conducted in the 1970s and 1980s, it laid the groundwork for what many scientists have dubbed a revolution in recent years. Subsequent improvements in the sensitivity of electron microscopes and in software used to transform their images into 3D structures have caused many labs to favour the technique over X-ray crystallography.



V. Falconieri, S. Subramaniam, NCI-NIH

Cryo-electron microscopy of proteins such as this β-galaxtosidase enzyme has progressed from the low-resolution density map on the left to the atomic coordinates on the right.

Frank told journalists gathered at the Royal Swedish Academy of Sciences in Stockholm that technological innovations can have a larger impact than discoveries. “Cryo-electron microscopy is about to completely transform structural biology,” he said. He added that the ribosome — the machinery that makes proteins inside cells — was the “coolest” molecule he had imaged.

Venki Ramakrishnan, a structural biologist at the Laboratory of Molecular Biology who shared the 2009 Nobel Prize in Chemistry for his work to reveal the structure of the ribosome using X-ray crystallography, is one of many converts to cryo-EM. After learning about the award from a *Nature* journalist, he said: “Oh, fantastic! Those are exactly the people I thought should win the Nobel prize.”

Benoît Zuber, a structural biologist at the University of Bern in Switzerland, who did his PhD with Dubochet, says his mentor was always confident that

cryo-EM would become a vital tool, even as others derided the field as “blobology” for the low-resolution molecular images it captured.“He had a vision and he was convinced about it, even when everybody was telling him that this was just a dream," says Zuber.

“It’s a great recognition for all the developments that have happened in the past. It’s fantastic,” says Sjors Scheres, a cryo-EM specialist who works alongside Henderson. The two were returning from a conference in Leicester, UK, yesterday, when Scheres asked Henderson whether he would keep his phone close in case the Nobel Committee called. “He said, ‘I think they should give it to Jacques Dubochet.’ He would never say that he should get one,” Scheres says. “It’s a well-deserved trio.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22738

Corrections

Corrected:

This story originally indicated that bacteriorhodopsin moves proteins across the cell membrane. In fact, it moves protons.

Comments

Commenting is currently unavailable.

Crash in sea-turtle births stumps ecologists

Leading suspect — climate change — doesn't fully explain what is happening to leatherback turtles in the US Virgin Islands.

04 October 2017

Jurgen Freund/NPL/Getty

While buried in the sand, sea-turtle eggs are very sensitive to several environmental conditions that affect whether they hatch or not.

The mystery behind a dramatic fall in the number of leatherback sea-turtle (*Dermochelys coriacea*) hatchlings in the US Virgin Islands remains unsolved, despite the latest efforts of researchers. Rising temperatures and

changes in rainfall patterns — the top two suspects — don't seem to be connected to the decline, according to a study published on 4 October[1]. The finding contradicts previous work, leaving researchers scratching their heads over what could be happening.

The latest study focused on a nesting beach in the Sandy Point National Wildlife Refuge on St Croix island in the Caribbean Sea. The researchers found that about 74% of the leatherback sea-turtle eggs laid there in 1990 hatched, but that rate had plummeted to 55% by 2010.

The study analysed detailed temperature and precipitation data at these nests over the 20 years, and found no corresponding trend in either climate-change factor that could fully account for the decline. The researchers reported their results in *Royal Society Open Science*.

Increases in temperature and more-erratic precipitation patterns do affect the nests, but they aren't the sole reason for the hatching declines, says Anthony Rafferty, a marine biologist at Monash University in Melbourne, Australia, and a study co-author.

This trend is especially confusing in light of the increase in the adult sea-turtle population. "The number of nesting females and the population size has been trending upwards at this site," Rafferty says. "But there's been a decrease in hatching success that we are worried about." That could have negative effects on leatherback populations within one or two decades, he says, when those hatchlings come of age.

Conundrum continues

"It's hard to say how much of that is happening because of climate change," says Vincent Saba, a climate scientist at the US National Oceanic and Atmospheric Administration in Princeton, New Jersey. He co-authored a 2015 study[2] that did find a relationship between air temperature, precipitation patterns and declines in leatherback hatching success. That study examined data from 1982 to 2010 and looked at seasonal rainfall, unlike the latest paper, which analysed rainfall only during the nesting season. The study predicted that, by 2100, Sandy Point would have the most unfavourable climate conditions out of all leatherback nesting sites around the world.

“I like the study. They looked at the effect of climate in finer detail,” says Pilar Santidrián Tomillo, a marine biologist and science director of the Leatherback Trust, based in Playa Grande, Costa Rica. She was a co-author on the 2015 study, and appreciates the fuller picture of what could be happening at Sandy Point that the most recent study has provided.

Sea-turtle eggs are exquisitely sensitive to climate because heat, carbon dioxide, oxygen and water all pass freely through their permeable shells. The surrounding temperatures determine the sex of the hatchlings: warmer conditions produce more females, whereas cooler conditions yield males. And rainfall can influence hatchling development and their ability to escape the nest, says Rafferty. Too little rain might mean that the sand is too dry for the young turtles to climb out of it; too much rain during the early stages of egg development might lead to a reduction in oxygen supplies to the growing embryo.

“I think changes in precipitation levels or patterns could explain the decline in hatching success partially, but there could be other reasons, too, like decline in fertility or increase in pollutants, for example,” Santidrián Tomillo says.

Rafferty, who specializes in embryo research, now plans to look at how the age and health of a female sea turtle might affect her fertility, or where she lays her eggs.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22748

Comments

Comments

There are currently no comments.

| 章节菜单 | 主菜单 |

Scientists plead with Brazilian government to restore funding

If officials don't act soon, research institutions could start shutting down next year.

04 October 2017

Leonardo Benassatto/Reuters

Protests against Brazilian president Michel Temer's policies have consumed the country amid severe budget cuts this year.

Anxiety is growing in Brazil over the country’s collapsing research budgets. President Michel Temer had slashed funding for science by 44% in March and has proposed additional decreases for 2018 — even as some science

institutes run out of money for basic needs, such as paying electricity bills. The 2017 science budget, at 3.2 billion reais (US$1 billion), is the lowest the country has seen in at least 12 years.

On 3 October, the government announced that it will release 440 million reais to science agencies to help keep them afloat until the end of this year. But the money is only about 20% of what's needed, said the Brazilian Society for the Advancement of Science in a statement.

Researchers continue to voice their alarm, with a march scheduled for 8 October in São Paulo — the third such demonstration this year protesting the funding shortfalls. And on 10 October, a public awareness campaign called *Conhecimento Sem Cortes* (Knowledge without cuts) will deliver a petition to Congress with more than 80,000 signatures protesting both the cuts and a 2016 constitutional amendment that put a 20-year cap on federal spending.

Last week, 23 Nobel laureates and nine of the country's scientific societies warned Temer that continued budget reductions will seriously jeopardize Brazil's future. They say that the ongoing uncertainty over science funding risks dismantling research groups and prompting a brain drain.

They all hope to influence a revision of the 2018 budget proposal — first submitted to Congress by the executive branch in August — which included a 16% cut to the Ministry of Science, Technology, Innovations and Communications (MCTIC). The Temer administration has promised to release a revised budget in the coming weeks.

On life support

If the 16% cut remains, it would leave a total of about 2.7 billion reais for 22 federal laboratories and research institutes, 73 National Science and Technology Institutes and Brazil's major science funding agencies, the National Council for Scientific and Technological Development (CNPq) and the Funding Authority for Studies and Projects. "This means institutions will shut down by August next year", says physicist Luiz Davidovich, president of the Brazilian Academy of Sciences.

Davidovich's estimate is based on what has happened this year. MCTIC started 2017 at 5 billion reais, its smallest budget in a decade when adjusted for inflation. In March, after the 44% cut, the ministry was left with 2.8 billion reais, not including money for special projects such as the Sirius synchrotron. The budget rises to 3.2 billion reais with those projects. As a result, institutions began running out of cash in September.

“We don’t have money for electricity bills or for buying radiopharmaceuticals”, says José Augusto Perrotta at the federal Institute of Nuclear and Energy Research. Perrotta is the coordinator of the multi-purpose reactor, a 1.6-billion-reais project that is facing delays because of a lack of funding. This year, the reactor was supposed to receive 106 million reais but got nothing.

The Brazilian Center for Physics Research isn’t doing much better. “We‘ll be able to see it through December without layoffs, but next year I’ll have to cancel all equipment maintenance contracts”, says Ronald Shellard, the centre’s director. The institution’s proposed 2018 budget is 7.8 million reais — well below the 12.7 million reais Shellard says it needs to survive.

Brazil’s 1.6-billion-reais Sirius synchrotron is also in jeopardy. The 2018 budget proposal doesn’t provide funding for the facility’s construction, which is slated for completion in mid-2018.

The build is still on schedule after science minister Gilberto Kassab unfroze 85 million reais this month, says Antonio José Roque da Silva, director of the Brazilian Synchrotron Light Laboratory and head of the project. However, the synchrotron will need an additional 331 million reais to complete construction. “I pay contractors with cash, not with promises,” says Roque.

A skeleton crew

Also at risk is Brazil’s collaboration with CERN, Europe’s particle-physics laboratory near Geneva in Switzerland. The 2017 budget cuts eliminated Brazil’s financial support for CERN, and the proposed 2018 budget doesn’t resume those payments.

The biggest threat, however, is to CNPq, Brazil’s main source of federal research grants. The agency hasn’t paid out the grants it green-lit last year, didn’t launch its annual call for project proposals this year and is 400 million reais short of what it needs to honour its commitments in 2017. If the situation isn’t sorted, Marcelo Morales, a CNPq executive director, fears a repeat of 2016, when scholarships for undergraduates and scientists abroad were suspended.

The continuing funding crisis is already driving away students and young scientists. Sergio Ferreira, a neuroscientist at the Federal University of Rio de Janeiro, runs a lab whose budget has gone downhill since 2014. It's now an average of 85,000 reais — one-tenth of what it used to be. This year, five of Ferreira’s graduate students had to spend six months abroad working with his collaborators because he couldn’t afford the materials the students needed for their research.

“In my group I have several people who have left or are about to leave for good, with no plans to come back”, Ferreira says. “I can’t keep a skeleton colony of students.”

Journal name:
    Nature
DOI:
    doi:10.1038/nature.2017.22757

Comments

Comments

There are currently no comments.

Supercomputer redesign of aeroplane wing mirrors bird anatomy

Bird-bone structures emerge from an evolution-like algorithm.

04 October 2017

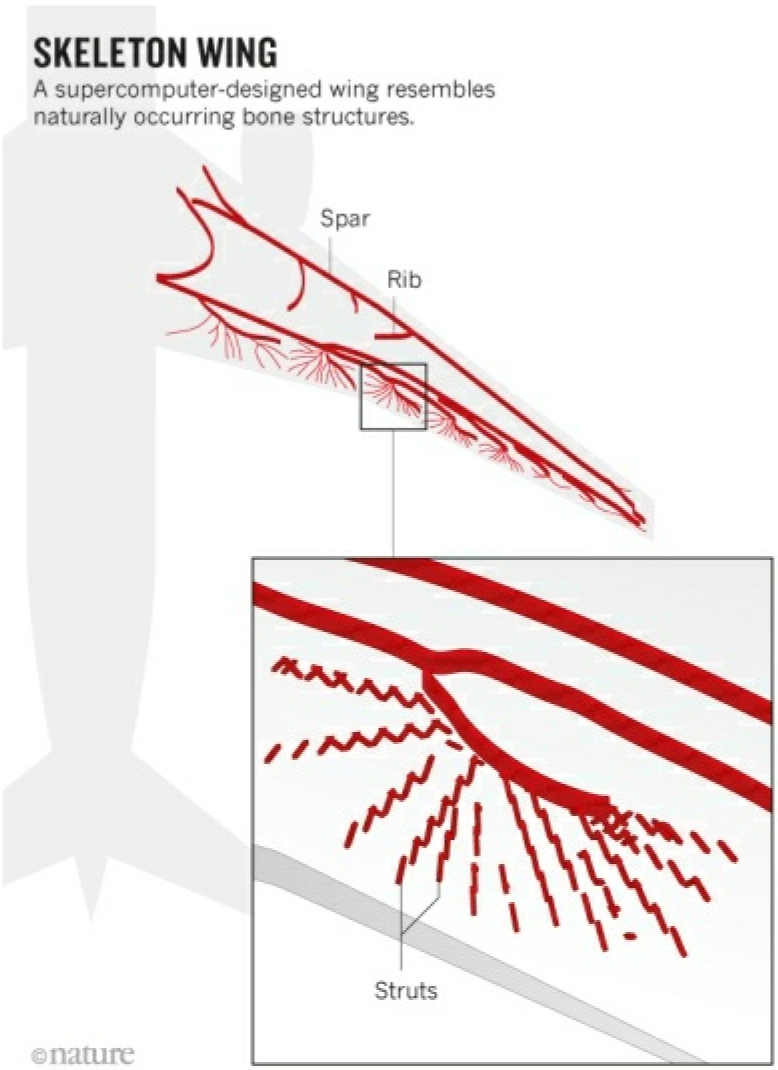
Samuel Taylor/Alamy

Conventional aeroplane wings are supported by straight bars and struts, but a supercomputer has suggested a more organic design.

Engineers have used a supercomputing technique that mimics natural selection to design the internal structure of an aircraft wing from scratch. The

resulting blueprint is not only lighter than existing wings, it also resembles natural formations, such as bird wing bones, that are not present in current aeroplanes. The organic-looking product is as stiff as a conventional aircraft wing but lighter, which could save up to 200 tonnes of fuel per year per plane.

“This is a really nice illustration of how to employ computing-based optimization methods at immensely high resolution,” says Matthew Santer, an aerospace engineer at Imperial College London. The method could feed into the design process, although there are a number of hurdles to using it in aerospace applications in its present form, he adds.



Engineers have been using these kinds of optimization techniques for around

20 years, but only for smaller-scale problems, such as individual wing components, or much simpler structures, says Niels Aage, an engineer at the Technical University of Denmark, near Copenhagen, who led the work[1]. Aage and his colleagues used the Curie supercomputer in Bruyères-le-Châtel near Paris to increase the resolution, enabling them to model the entire 27-metre-long wing of a Boeing 777.

The team started with a wing outline already optimized for maximum lift and minimum drag, known as an aerofoil, and split it into 1.1 billion 3D pixels or 'voxels'. Each is about the size of the smallest Lego brick — a resolution roughly 200 times greater than previous efforts. The algorithm began by simulating the force exerted on every block and distributing material in response to where the wing experienced a load. Without any human guidance, the program then repeated the analysis several hundred times, adding or removing material depending on the strain felt by each brick, until it reached a final optimum design. "The structure evolves through each design cycle," says Aage. "The process has many similarities to nature's own evolution."

Organic flight

Unlike conventional wings, the resulting structure did not contain the usual straight beams running the length of the wings, interspersed by crossing supports. Instead, the design looks organic, says Aage. Curved supports fan out at the trailing edge of the wing, resembling the bones in birds' wings, and intricate support structures in the leading edge look like the internal structure of a beak.

Without compromising stiffness (resistance to deformation), the design weighs 2–5% less than conventional wing structures. That translates into 200–500 kilograms per wing, potentially saving each plane between 40 and 200 tonnes of fuel per year, say the authors. The technique could also be applied to other industries, says Aage, for example, to design high-rise buildings in earthquake-prone zones that maintain their stiffness yet can withstand the dynamics of a quake. It could be used to optimize acoustics, ventilation systems and antennas, as well, he adds.

The technique’s high resolution, which allows the computer to design structures that include features that range in size from millimetres up to tens of metres, could lead to more-innovative designs in these other disciplines, says Liang Xia, a computational engineer at the Huazhong University of Science and Technology in Wuhan, China. But he stresses that running the algorithm requires a heavy computing burden — the equivalent of running a single standard computer for 100 years. This computing cost could be reduced, however, if the team were to employ more-advanced simulation methods, used in artificial intelligence, which in effect model only parts of the wing in such high resolution.

The design is also too intricate to be made by existing manufacturing methods, and would require a giant 3D printer to build. But for now, key aspects of it could be fed into structures produced using conventional methods, says Aage. “We’re speeding up evolution rapidly, meaning we can see how designs should be, and then extract the key features — or those we can afford.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22759

Comments

Commenting is currently unavailable.

Elite Hungarian university may be saved

Hungary-New York agreement could allow Central European University to sidestep law change.

04 October 2017

Bernadett Szabo/REUTERS

Seventy thousand people protested in Budapest last April against a law apparently targeting the Central European University.

The prestigious Central European University (CEU) in Budapest, Hungary, seems to have found a way around a threat to close it down. The university had been affected by a law change that is widely thought to be politically

motivated.

The threat arose in April, when the government rushed through an amendment to its higher-education law, requiring that all international universities operating in Hungary had also to operate as higher-education institutes in their countries of origin.

The law change seriously affected only the CEU, which is legally registered in New York state. The university was founded in 1991 by Hungarian-born philanthropist George Soros, whom Hungarian Prime Minister Viktor Orbán has described as an enemy, because of Soros's statements in support of refugees, which run counter to Orbán's policies. The revised law, which includes other, smaller amendments, comes into effect on 11 October.

New York connection

A CEU spokesperson said on 3 October that the university has now signed a Memorandum of Understanding with Bard College in Annandale-on-Hudson, New York, to provide educational activities. She added that negotiations between the State of New York and the government of Hungary, which opened at the end of June, have now concluded, although the agreement still has to be signed off by Hungary's government and Parliament.

The law change sparked immediate protest last April, when 70,000 protestors took to the streets in Budapest, and the Hungarian Academy of Sciences expressed concern. The European Commission is pursuing an infringement procedure against what it sees as an illegal restriction of academic freedom, and an investigation by legal experts of the Council of Europe, a powerful human-rights organization with 47 member states, published a preliminary opinion in August indicating that the law was inappropriate.

"It's no secret that it has been a hell of a way to treat a university," says CEU rector Michael Ignatieff.

The university has nearly 1,500 mostly postgraduate students from more than a hundred countries, including a large number from Hungary. It operates mainly in the humanities, but recently expanded to include the cognitive and

network sciences.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22761

Comments

Comments

There are currently no comments.

Science without walls is good for all

International mobility and collaboration are linked to stronger research.

04 October 2017

David Williams/Bloomberg/Getty

New studies highlight how closing borders would be bad for science.

Some US biotechnology labs have responded to President Donald Trump's attempts to restrict immigration by releasing contrasting group photographs showing what less-open international borders would do to their workforces. A first image typically shows everyone who works in the lab. A second image includes only those who are permanent US residents, then just US citizens, and then only those who were born in the United States and whose parents also were (see, for example, go.nature.com/2ft02xj). The shrinkage

from the first to the last image is striking — in some cases, about two-thirds of staff are lost. This reflects a widespread reality in research. A 2012 analysis showed that more than 60% of postdocs in the United States grew up overseas (see *Nature* **490,** 326–329; 2012).

When it comes to co-authorship, researchers in Europe are the most international. In 1981, only about one in six papers by a European scientist included co-authors from a different country. By 2011, that had risen to one in two. Papers with authors from more than one country also tend to be more highly cited (J. Adams *Nature* **497,** 557–560; 2013) .

This week, *Nature*'s Comment section publishes two bibliometric analyses that suggest international mobility has similar science-boosting effects.

The first finds that researchers build strong links between nations as they travel around the world. The authors track 16 million individuals who published papers in 2008–15. Only about 4% of these people changed countries, but those who did had 40% higher average citation rates than those publishing solely in one region, a trend that held true across 13 regions. Importantly, mobile scientists retained ties in the countries they left.

The second argues that countries with mobile scientific workforces produce papers that are more highly cited. (These are the same countries that have the greatest fraction of internationally authored papers.) The analysis shows that a nation's willingness to let scientists cross borders was a better predictor of highly cited papers than was the proportion of its gross domestic product that it spent on research.

These are complex issues. Citation rates are not necessarily a sign of quality, influence or long-term importance. And many confounding factors hamper attempts to link policies to impact. Still, such studies are necessary to provide evidence for policies on how to best support the scientific system.

The benefits of international movement are not entirely clear-cut. Leading scientists who change institutional affiliation (but not country) seem to boost both output and impact (G. Halevi *et al. Publ. Res. Q.* **32,** 22–37; 2016). Further work could reveal whether international papers — or more-open countries — prompt more innovative or worthy science. Details of the

relative benefits of collaboration, or how the effects of an international move are mediated by discipline or career stage, must be teased out. So must the effects of particular policies, such as the ease with which potential trainees and working scientists acquire visas or other travel support.

There is a bigger question: does the flow of leading scientists into a country bring tangible benefits for the citizens whose taxes fund their work? What about when one country's funds flow to a scientist's international collaborators? Evidence from patents and technological advances suggests that such investment is rewarded. But attention must be paid to ensure that a nation's connection to elite international scientists also supports work on local interests and needs.

Meanwhile, the scientific powerhouses of the United States and the United Kingdom seem determined to close their doors. US travel restrictions put in place last week tell working scientists from eight countries to stay away. And Britain's departure from the European Union puts scientific collaboration and access to European funds at serious risk.

Many nations with more-welcoming attitudes are poised to benefit. One long-term trend is clear: existing scientific powerhouses are not destined to stand forever. The picture can change — and quickly.

Journal name:
Nature
Volume:
550,
Pages:
7–8
Date published:
(05 October 2017)
DOI:
doi:10.1038/550007b

Comments

Comments

There are currently no comments.

Nobel prizes, giant telescope and buried treasure

The week in science: 29 September–5 October 2017.

04 October 2017

Events | Research | Funding | Facilities | People | Trend watch

EVENTS

Antikythera wreck yields more treasures Marine archaeologists investigating an ancient shipwreck near the island of Antikythera, Greece, announced on 4 October that they have recovered bronze and marble statue pieces, a sarcophagus lid and a mysterious bronze disc decorated with a bull. The cargo ship, which dates to the first century bc and was rediscovered in 1900, is famous for yielding the Antikythera mechanism, a complex bronze geared device that showed the movements of the Sun, Moon and planets in the sky. A team led by archaeologists Brendan Foley of Lund University, Sweden, and Theotokis Theodoulou of the Greek Ephorate of Underwater Antiquities in Athens found the latest artefacts under boulders in a previously unexplored part of the site. They think that at least seven complete statues are still buried nearby.

Brett Seymour/EUA/ARGO 2017

The bronze disc found near the shipwreck.

Volcano threats More than 100,000 residents on the Indonesian island of Bali have reportedly been evacuated to shelters following increased seismic activity from Mount Agung. The government's Center for Volcanology and Geological Hazard Mitigation said on 29 September that, on the basis of the latest information, an eruption was still a probability. Meanwhile, in Vanuatu, the government ordered the evacuation of all residents of Ambae island — about 11,000 people — on 28 September, after Manaro Voui started ejecting lava, poisonous gas and ash. On 1 October, the Vanuatu Meteorology and Geo-hazards Department said the volcano's activity was settling, and a large eruption was less likely. However, as *Nature* went to press, evacuations continued.

Time capsule On an Arctic island, scientists have buried a stainless-steel tube stuffed with artefacts that they say sum up science and technology in 2017. The time capsule, placed in an out-of-use borehole near the Polish

Polar Station in Hornsund, Svalbard, contains samples that include DNA, silicon-based electronics, an ancient meteorite fragment and other items to inform a future discoverer of our present understanding of technology, geology and biology. A team with the Polish Academy of Sciences described the capsule — created to celebrate the sixtieth anniversary of Poland's polar station — in a report in *Gondwana Research* on 28 September.

RESEARCH

Space-time ripples Physicists have announced the first discovery of gravitational waves made together by observatories in Europe and the United States, and the fourth-such discovery overall. At a 27 September press conference, researchers said that on 14 August, both the Virgo observatory near Pisa, Italy, and the twin laboratories of the US Advanced Laser Interferometer Gravitational-Wave Observatory (LIGO) in Livingston, Louisiana, and Hanford, Washington, had picked up gravitational vibrations emanating from a pair of merging black holes 540 million parsecs (1.8 billion light years) away. Observing the event with three detectors, rather than LIGO's two, enabled scientists to pinpoint the location of and distance to the black holes with much greater accuracy. Virgo rejoined the hunt for the waves only on 1 August, after a five-year upgrade.

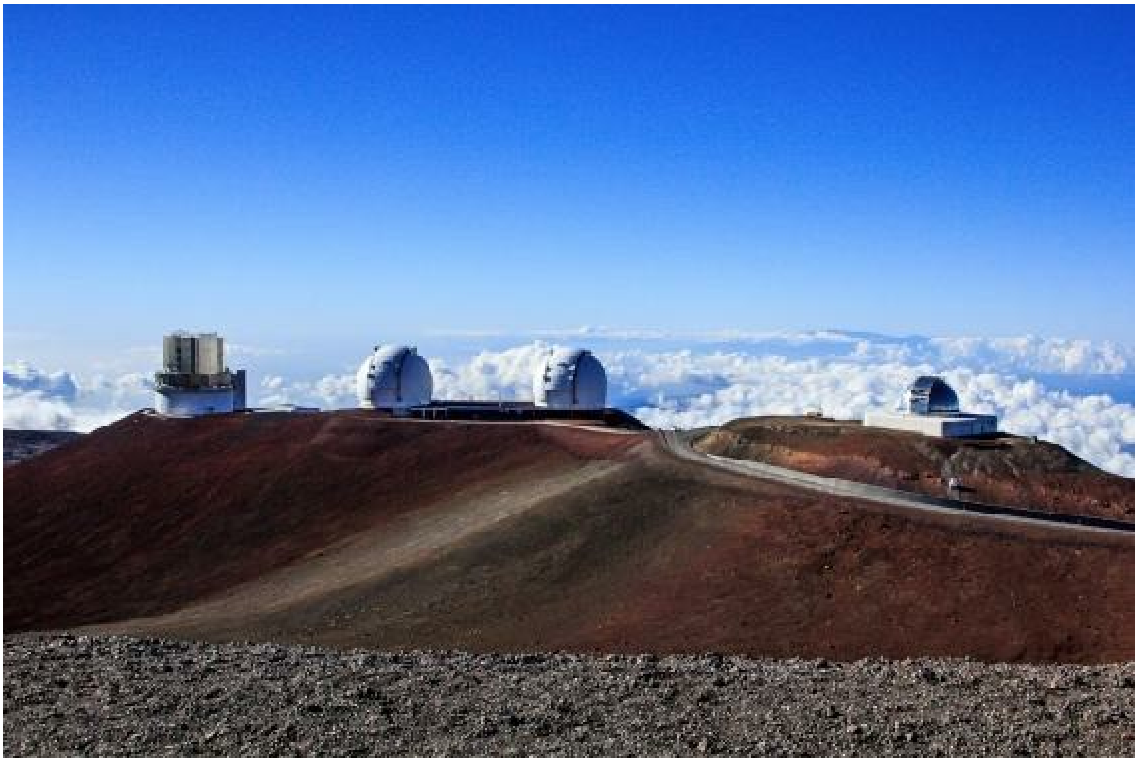
Monkey research The US Food and Drug Administration (FDA) has suspended a study on the effects of nicotine on monkeys after activists, including primatologist Jane Goodall, decried the experiments as cruel. On 25 September, FDA commissioner Scott Gottlieb responded to a 7 September letter from Goodall that called the experiments unnecessary, given that the effects of smoking are well known. The study, which began in 2014 at the FDA's lab in Jefferson, Arkansas, allows monkeys to self-administer nicotine. Gottlieb told Goodall that it would be halted while a team of experts assesses the monkeys' health and determines whether more precautions are needed. The team will also decide whether the study should resume.

FUNDING

French budget French research funding is set for a heartening increase in the country's first budget under President Emmanuel Macron, if draft 2018 plans released on 27 September are voted into law. The research portfolio of France's ministry of higher education, research and innovation would rise by more than 6%, to €8.4 billion (US$9.9 billion) in 2018. And a giant economic-recovery plan unveiled on 25 September by Prime Minister Edouard Philippe should divert an extra €2.4 billion to research over the next five years. Separately, in a 26 September speech, Macron backed the idea of a European Union funding agency to accelerate the commercial applications of basic science, an idea also suggested by EU research commissioner Carlos Moedas.

FACILITIES

Hawaii telescope Hawaii's board of land and natural resources granted a new construction permit to the Thirty Meter Telescope (TMT) on 28 September, reviving the chances that it could be built on the Hawaiian mountain of Mauna Kea. Some Native Hawaiians oppose the TMT, saying that its construction would further violate the sacred mountain, which already hosts multiple telescopes. Hawaii's supreme court invalidated the TMT's first construction permit in December 2015, ruling that the board had not followed appropriate procedures. The new permit gives the project the right to proceed on Mauna Kea, but telescope opponents have filed motions that would put the permit on hold until the state supreme court can hear an appeal.



Julie Thurston/Getty

PEOPLE

Nobel prizes Three biologists were awarded this year's Nobel Prize in Physiology or Medicine for their work on circadian clocks. Jeffrey Hall and Michael Rosbash, both at Brandeis University in Waltham, Massachusetts, split the award with Michael Young at Rockefeller University in New York City. The physics prize was awarded to Rainer Weiss, at the Massachusetts Institute of Technology in Cambridge, and Barry Barish and Kip Thorne, both at the California Institute of Technology in Pasadena, for their work on detecting gravitational waves. *Nature* went to press before the chemistry prize was awarded, but full details will be available at go.nature.com/chem2017.

Science adviser On 26 September, Canadian prime minister Justin Trudeau appointed biochemist Mona Nemer as his country's chief government science adviser, fulfilling his campaign promise to establish the position. Nemer was

most recently vice-president of research at the University of Ottawa and director of the Molecular Genetics and Cardiac Regeneration Laboratory there. Her scientific work has focused on the genetics of cardiovascular disease and birth defects. In her new role, Nemer will have a budget of Can$2 million (US$1.6 million) and report to Trudeau and science minister Kirsty Duncan. The country has been without a science adviser for nearly a decade; the last time such a post existed was from 2004 to 2008.

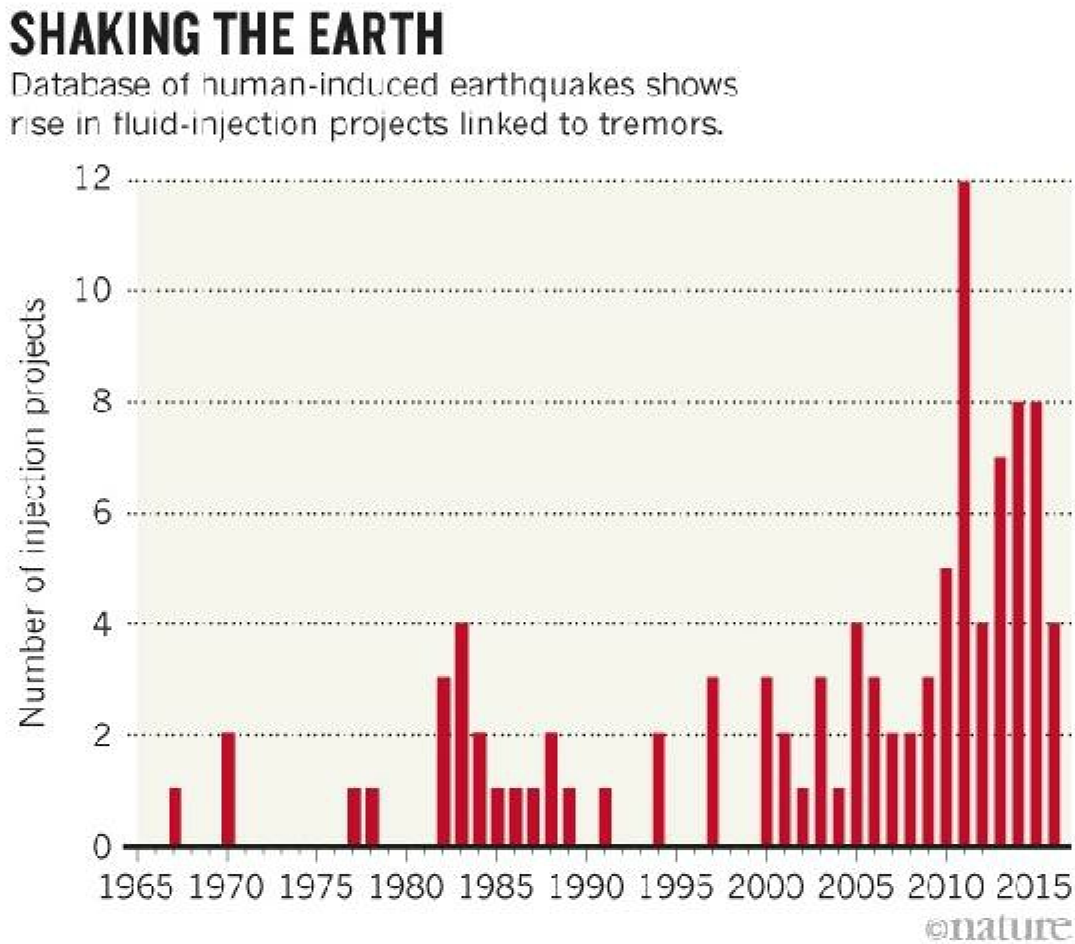
Russian academy After almost six months without a head, the Russian Academy of Sciences (RAS) has a new president: Alexander Sergeyev, a laser physicist and director of the RAS Institute of Applied Physics in Nizhny Novgorod. The academy, which operates a network of hundreds of institutes, is undergoing controversial reforms. In March, its planned presidential elections were unexpectedly cancelled at the last minute, allegedly following a row over voting procedures (see *Nature* **543,** 601; 2017). In the latest elections announced on 26 September, Sergeyev won a majority of votes from the academy's general assembly. A new state law requires that Russia's president Vladimir Putin must also approve the post, which he did the following day.

Defraud alert The FBI has charged bioengineer Yiheng Percival Zhang with defrauding the US government and his employer, the university Virginia Tech in Blacksburg. Zhang was arrested on 20 September and will remain in custody pending a trial, according to court documents. In an affidavit in support of a criminal complaint filed on 18 September, the FBI alleged that Zhang and two of his colleagues at the Tianjin Institute of Industrial Biotechnology in China — Zhiguang Zhu and Chun You — conspired to win US National Science Foundation (NSF) grants for studies that had already been completed in China. The affidavit also claims that Zhang withheld a portion of funds owed to his university from NSF and Department of Energy grants.

TREND WATCH

A database of human-induced earthquakes reveals a rise in tremors linked to wastewater injected into the ground by oil and gas operations. Such projects

spiked in the early 2010s, particularly in the central United States. The HiQuake database is described in *Seismological Research Letters*. Of 728 entries, 37% are linked to mining, 23% to water piling up behind a dam and 15% to conventional oil and gas development. Just 4% are linked to hydraulic fracturing, or fracking, for oil and gas.



Source: M. P. Wilson et al. Seismol. Res. Lett. http://dx.doi.org/10.1785/0220170112 (2017)

Journal name:
Nature
Volume:
550,
Pages:

12–13
Date published:
(05 October 2017)
DOI:
doi:10.1038/550012a

Comments

Comments

There are currently no comments.

Why fake islands might be a real boon for science

The seasteading movement is getting close to building its first prototype, an artificial archipelago where people will live, play and do research.

04 October 2017

Blue Frontiers

Early designs for a floating island in Tahiti aim to mimic a natural landscape.

The view is unbeatable. To the right, steep volcanic mountains, draped in green, rise up from a beachside coconut grove. To the left, the Pacific Ocean glitters turquoise under the midday sun. It is here in this Tahitian lagoon that a group of entrepreneurs plans to build an artificial island — three-quarters of a hectare of floating housing and research space, made up of linked platforms. If the team is successful, the vision could become reality by 2020. But it would be just the first step, says self-described “seavangelist” Joe Quirk. The ultimate goal is to build whole sovereign nations on the open seas, composed of modular floating units.

“French Polynesia has all the stepping stones: lagoons, atolls, shallow waters

right next to deeper waters," Quirk says.

Quirk, one of five managing directors for the company behind the project, and his colleagues propose that artificial islands could serve as laboratories for testing out new technologies and exploring different social structures, or act as life rafts for coastal peoples displaced by sea-level rise.

The non-profit Seasteading Institute was founded by former Google engineer Patri Friedman in 2008, and it has garnered support from influential people in the linked worlds of Silicon Valley, libertarian politics and the anything-goes desert festival, Burning Man. Most media reports have been sceptical, however. The project has been characterized as the dream of "two guys with a blog and a love of Ayn Rand"[1] and "a hacker's approach to government with a *Waterworld*-esque conception of Manifest Destiny"[2].

But the Seasteading Institute and the new for-profit spin-off, Blue Frontiers, have racked up some real-world achievements in the past year. They signed a memorandum of understanding with the government of French Polynesia in January that lays the groundwork for the construction of their prototype. And they gained momentum from a conference of interested parties in Tahiti in May, which hundreds of people attended. The project's focus has shifted from building a libertarian oasis to hosting experiments in governance styles and showcasing a smorgasbord of sustainable technologies for, among other things, desalination, renewable energy and floating food-production. The shift has brought some gravitas to the undertaking, and some ecologists have taken interest in the possibilities of full-time floating laboratories.

LISTEN

Reporter Geoff Marsh investigates ambitious plans to build artificial floating cities.

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But the project still faces some formidable challenges. The team must convince the people of French Polynesia that the synthetic islands will benefit them; it must raise enough money to actually build the prototype, which it estimates will cost up to US$60 million; and once it is built, the group must convince the world that artificial floating islands are more than just a gimmick. Producing solid science and broadly useful technology would go a long way towards making that case.

“What we are dreaming is that this structure will be a scientific laboratory,” says Winiki Sage, head of the Economic, Social, and Cultural Council of French Polynesia in Tahiti, who has been concerned about brain drain from his country.

Aesthetic appeal

Designs are surfacing for the prototype island, and its look is a key part of Blue Frontiers's public-relations strategy. The company's current plans don't entirely align with the concept art on the Seasteading Institute's website, which swings from tiki bar to Tomorrowland in various iterations. Bart Roeffen, a 'water pioneer' at the Dutch design firm Blue21 in Delft, has been drawing up new plans that fit with the landscape and culture.

“We are working together with Tahitian designers to make something that is not like an alien invasion,” Roeffen says. In particular, he plans to take cues from Polynesian shipbuilding. The elegant outrigger canoes, or *va'a*, used by islanders are stable and light; oceangoing versions are the type of boat rowed by the Tahitian voyagers who discovered Hawaii and New Zealand around AD 1100. Linked platforms would be arranged to ensure that no coral below is completely shaded and killed. The goal is to actually expand the habitat for reef species (see 'Seasteaders in paradise').

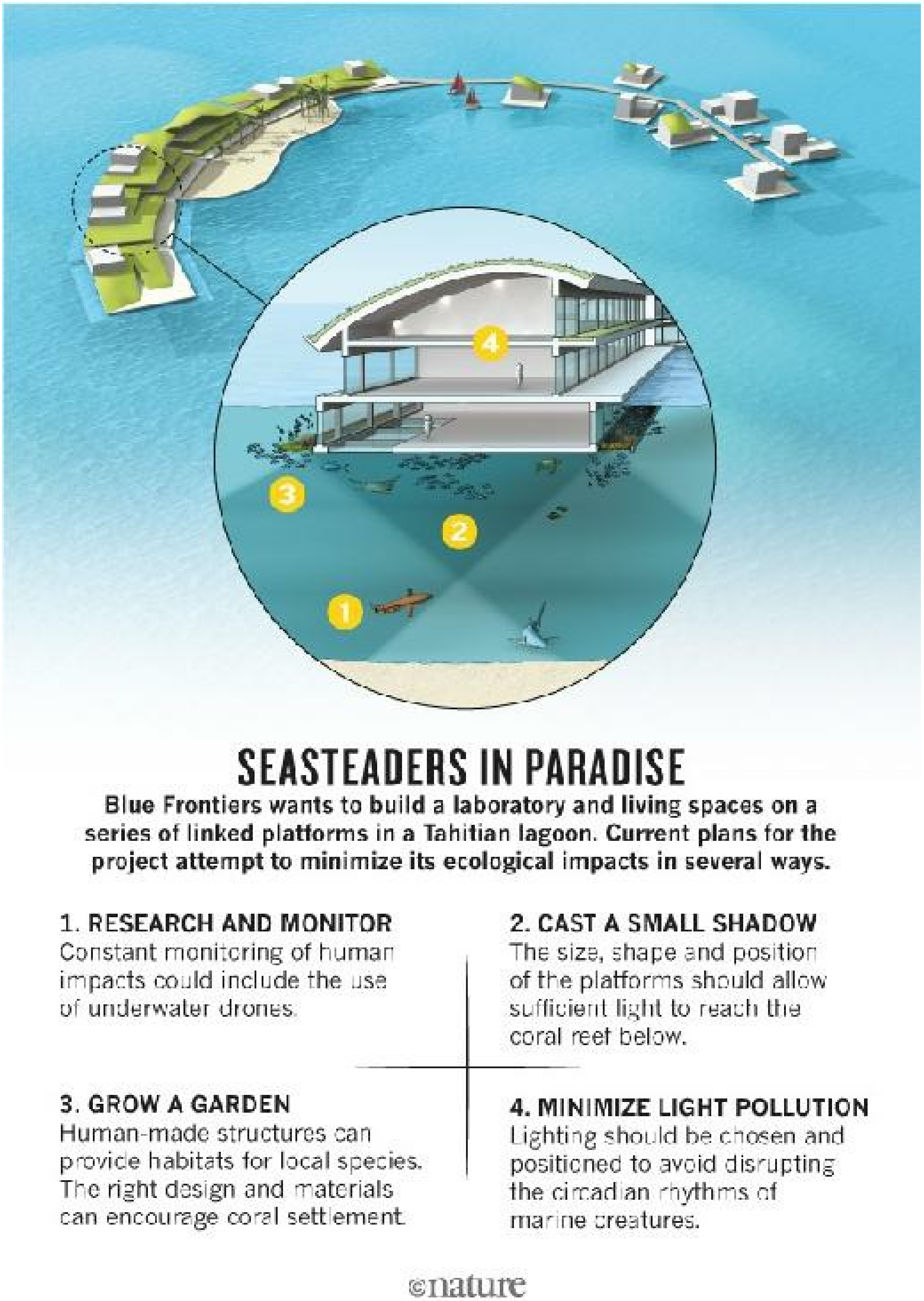


Illustration by Emily Cooper

The team would not provide direct information about funding. Paypal

founder and one-time Donald Trump enthusiast Peter Thiel provided a reported $1.7 million to the Seasteading Institute, but he last contributed to the project in 2014, and any recent investors are keeping a low profile. Quirk says that they have “a nice amount” of seed money and are preparing for what is called an initial coin offering — an investment mechanism that uses digital cryptocurrency. Looking ahead, the company hopes to generate revenue by renting out space on the island and acting as consultants for other would-be island builders. Along with hiring Quirk and the other four managing directors, Blue Frontiers has recruited ten staff members and commissioned environmental, legal and economic studies on the impacts of the project for investors and the government.

The “why?” — everyone's first question about seasteading — is answered differently by everyone involved. Some are captivated by the project because it is an excuse to push sustainable design to the next level. For people on low-lying islands, it looks like a life raft. Félix Tokoragi, mayor of Makemo, an atoll in the Tuamotu archipelago in French Polynesia, told Blue Frontiers that he's interested. The Tuamotus have experienced widespread flooding, and Tokoragi is worried that his people will become climate-change refugees. “We are attached to our atoll; we are attached to our culture,” he says. “We are not against this idea, since the technology can respond to the problems that we face.”

For others, the pull of the project comes down to autonomy and self-reliance, particularly with respect to governance: anyone who decides their island's political style is not for them can detach and depart for another system that they like better.

For at least one scientist advising the project, Neil Davies, executive director of a field station of the University of California, Berkeley, on the neighbouring island of Moorea, the island's appeal is as a base for research that would “fill the gap between oceanographic-research vessels and coastal marine labs”. Ships are on the water, but they are “phenomenally expensive”, he says, and they don't stay put. Coastal labs can gather long time-series of data in one place, but don't provide access to deeper water. Davies dreams about floating “sea stations” that would allow low-cost, long-term access to the ocean for research, especially for students in tropical countries “where

natural systems are among the most sensitive to human activities”, he says. Experiments could include modifying pH or temperature on small sections of a reef to simulate future environmental conditions, and 'planting' different corals to investigate which will thrive best in the future. Data could be gathered using semi-permanent sensors and cameras, along with regular biological-sample collection.

Some scientists not involved in the project see value in the concept, as well. “If you have a floating island and you want long-term study, that is a perfect way to do it,” says Ross Barnes, marine-operations superintendent at the University of Hawaii Marine Center in Honolulu, who oversees two large research vessels and on-shore labs. The university has been conducting research at a spot in the ocean that it calls Station ALOHA, which scientists have visited nearly 300 times by boat since 1988. A floating platform, he says, would mean that scientists could leave behind some instruments — and that some of them could stay as well — allowing for continuous measurement. “It's a good idea,” Barnes says.

Currently, Davies is advising the seasteaders on site selection and environmentally positive design choices. He also plans to help them to document the installation's performance using sensors that measure things such as energy expenditure and waste generation on the platforms, as well as water temperature and quality. And he sees it as a great teaching opportunity for the many students who visit his station. “Seasteading raises many social, legal, ethical, environmental issues, even if it never gets anywhere,” he says.

Whether the seasteaders make progress depends on whether the project is embraced by French Polynesia, a largely autonomous 'overseas collectivity' of France with a population of 287,000 on 67 islands spread out across an area nearly the size of Europe. At one level, a grand floating project could appeal to a nation of voyagers and boat builders. But French Polynesia has been burnt by big-science and technology projects before. From 1966 to 1996, France conducted 193 nuclear tests in its Polynesian possessions, many in the atmosphere. In February 2016, then-president of France François Hollande admitted that the testing had harmed the environment and human health. And the place is littered with defunct projects and closed hotels.

“We have a history of being taken for fools,” says Pauline Sillinger, a

sustainable-development specialist at Te Ora Naho, a federation of environmental groups in French Polynesia, who took a job with Blue Frontiers this year, and also teaches Tahitian dance. “Nuclear testing, big hotels, nice, smiling, white, intelligent people telling us it'll be good for us.”

But their wariness vies against their desperation for new revenue streams, Sage says. After winding down nuclear testing, France began paying French Polynesia more than US$100 million per year in compensation for lost income from military activity. But in 2016, that amount was reduced. Meanwhile, tourism revenues have never recovered from the 2008 recession. Thanks to increased political stability and other factors, things have improved since 2014, when the collectivity was so broke that it risked not being able to pay its civil servants, according to Sage. But it is still dangerously reliant on a small number of income sources — tourism, pearls, coconut oil. Unemployment stands at nearly 18%. “We are looking for new ideas,” Sage says. “We are really open to any ideas, any investors.”

If Sage is sceptical but willing to give it a shot, there are others who have had enough of grandiose project ideas. Among them is a religious leader in Tahiti, Frère Maxime Chan, who heads Association 193, which advocates on behalf of those harmed by nuclear testing. Chan is also vice-president of Te Ora Naho. (Sage, incidentally, is the organization's president.) Chan says that his old friend Sage and the rest of the government are “dazzled” by the flash and money of the Seasteaders. He talks about recent projects — including a tourist resort, an aquaculture scheme and an eco-resort — that were all announced with fanfare and optimistic job projections, only to be cancelled, scaled back or put on indefinite hold. Chan wishes the government would admit that the standard of living for the average Tahitian has been artificially inflated by nuclear-test payments and must come down. This can be done without suffering, Chan contends, by gracefully returning to a version of the pre-1960s subsistence economy. “Small is beautiful,” he says.

Convincing French Polynesia to support the project will fall mainly to Marc Collins, another managing director of Blue Frontiers. Collins is Tahitian and lives there now, but in the early 1990s he lived in Silicon Valley, and fell in love with its fast-paced culture of big ideas and endless possibility. Ever since, he's kept his toe in those waters in part by maintaining a subscription to

Wired magazine. In May 2015, the digital lifestyle glossy ran a story[3] about how the seasteading movement planned to scale back its grand, high-seas concept, reorienting towards safer, shallower waters and looking for “cost-reducing solutions within the territorial waters of a host nation”.

Collins, a serial entrepreneur who has dabbled in every major French Polynesian industry, from hotels to black pearls and telecommunications, saw an opportunity to, as he puts it, “bring some of the DNA of Silicon Valley to Tahiti”. Tahiti joined the world of high-speed Internet in 2010, with the completion of an undersea fibre-optic cable linking it to Hawaii. It has calm lagoons aplenty and daily flights from Los Angeles, California, and, as a minor bonus, is widely regarded as paradise on Earth. Collins fired off a LinkedIn request to the Seasteading Institute's executive director, Randolph Hencken.

The Seasteaders were interested in Collins's pitch, but they wanted a more official gesture of support. So Collins, who served as French Polynesia's minister of tourism in 2007 and 2008, began working his government contacts. By August, the president of French Polynesia, Édouard Fritch, signed a letter formally inviting the Seasteaders to present their ideas. A delegation of nine took him up on the offer the next month, and by January, a memorandum of understanding with pledges of cooperation was signed.

The next step in making the island a reality will be the passage of a law defining the 'special economic zone' that will cover the synthetic island. Blue Frontiers isn't asking French Polynesia for any subsidies to build the island, but it is asking for a 0% tax rate, among other regulatory exceptions. It has hired French firm GB2A, based in Paris, to prepare legal research and a set of requests, which Blue Frontiers presented to the government at the end of September. The team hopes to see a bill emerge before the end of the year.

In the meantime, the Seasteading Institute is building excitement and courting potential investors with a series of gatherings. In May, it held talks, networking events and tours in Tahiti. Speakers included Fritch; Tony Hsieh, chief executive of online retailer Zappos in Las Vegas, Nevada; Tua Pittman, a master canoe navigator from the Cook Islands; and engineers, nanotechnologists and a 'blockchain strategist', a specialist in the distributed information systems behind cryptocurrencies. The seasteaders hope to use

such systems to handle their financials, as well as any scientific data that they generate. But the event wasn't all work. An announcement for a party on outrigger canoes cheerfully suggested: “Do not wear heels. Bring a swimsuit for an optional moonlight swim.”

On 22–29 October, Blue Frontiers will hold an Insiders Access Week for supporters and potential investors, a mix of tours, discussion and morning yoga with Hencken. Always ambitious, the team hopes to have draft legislation from the Polynesian government by then, and some detailed architectural plans. The goal is to break ground — or rather, sea — in 2018.

While all this work goes on behind the scenes, the lagoon remains fairly quiet. On a day in July, locals compete in a stand-up paddle-board race while families play on the shore and young women drink beer with their feet in the waves. By the roadside, freshly caught tuna are for sale. On one level, it is hard to imagine this place being improved upon.

Time will tell whether the Seasteaders' island becomes a refuge for Polynesians facing rising seas and an incubator for Polynesian science and business, or merely a playground for wealthy foreigners who want to dodge bothersome regulations. That is, if it materializes at all.

Journal name:
Nature
Volume:
550,
Pages:
22–24
Date published:
(05 October 2017)
DOI:
doi:10.1038/550022a

Comments

Comments

There are currently no comments.

How fracking is upending the chemical industry

As shale-gas compounds flood the market, chemists are working out the best ways to convert them into the ingredients of modern life.

04 October 2017

Jeff J Mitchell/Getty

A ship carrying US shale gas, the *Ineos Insight*, approaches port in Scotland in September 2016.

As the *Ineos Intrepid* cruised slowly through the sapphire waters of Norway's Frierfjord, chaperone tugboats sprayed jets into the sky to herald her arrival. In giant refrigerated tanks below decks, the ship carried 27,500 cubic metres

of liquid ethane — enough to fill 11 Olympic swimming pools. *Intrepid* also brought a message, painted in giant capital letters along her side: “SHALE GAS FOR PROGRESS”.

The vessel's arrival in March 2016 brought the first ever shipment of shale gas from the United States to Europe — and marked the start of a burgeoning business. More of these 180-metre-long 'Dragon'-class vessels have followed in her wake, forming a 'virtual pipeline' for ethane across the Atlantic Ocean. This gas, which is extracted from the ground through the hydraulic fracturing of shale deposits, isn't destined to fuel power stations or domestic stoves. Instead, it will be transformed into the chemical building blocks needed to make a panoply of products, including plastics, clothes, adhesives and medicines.

Intrepid's voyage is a striking demonstration of how cheap US shale gas is reshaping the chemical industry and changing the origin of countless manufactured objects. For decades, the industry's raw ingredients have mostly come from crude oil. Chemical plants break down long hydrocarbon molecules in crude to produce a smorgasbord of smaller molecules, such as ethene, propene and benzene — all important precursors to polymers.

But shale gas, which is composed mainly of methane, ethane and propane, is turning that pathway on its head. The abundance of the gas has slashed the costs of these molecules. As a result, some are now usurping large hydrocarbons as the preferred starting point for industrial synthesis.

This shift from oil to gas brings enormous opportunities. According to the American Chemistry Council, a trade group based in Washington DC, the shale boom has attracted about US$160 billion in investment from the US chemical industry since 2011, and will help to create half a million jobs in plastics manufacturing over the coming decade[1]. But it also poses huge challenges. Some of the main techniques that are used to turn the components of shale gas into more valuable compounds — processes generally known as upgrading — are decades-old, dirty and energy-intensive. And they rarely produce the same mix of chemicals as conventional oil-based routes, which means that some relatively minor, yet valuable, chemicals such as butadiene, an ingredient of synthetic rubber, are becoming scarcer.

These challenges are driving an intensive research effort, spanning industry and academia, to develop catalysts and reactors that can transmute small hydrocarbons in cleaner, cheaper and more efficient ways.

Translating that research into commercial production will depend on the finely balanced economics of a changeable market. It will also require a reliable supply of gas. The US Energy Information Administration predicts that natural-gas extraction in the United States will continue to grow until at least 2040, but that might be too optimistic (see Nature 516, 28–30; 2014). Meanwhile, concerns that fracking can contaminate groundwater — along with the broader climate implications of extracting fossil fuels — continue to dog the technology. If the glut does persist, however, it could usher in technologies that would form the foundations of a much more sustainable chemical industry. “We could totally redesign our chemical plants,” says Bert Weckhuysen, a chemist at Utrecht University in the Netherlands.

The ethane revolution

Shale gas is extracted from kilometres below ground, and typically contains about 70–95% methane, less than 15% ethane and less than 5% propane. After traces of oil, water and other impurities are cleaned out, the gas is chilled so that ethane and propane can be separated in liquid form, leaving methane behind.

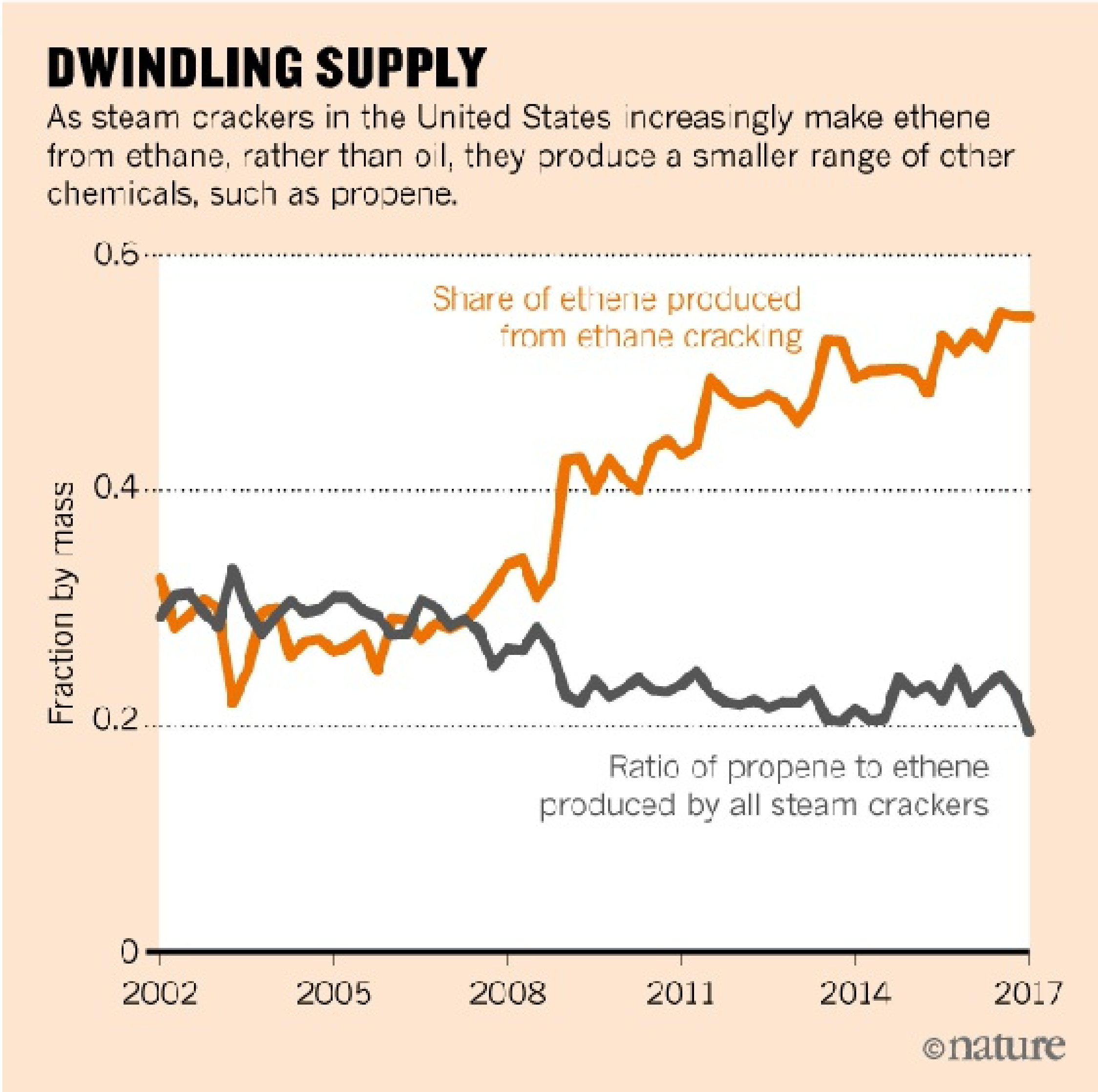
Although ethane makes up a small proportion of shale gas, it has so far had the biggest impact on the chemical industry. That's because chemists can easily use it to make ethene, also known as ethylene. Ethene is used to make various types of polyethylene and the precursors to other plastics, such as polyvinyl chloride (PVC) and polystyrene. So voracious is the world's appetite for these plastics that the chemical industry produces roughly 150 million tonnes of ethene every year, more than any other chemical building block.

Most processes in the chemical industry use catalysts. But ethene can be produced simply by steam cracking ethane or larger hydrocarbons. First developed in the 1920s, steam cracking is a blunt, energy-intensive process

that requires little more than water and 850 °C temperatures. “You basically just heat the snot out of it,” says Jeffrey Plotkin, an industry analyst at IHS Markit in New York City. “The heart and soul of the thing is this gigantic furnace, that's where all the chemistry happens.”

The boom in shale-gas-derived ethane has driven the chemical industry to invest nearly $45 billion in extra steam-cracking capacity[2]. But the transition to this feedstock is also creating a headache. When steam crackers are fed with mixtures of long hydrocarbons from crude oil, they make an array of useful by-products. But when they are supplied with ethane, the output is almost entirely ethene. “So there is a shortage of other building blocks,” says Weckhuysen.

One of those building blocks is propene, arguably the second most important product of the chemical industry after ethene. Propene is turned into polypropylene, a plastic used in packaging and textiles, along with other polymer ingredients such as acrylic acid. But by one estimate, propene production by US steam crackers dropped by almost half between 2005 and 2014, even as global demand rose (see 'Dwindling supply').



Source: S&P; Global Platts

To combat the shortfall, the industry is rolling out alternative ways to make propene. One of the leading routes starts with the shale-gas component propane. A combination of heat and a catalyst to remove two hydrogen atoms can be used to turn it into propene.

The conversion is becoming more profitable: more than 20 of these propane-dehydrogenation units are already operating worldwide, and at least 40 more have been ordered since 2011. But Weckhuysen says that there is much scope to improve the process, which tends to chew up catalysts quickly, requires a

time-consuming and costly catalyst-regeneration step, and can use harsh reagents.

The methane question

Although ethane and propane are already making waves as commercial feedstocks, the big prize for chemists is to upgrade the most abundant component of shale gas: methane.

Most of the world's methane is currently burnt as fuel, its lowest-value application. The gas can also be used as a chemical feedstock, but it contains strong carbon–hydrogen bonds that are difficult to break in a controlled way. When methane is converted into other molecules, it is done mainly through an inefficient sledgehammer of a process called steam reforming. First commercialized in the 1930s, this involves smashing methane and water together at up to 1,100 °C, over a metal catalyst. It produces an extremely useful mixture of carbon monoxide and hydrogen called syngas — and also emits several hundred million tonnes of carbon dioxide per year, accounting for roughly 3% of all industrial emissions[3].

Syngas is the world's principal source of hydrogen, much of which goes to make the ammonia in fertilizer. Syngas can also be used to produce longer hydrocarbons, such as basic components of diesel and waxes.

Such upgrading is typically done through a technique called the Fisher–Tropsch (FT) process, which uses cobalt or iron catalysts and heat to create daisy-chains of carbon atoms. FT was developed in Germany in the 1920s to make petrol and a wide range of other hydrocarbons from syngas derived from coal.

Producing transport fuels in this way is generally more expensive than refining oil. There are just six large-scale FT plants in the world, made economical only thanks to their proximity to huge coal or gas fields and the mind-boggling scale of the plants themselves: the world's largest, in Qatar, cost $19 billion to build and munches through 45 million cubic metres of methane every day, on a par with the natural-gas consumption of Belgium.

Courtesy Velocys

A plant in Oklahoma City owned by ENVIA Energy uses compact reactors developed by Velocys to turn methane-derived gas into products such as diesel.

But the shale boom has prompted chemical engineers to take a fresh look at the FT process. Shale-gas wells typically don't produce enough gas to support a conventional FT plant, so research teams and companies have been developing smaller reactors that can process modest gas flows. One of those is Velocys, based in Houston, Texas, which developed a 5-metre-long reactor that can convert syngas into substances such as naphtha, diesel and wax. Its reactor technology is being used in Oklahoma City in the first commercial mini-FT plant in the United States. The plant, which is owned by ENVIA Energy, started production earlier this year.

Temperature control is a big challenge for the FT process: the reaction kicks in at about 180 °C, then generates huge amounts of heat. If not carefully controlled, it will run away with itself, turning carbon atoms into useless soot. To address this, Velocys's reactor contains corrugated layers of channels that

are alternately stuffed with catalyst or filled with water. This keeps the reaction running at a steady 200 °C, so that the reactor can use an efficient catalyst without risking a runaway reaction. “It allows you to pack a lot of reaction in a very small space,” says Neville Hargreaves, business-development director for Velocys in Oxford, UK.

The reactor in Oklahoma City pulls methane from a landfill site, an activity that comes with renewable-energy credits. But Hargreaves thinks companies could ultimately profit by tapping remote and relatively small natural-gas reserves that are unlikely to get a pipeline. Another potential target is unwanted gas from oil wells, which is often simply burnt off. Such 'flaring' puts about 350 million tonnes of CO_2 into the atmosphere every year. According to the World Bank, it carries enough energy to meet Africa's entire current electricity requirements.

The direct route

The high temperatures involved in producing syngas will always make it a costly way to create complex chemicals — as well as a major source of CO_2 emissions. Researchers have spent decades looking for ways to convert methane directly to methanol or other products, cutting syngas out of the route altogether. The shale boom has given this effort fresh urgency, along with a burst of investment in research and development in both academia and industry.

Turning methane into methanol — itself a key precursor to a wide range of other compounds — involves adding only a single oxygen atom. But first, one of methane's strong carbon–hydrogen bonds must be broken, and the high temperatures or strong oxidants needed to do that can set the molecule on a one-way journey down a thermodynamic roller coaster with a messy end. Methanol sits on a brief crest about halfway down, but it is all too easy to race downhill as the reaction goes too far, producing a mixture of other molecules, including formaldehyde, formic acid or carbon monoxide.

In 2005, however, a team led by Robert Schoonheydt at the University of Leuven in Belgium, found[4] that copper seeded onto a porous material called a

zeolite could unite oxygen and methane to make methanol at less than 200 °C. Crucially, the methanol became trapped in the zeolite's pores, preventing further reactions. But extracting methanol from the pores and reactivating the catalyst would have proved expensive and impracticable in a commercial setting.

Since then, research groups have developed a range of copper–zeolyte catalysts that are more industry-friendly. Others have focused on completely redesigning chemical reactors. The European Union-funded project Adaptable Reactors for Resource- and Energy-Efficient Methane Valorisation, for example, aims to build small reactors that use renewable electricity, rather than heat generated from fossil fuels, to turn methane into compounds such as ethene and methanol. One approach uses microwaves to generate intense hotspots in the catalyst, lowering the heating requirements for the incoming gas.

Another approach to direct methane upgrading aims to couple pairs of the molecule together to make ethene. Since 2015, Siluria Technologies, a start-up in San Francisco, California, has been running a demonstration plant for this process in La Porte, Texas. It relies on a catalyst made of metal-oxide nanowires that collectively offer a surface area of about 200 square metres per gram of catalyst, hundreds of times more than a bulk catalyst could offer.

The company builds its catalysts in a unique way, based on a technique[5] developed by co-founder Angela Belcher, a materials scientist at the Massachusetts Institute of Technology in Cambridge. First, viruses are genetically engineered to express proteins that bind to dissolved metal ions. The ions form orderly arrangements as they stick to the surface of the virus. When the biological template is burned away, it leaves behind a highly stable, crystalline nanowire.

Rahul Iyer, Siluria's vice-president of corporate development, says that the process is cost-competitive with steam cracking ethane, and produces far fewer CO_2 emissions than steam reforming methane. Siluria has already licensed the technology to some chemical companies, and expects the first commercial facilities to be operating in 2019.

Plotkin says that Siluria is currently in the lead in the race to commercialize direct methane upgrading, and is backed by multimillion-dollar investments from big players in the industry. “People are keeping a watchful eye on it,” he says.

Gas that's greener

The shale-gas boom is credited with spurring a major renaissance in the US chemical industry, which has invested heavily in chemical plants and other infrastructure, as well as research and development. Enthusiasm for shale-gas upgrading has fostered major collaborations between academia and industry.

Translating laboratory results into commercial production is an ongoing challenge, although the trend towards small, modular reactors is helping to make it less daunting. The chemical industry is notoriously conservative: if a process succeeds in the lab but fails at commercial scale, tonnes of catalyst can be wasted and a plant shut down for months. “Industry will not take the risk unless they are sure it will work,” says Weckhuysen.

Despite these challenges, he is optimistic that gas upgrading could have a huge impact — not only on the chemical industry's processes, but also on its environmental footprint. Some of the reactor technologies being developed to feed on shale gas could be adapted to use bio-based feedstocks, such as methane from landfills, as Velocys has found. Meanwhile, shortages in some compounds caused by the shift to shale gas could improve the economic case for starting with ethanol from crops, or lignin from wood[6]. There has already been movement along these lines. In 2013, for example, French tyre-maker Michelin and partners launched a €52-million (US$61-million) project to make butadiene from bioethanol.

But for now, US shale ethane continues its relentless march around the world. More chemical companies are commissioning ships to transport the gas to destinations in Europe, Brazil and India. By 2022, according to one estimate, about 8 million tonnes of ethane will flow through these virtual pipelines each year. They will carry this revolution in the US chemical industry to the rest of the globe — both its challenges and its opportunities.

Journal name:
Nature
Volume:
550,
Pages:
26–28
Date published:
(05 October 2017)
DOI:
doi:10.1038/550026a

Comments

Commenting is currently unavailable.

Scientists have most impact when they're free to move

04 October 2017

An analysis of researchers' global mobility reveals that limiting the circulation of scholars will damage the scientific system, say Cassidy R. Sugimoto and colleagues.

Spencer Platt/Getty Images

Measuring the global movements of researchers will help to assess the effects of political actions on science.

Recent political upheavals portend an era of increased isolationism in

science, with a chilling effect on collaboration and mobility. Last month, US President Donald Trump issued his third travel ban in a year, suspending entry of individuals from several countries into the United States, and placing restrictions on many more for visa renewals. These orders have stranded scholars abroad and prevented those who were in the country from engaging in international work. In March, UK Prime Minister Theresa May began the process of formally severing ties with the European Union. As a result, British institutions face a potential exodus of non-resident EU researchers and will have to overcome barriers to participating in and receiving funding for European collaborative projects. The list of countries engaging in these isolationist actions, and the list of actions themselves, grows longer.

To assess the impacts of such political actions, we need better ways to measure researcher mobility. Although the size and composition of the scientific workforce is fairly well established through national surveys and registries[1], less is known about how often researchers move, where they go, what networks they form, and how important their movement is to the scientific impact of their work[2].

We present here a new analysis based on the records of 14 million papers from nearly 16 million unique individuals who published between 2008 and 2015. In our study, some 96% of researchers had only one country of affiliation; we classed these as non-mobile. About 4% (more than 595,000 researchers) were mobile — meaning that they had more than one affiliation during that period. Our analysis revealed surprising trends.

Chain reaction

Over the study period, Europe and Asia saw a dramatic net loss of researchers, whereas North America saw large gains. Many commentators have anguished about 'brain drain' or 'brain gain', assuming that receiving countries get the lion's share of scientific capital at the expense of the nations from which researchers originate. The reality is more complicated (see 'Brain circulation').

We found that the majority of scientists didn't cut ties with their country of

origin but instead built a chain of affiliations that linked nations together. Many researchers returned to their home country. Brain circulation may be a more apt term for the movement of contemporary scholars[3].

Different nations have different roles in the circulation of elite scholars (for which our proxy is highly cited researchers). But wherever they are, wherever they stop off and wherever they come from, mobile scholars have about 40% higher citation rates, on average, than non-mobile ones (see Supplementary Information; Table S7). Closing borders takes these elite scholars out of circulation.

Origin stories

Our study looks at the country stated in a researcher's affiliation when they published their first paper, and uses this as their country of scientific origin (this should not be confused with where they were born). We then track whether they moved or gained new affiliations in other countries over the eight years of this study.

The conventional idea of mobility focuses on migrant researchers — those who begin publishing in one country and then move to another, at some point discontinuing their attachment to the previous country. This group made up less than one-third of the mobile researchers in our study (27.3%, or 162,519 researchers). By far the largest proportion were those we call travellers: scholars who retain a footing in their country (or countries) of scientific origin throughout their career, while gathering up more international affiliations to add to their name (72.7%, or 433,375 researchers). Nearly half of the travellers are 'non-directional': they have more than one affiliation in their first year of publication, and they retain all these affiliations in each publication year.

Circulation networks that map the number and flow of researchers reveal the importance of the United States, United Kingdom, France, Canada and Germany as prominent nodes in the global scientific network (see Supplementary Figure S2). Isolation of these countries would have dramatic consequences. Although the United Kingdom is not particularly central to researcher migration in the European Union, it serves a crucial function in providing a bridge for European scientists to other areas of the world (see Supplementary Figure S2). Isolationist policies in the United Kingdom could deconstruct this network, redirecting scholars through other countries.

More patterns emerge if we look only at migrants and directional travellers who moved between and within continents, who first published in 2008, and who published at least eight papers during the study period. Admittedly, our short time window means that we focus on junior scholars. But it avoids conflating them with senior scholars whose movement and networking are likely to differ.

This group comprised 12,046 researchers. Europe provides the largest share (35%) followed by about one-quarter each from Asia and North America (see 'Making tracks'). The relationship between these latter continents is strong:

the majority of mobile scholars associated with an Asian address in their first publication in 2008 have a North American address by 2015, and more than one-third of mobile North American scientists end up in Asia. Both of these trends can probably be explained by the same underlying phenomenon — the influx of Asian students into the United States (some of whom publish before their arrival, and others of whom do so afterwards), and their subsequent moves back to Asia.

We see a 22% net loss of researchers from Europe, a 20% loss from Asia, and a nearly 50% gain for North America (see Supplementary Table S4). European scholars make up the largest population of mobile scholars in nearly every country, with the exception of Asian countries, where most scholars are drawn from North America (see 'Scientist shuffle').

It is also of interest to know the degree to which certain countries are responsible for the production and cultivation of high-impact scholars. We assess this by looking at citation scores for mobile researchers before and after their moves (see 'Trip adviser').

Countries in North America and Northern Europe act as strong producers: they put into circulation scholars who are well-cited before they move. The same countries are also strong cultivators, identifying talent early and providing fertile ground for scholars to achieve high impact once they arrive. Asian regions are strong recruiters, gaining affiliations with established scholars who were well-cited before their arrival. Oceania is a notable incubator, affiliated with scholars who realize high potential once they move on.

Some migratory routes tend to be associated with highly cited scholars. Those from North America with the highest impact tend to land in Northern and Western Europe and, to a lesser extent, in Southeastern Asia. Mobile, high-impact Northern Europeans are recruited to Southern Europe; mobile, high-impact Western Europeans are recruited to Oceania and Eastern Asia.

Mobile scholars from Oceania produce particularly high-impact work when they arrive in North America and Southern Europe. Central and Western Asian scholars (including those from countries implicated in the US immigration ban) realized their highest citation rates for work done in North

America and Europe. Barring scholars from these countries is likely to displace high-impact ones to other nations.

Regardless of region, mobility pays in terms of citations. Across all regions, mobile scholars are more highly cited than their non-mobile counterparts. The advantage varies by region. Mobile North Americans see only a 10.8% boost in citations over their non-mobile colleagues. For Eastern European scholars, the gulf is 172.8%.

Mobility measures

Of course, our method has limitations. We cannot tell if our 'country of academic origin' represents country of birth, of academic training or of academic employment — it reveals solely where an individual began publishing. If researchers from some countries tend not to publish first in a journal indexed in the Web of Science, then our measures would underestimate mobility from these places. Those we have counted as 'non-mobile' might really be 'pre-mobile' — meaning that they have not yet moved. Furthermore, examining less than a decade of papers, focusing on journal articles and adding restrictions for number of publications may privilege certain disciplines in the analysis. And our study does not look at mobility rates within each country: for large nations such as the United States, these might be significant and interesting.

Internationally comparable mobility indicators for the scientific workforce are particularly necessary in an era in which mobility is growing, complicated and increasingly threatened. We need indicators that provide more nuanced and dynamic assessments of the exchange of human capital and the effect of this exchange on the knowledge economy, particularly given that the 'travellers' in our analysis account for the majority of mobile scholars. This study provides a start.

It might be argued that collaboration can continue, even when mobility is restricted. However, despite advances in computing, collaboration tends to be initiated and sustained through interactions that happen in person[4]. Limiting mobility is likely to have adverse effects on the scientific system, which is

increasingly dependent on international collaboration[5].

Disruption of the existing network would have serious effects on many nations, including large science producers and cultivators such as the United States. The country benefits significantly both from its centrality in the global knowledge network, and from the educational investments of other countries. Its exceptional contributions are disproportionately made by researchers who are both foreign-born and foreign-educated[6]. Disconnection would also seriously affect those nations that benefit from the United States' role as a cultivator — it invests in researchers who come from Asia and elsewhere and later return home.

Some countries may see benefits, however: isolationism among central countries can lead to advantages for other competitive nations. For example, the number of graduate-student applicants to Canada has risen since the change in the US administration (see go.nature.com/2fjc4i). However, if adequate scientific capacity does not exist in these other countries, global talent will not be cultivated to the extent it is today. With good bibliometric standards to measure the impact of mobility, we can test the effects of these political changes in the decades to come.

One thing is already clear. Internationally mobile scholars are in the minority, yet show the highest impact across the globe. Limiting the circulation of scholars will damage the entire scientific system.

Journal name:
Nature
Volume:
550,
Pages:
29–31
Date published:
(05 October 2017)
DOI:
doi:10.1038/550029a

Supplementary information

PDF files

1. Supplementary information (1.6M)

Comments

Comments

There are currently no comments.

Open countries have strong science

04 October 2017

Caroline S. Wagner and Koen Jonkers find a clear correlation between a nation's scientific influence and the links it fosters with foreign researchers.

Spencer Platt/Getty

Nations that welcome international researchers and encourage cross-border collaboration tend to produce papers with high scientific impact.

International projects account for at least 20% of national government spending on scientific research. Some countries spend as much as 50% of these funds on international collaborations[1, 2]. The number of internationally co-authored papers is growing rapidly[2]. For countries at the forefront of

research, the fraction of papers that are entirely 'home grown' is falling[3].

Is there a connection? We analysed publication and citation data for 36 nations, along with government expenditures on science. We found that although government spending on research and development (R&D;) does correlate with the number of publications produced, it does not correlate with scientific impact — at least as assessed by citations, one of the few practical metrics available. What does correlate with impact is a country's openness, which we approximated by combining metrics of international co-authorship and the mobility of each nation's research workforce.

In 2016, we partnered with Jeroen Baas, head data scientist at Elsevier, the publication house that also runs the citation database Scopus, to examine nearly 2.5 million publications that were published in 2013 across all scholarly fields and that had three years' worth of citation data available. Publications and a field-weighted citation index were apportioned to countries according to authors' locations. (So if two-thirds of the authors on a publication were in the United Kingdom and one-third in Singapore, those fractions were applied to determine the publication count and citations assigned to those countries for that paper.)

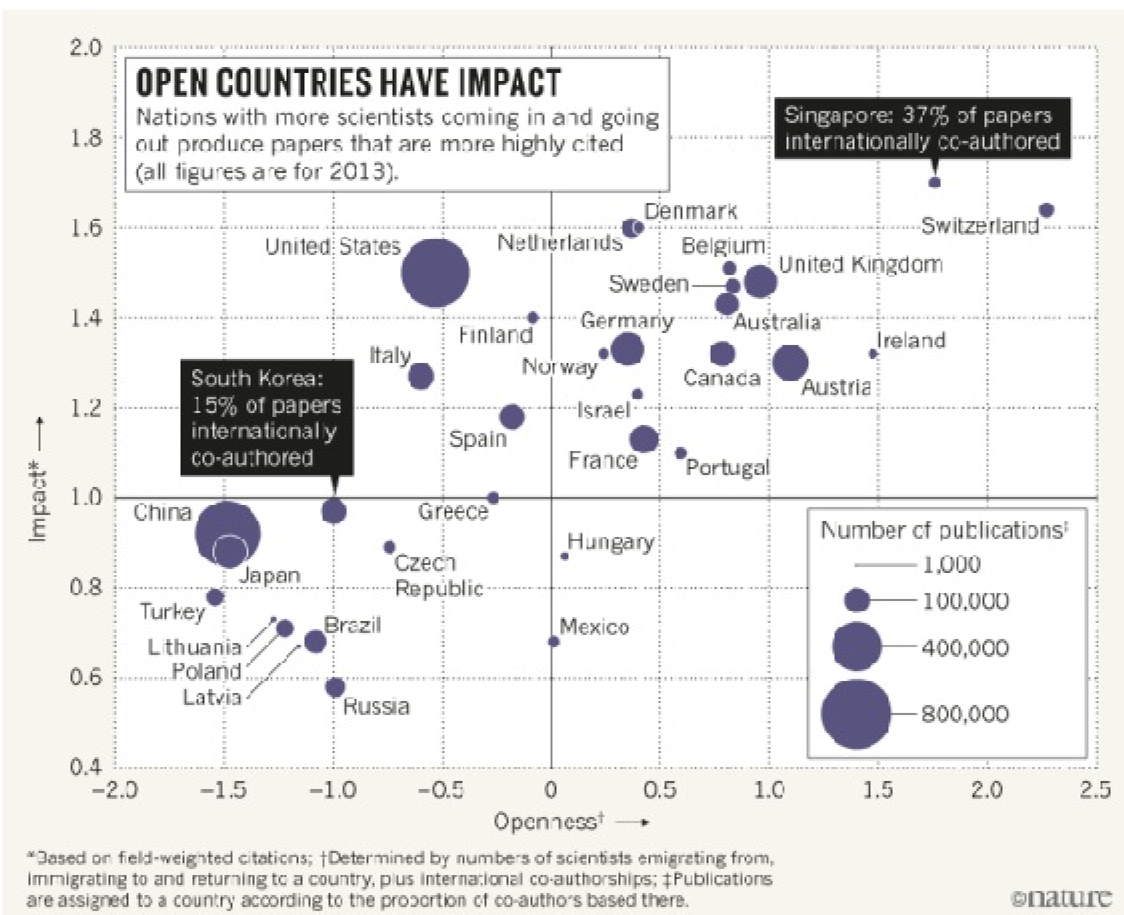
In terms of papers published, the United States and China dominate. For 'international papers' (those with authors from more than one country), the United States still leads, followed by the United Kingdom, China, Germany, France and Canada. When international papers are considered as a percentage of all of a country's papers, Switzerland (42%) appears as the most connected country, followed by Belgium (38%), Singapore (37%), Austria (36%) and Denmark, the Netherlands and Sweden (all 34%). In terms of impact for international papers, Singapore tops our list, followed by the United States, and then Sweden, Belgium, Switzerland and the Netherlands.

We looked for factors that could explain this. In addition to international collaboration, scientific mobility was expected to contribute to impact[4]. So we also considered new researchers coming in, returnees and emigrating researchers, all of which are tracked by the Organisation for Economic Co-operation and Development (OECD). These variables, together with collaboration, proved to be highly correlated as measures of international

engagement; so we used them to create an index of openness and were able to assign values to 33 of the countries that we looked at (data available at go.nature.com/2fzrnt3).

To assess whether government R&D; spending (as tracked by the OECD and Eurostat, the statistical office of the European Union) and our openness measure explained the relatively higher impact for smaller countries, we used a Pearson correlation analysis, which allows comparisons to be made across a large quantitative range, such as the publication output of the United States versus that of Singapore.

Public R&D; funding is tied to publication output: the more money spent, the more articles produced (counting sole-authored, co-authored and internationally co-authored). But we found only a weak correlation between spending and impact. In other words, more government funds spent does not necessarily result in more citations.



Countries that are highly 'open' and that produce high-impact research seem to benefit from participating in international collaboration. This is seen in the higher impact of smaller nations, which cluster in the top-right quadrant of the graphic (see 'Open countries have impact'). Singapore, the United Kingdom, the Netherlands, Switzerland, Sweden and Denmark all scored highly on this measure as well as on citations. The correlation between openness and citation impact was tight ($r^2 = 0.7$ according to a regression analysis) regardless of R&D; spending or numbers of articles published.

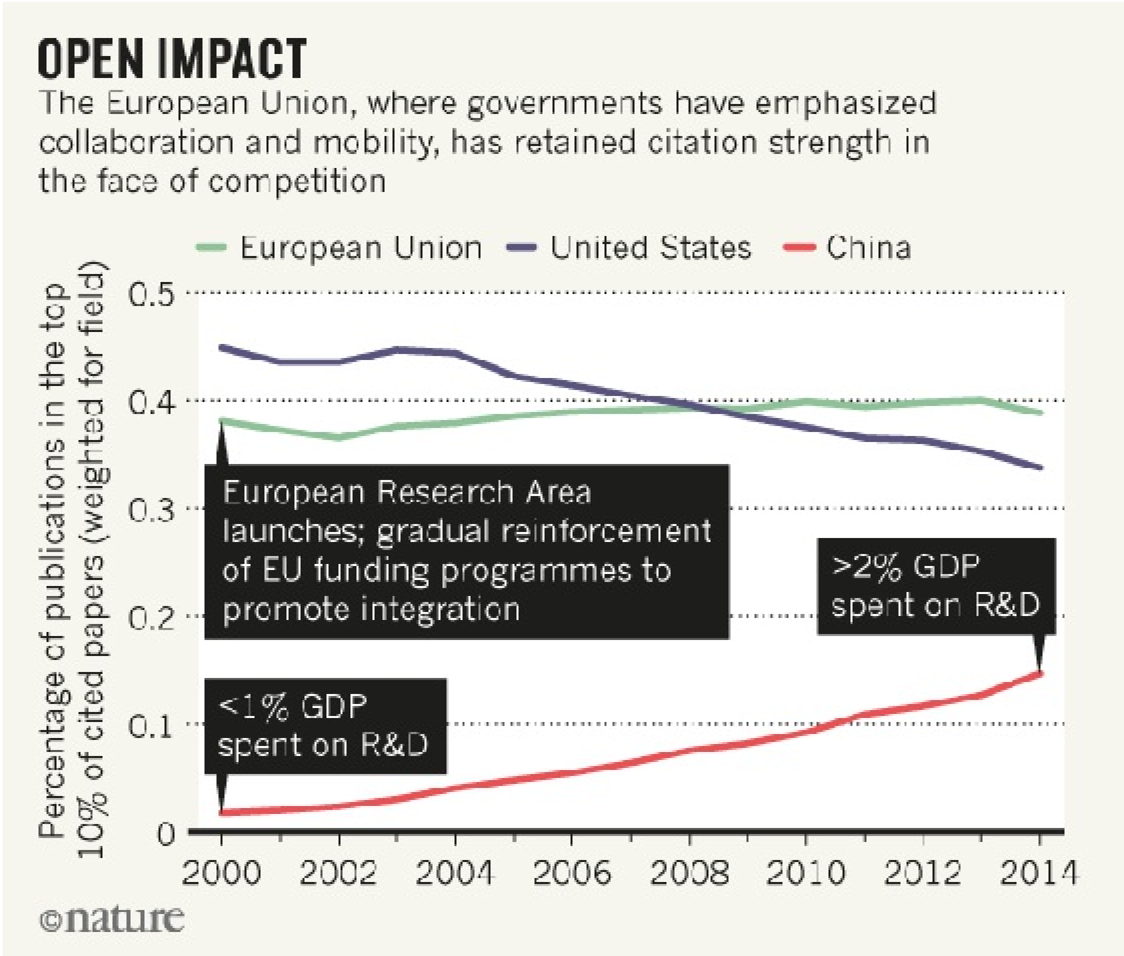
Countries with low openness and low impact include Russia, Turkey and Poland, China, Japan, Latvia, Lithuania, the Czech Republic and, against expectations, South Korea (which spends a higher percentage of its GDP on R&D; than almost every country, including the United States) These countries are shown in the lower-left quadrant.

The United States scores highly on impact, but less so on openness — perhaps because of the magnitude of its scientific enterprise and its geographic distance from possible collaborators. Of our 33 countries, only 4 (the United States, Italy, Spain and Finland) have low openness and high impact, and only 2 (Hungary and Mexico) have high openness and low impact.

Our analysis suggests that openness is related to impact, although we recognize that correlation is not causation. Nevertheless, we note that many of the countries whose scholarship has high impact, and whose policies encourage international engagement, are from Europe. The EU has established the European Research Area (ERA). Its governments have been implementing measures to strengthen domestic research systems while also promoting both international collaboration and mobility. The EU's Framework programmes have similar aims — one of the current stated objectives of EU research policy is to be more “open to the world”.

Analysis of citation strength for countries in Europe shows that they have greatly enhanced their impact compared with the United States (see 'Open impact'). As a bloc, the EU now outperforms the United States. Both far exceed China in impact, although China's share of high-impact papers is growing rapidly[5]. Other countries that promote openness also perform well in

terms of impact: examples include Singapore and Australia.



EU Joint Research Centre Tools for Innovation Monitoring, based on Scopus data release August 2016

Some will argue that citation is not synonymous with quality or importance, but it does signal engagement and recognition. Studies dating as far back as 1992 show that international papers are, on average, more highly cited[6]. The countries that are engaging internationally are seeing a dividend in terms of attention to their research.

It may be that the exchange of ideas encourages greater creativity, or that a virtuous cycle of quality work attracts others to work with those in higher-impact countries. In fact, we had very similar results when we considered each component in our openness metric separately, although most of the

effect of the mobility variables is mediated by international collaboration. Analytically, it makes sense to combine these into a single variable. However, other factors — such as the ease of obtaining visas or support to study in a country — are not explicitly incorporated.

In Japan, especially, output and citation impacts have remained flat since 2000. Japan is also among the least internationalized of leading nations, and this could be dragging on its performance. Lack of professional mobility, as well as language barriers, may be hindering engagement.

Our analysis suggests that national funding programmes should, whenever possible, move away from policies that fund only national researchers. In the longer term, countries could benefit more by funding the best science, wherever it is, and ensuring that domestically based scientists are linked with it. Restricting the movement of researchers — by limiting exchange opportunities or imposing visa restrictions, for example — could be counterproductive.

Just as industries make 'build or buy' decisions, so governments must make 'link or sink' decisions about research investment. Our data add to a growing body of work about the changing science system, indicating that science policymakers who seek to enhance impact should prioritize international exchange.

Journal name:
Nature
Volume:
550,
Pages:
32–33
Date published:
(05 October 2017)
DOI:
doi:10.1038/550032a

Comments

Commenting is currently unavailable.

| 章节菜单 | 主菜单 |

Collaborative software development made easy

Save time and protect critical code with 'continuous integration' services.

04 October 2017

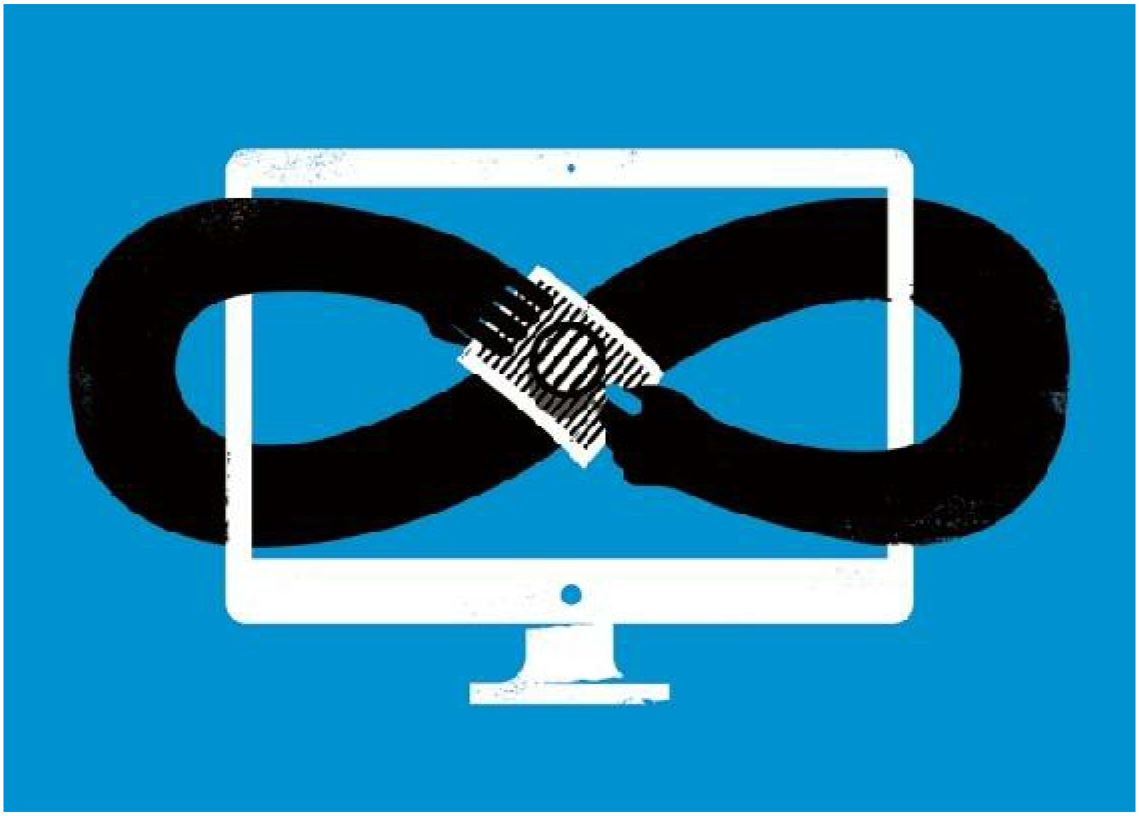


Illustration by the Project Twins

Sebastian Neubert, a particle physicist at Heidelberg University in Germany, leads a group studying subatomic particles called pentaquarks. The six team members all have access to the software code used to run their multi-step analyses, and the programmers update it daily with new features and bug fixes. With each code change, however, they run the risk of introducing

inadvertent errors that foul the underlying algorithms.

To prevent that, the team checks and rechecks the analyses, and uses error-checking algorithms, functions they can call whenever a change is proposed, to ensure that their software works as intended. One test, for example, verifies that a noise-cancelling algorithm gives the correct output when it is run on practice data.

In 2015, in an effort to save time and resources, the team took inspiration from the technology industry, automating their testing using a process called 'continuous integration'.

In continuous integration, changes to software code automatically trigger repetitive tasks, such as error-checking. Fundamentally, the process simplifies a task that diligent coders already perform. Programmers usually write lists of tests that they will run periodically to ensure that their code still works, just as Neubert's team do. But a busy team might forget or lack the time to run them, allowing errors to creep in. Continuous integration automates that process so those checks run whenever a change is proposed, saving team members the time they would spend hunting down an error. A team running genomic analyses could spend more time at the bench, while a group developing climate-prediction software could better refine its models. That said, the resulting peace of mind is only as good as the tests themselves: a poorly designed test can still allow mistakes to pass undetected.

The process is common in the commercial and open-source sectors. A study presented at the 2016 IEEE/ACM International Conference on Automated Software Engineering in Singapore found that about 40% of the 34,544 most-popular open-source projects hosted on the coding collaboration site GitHub used continuous integration in some form.

Only a few of those open-source projects might be considered scientific software, but an increasing number of scientists are looking to continuous integration to automate all sorts of time-consuming tasks, from testing code to updating documents with the latest data.

Researchers at institutions such as CERN, Europe's particle-accelerator laboratory near Geneva, Switzerland; the Pacific Northwest National

Laboratory in Richland, Washington; and the Ontario Institute for Cancer Research in Toronto, Canada, have embraced the practice, but adoption in the scientific sector remains relatively sparse.

For Neubert, continuous integration ensures that the pipeline's behaviour remains correct and consistent as his team refines its code, providing an “incredibly valuable” safeguard. “There is a real danger of just missing something or making a slight mistake,” he says.

Exceptions

A variety of continuous integration services exist. These include the open-source Drone, and commercial options such as CircleCI, Codeship, GitLab, Shippable and Travis CI, all of which offer pricing tiers based on the desired testing behaviour, number of users and whether the project is public or private. Travis CI, for instance, is free for open-source projects; private projects cost from US$69 per month. Shippable offers a free basic service for public projects, but charges $25–150 per month for support for private projects and greater computing power, among other features.

Researchers should consider what is a suitable and worthwhile investment, however. Not every project needs continuous integration and setting up and configuring a service can be challenging. Further difficulties can arise if the services need to interact with software or data with legal restrictions on its use, says Daniel Himmelstein, a data-science postdoc at the University of Pennsylvania in Philadelphia.

Also, code is often used only once, making the cost even less worthwhile. “For day-to-day research coding, the amount of code is not large enough to make continuous integration valuable,” says Andrea Zonca, a specialist in high-performance computing at the University of California, San Diego. He uses Travis CI when publishing code, but most that he writes is for his own one-time use and is not executed again.

Computing costs can also mount if code is being constantly updated and requires repeated testing, which is why Neubert's lab only tests its most

critical data analyses after code changes.

Despite these challenges, continuous integration services tend to improve code quality, says Björn Grüning, a bioinformatician at the University of Freiburg in Germany, especially on large projects such as Galaxy, a bioinformatics toolkit that Grüning, along with about 160 others, contributes to.

According to Grüning, continuous integration has shortened the turnaround time for approving contributions to the Galaxy project and given programmers more confidence when submitting new features and fixes. Before these services were available, it was often impractical for researchers in such projects to test every new feature collaborators proposed because they didn't have the time, he says.

Some researchers use continuous integration to automate non-programming tasks. In April, as part of a project studying how ecosystems change over time, Ethan White, an ecologist at the University of Florida in Gainesville, helped to configure Travis CI to update tables and plots automatically with new field or weather-station data, saving the research team up to 5 hours a month.

Continuous integration helps Himmelstein automate revisions to scientific papers, citations and web pages following text or code updates. Without continuous integration, he says, human maintainers would probably “get lazy and update the manuscript less frequently than every change”.

Initializing

Whether hosted externally by a third party or on a user's own machine, the continuous integration service is controlled with a custom set of instructions. This configuration file defines the tasks to be run and sets up the server with the correct environment — the operating system and software libraries — required to run them. The service then executes those instructions at set times or on receipt of a code or data update.

University of Pennsylvania bioinformatician Casey Greene, who uses

continuous integration to rerun his data analyses, has tested many of today's most popular services. “The good news about all of these services is that they're quite similar,” he says.

Subtle differences do exist, for instance in the number of concurrent jobs users can run, or the amount of computing power available to run them. “I'd encourage people to dig into the limits of each service to make sure they are compatible with their workflows,” advises Greene.

Although continuous integration adoption in science right now is small, it is growing, and more researchers should get on board, Greene says. Getting up to speed takes time, he acknowledges, but often, the effort is worth the reward. “Scientists analysing data should have it in their toolbox.”

Journal name:
Nature
Volume:
550,
Pages:
143–144
Date published:
(05 October 2017)
DOI:
doi:10.1038/550143a

Comments

Comments

There are currently no comments.

A taste of Toolbox

Nature's technology editor, Jeffrey Perkel, started blogging about workplace technology in science in 2016. Here are some highlights.

04 October 2017

From stadiums to genomes

Most bioinformaticians are either biologists skilled in programming or programmers with an interest in biology. Mike Goodstadt, the programmer behind the 3D genome-visualization tool TADkit, took a different approach. In the early-to-mid 1990s, Goodstadt was a student at the University of Bath, UK. His course of study? Architecture, with an emphasis on 3D modelling. After graduation, he helped to design and build a 61,500-seat stadium. But a faltering economy and newly acquired programming skills helped to steer him towards biology.

Lorena Barba, reproducibility champion

Lorena Barba, a mechanical and aerospace engineer at George Washington University in Washington DC, has long championed research reproducibility. “I've always believed that the open-source model is ideal for science, as it exposes the complete sequence of steps that produces a given result,” she says. In January, she travelled to Chile to run a week-long course on reproducible research computing. The month before, she had been awarded a 2016 Leamer-Rosenthal Prize, which celebrates those “working to forward the values of openness and transparency in research”. In this Q&A;, she talks flying snakes, 'repro-packs' and copyright.

The sound of DNA

With an alphabet comprising just four letters, a DNA sequence isn't much to look at. So when sequence-analysis tools want to highlight key elements, they typically do so using colour or font, or by overlaying other types of information. In the not-too-distant future, there may be another option. Molecular biologist and part-time drummer Mark Temple at Western Sydney University, Australia, describes DNA sonification, “an auditory display tool” for DNA: sequence in, audio out. “I'm not saying audio by itself is the bees' knees for interpreting DNA sequence,” Temple says, “but surely audio can contribute to your visual interpretation.”

Journal name:
Nature
Volume:
550,
Pages:
144
Date published:
(05 October 2017)
DOI:
doi:10.1038/550144a

Comments

Comments

There are currently no comments.

South Korea cracks down on dirty air

Despite huge clean-up effort, scientists say country’s pollution problem could get worse over next five years.

03 October 2017

Ed Jones/AFP/Getty

South Korea's capital, Seoul, ranks among the world's most polluted cities.

In a major attempt to clean its increasingly dirty air, South Korea’s government last week unveiled a five-year, 7.2 trillion won ($6.3 billion) plan to close down old coal plants, get diesel vehicles off the road and curb polluting emissions from industrial plants, construction sites and ships.

Although much of the spending had already been pledged, researchers say that the new strategy, announced on 26 September, is the country's most ambitious attempt yet to scrub its air. But because it omits controls on a class of chemicals called volatile organic compounds (VOCs), the initiative might make air quality worse before it improves.

The plan fulfils a key campaign pledge by President Moon Jae-in, who was elected in May by a Korean public increasingly concerned about their country's worsening air quality. At times this year, Seoul ranked among the world's top three most polluted cities. And the Organisation for Economic Co-operation and Development (OECD), based in Paris, reports that in 2015 South Korea's average exposure to fine-dust particles under 2.5 micrometres in size was the highest of all OECD member nations. This particulate matter, known as PM2.5, is small enough to enter the lungs and can cause respiratory illnesses.

The government hopes to cut domestic emissions of PM2.5 by 30% before 2022. Moon's administration has already focused on shutting down coal plants, temporarily closing eight of them in June and beginning the permanent shutdown of three in July. And the previous administration of Park Gyun-Hye had pledged 5 trillion won by 2020 to speed the adoption of electric cars to replace diesels.

NOx-ious crackdown

But the new strategy also aims to crack down on emissions of nitrogen oxides (NOx), which can react with other atmospheric compounds, including VOCs, sulfides and ammonia, to form ozone and fine-dust particles. Large industrial facilities such as steel plants and petroleum refineries will be fitted with monitoring equipment and held to a cap on their NOx emissions starting in 2019, the environment ministry's deputy director JaeHyun Kim says.

That approach has been informed in part by data released in July from a joint US–South Korean study called KORUS-AQ[1], says Kim. The most comprehensive examination of air quality in the region, it involved more than 580 researchers from the United States and South Korea, as well as several

research aircraft, including a NASA DC-8 jet that flew across the Korean peninsula and the Yellow Sea. Researchers found that South Korea was emitting more NOx and VOCs than its own ministry estimated, and recommended reductions in these chemicals. This highlighted the importance of addressing South Korea's domestic pollution, says Kim, at a time when many in the country were more concerned about pollution blowing over from China.

The focus on NOx means the new plan is "a lot better than before", says Kyung-Eun Min, an atmospheric chemist at the Gwangju Institute of Science and Technology. But she and other scientists point out that it says little about curbing VOCs. These are typically aromatic molecules produced for activities such as painting, printing and dry cleaning. A compound called toluene, used to manufacture solvents, is particularly instrumental in producing fine dust and ozone, the KORUS-AQ study found. The VOCs often leak during production, or while being stored or used by small businesses.

Ozone up?

Paradoxically, Min says, reducing NOx without reducing VOCs is likely to increase ozone across much of South Korea. That is because, according to the KORUS-AQ results and Min's own work, relative levels of NOx are so high in Korea — especially in car-filled Seoul — that they restrict the efficiency of ozone production, much as an over-rich fuel mixture makes an engine sputter. The quickest way to cut ozone is to starve it of both NOx and VOCs, "but the VOC part is not really there," Min says. However, regions downwind of Seoul may benefit more quickly from NOx reductions, says Rokjin Park, an air chemist at Seoul National University.

Tracking VOC emissions is particularly difficult, because there is no clear way to monitor or regulate small businesses such as painters and dry cleaners. A first step would be to collect data to nail down where South Korea's VOCs are coming from, Min says. In the longer term, she suggests developing technology that can capture dirty air from such emissions sites so that it can be purified at treatment facilities — in a process analogous to sewage treatment.

Yong Pyo Kim, an environmental scientist at Ewha Womans University in Seoul and an author of the KORUS-AQ report, says he thinks that both ozone and fine dust could get worse for the next five years. “In my opinion, the environment ministry did not learn from the KORUS-AQ results seriously,” he says. The South Korean environment ministry has not responded to requests for comment from *Nature* about the criticisms.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22448

Comments

Comments

There are currently no comments.

Xenon view, butterfly wings and a strange squid

September’s sharpest science shots, selected by *Nature*’s photo team.

03 October 2017

CRISPR catches

Richard Wallbank/Smithsonian Institution and University of Cambridge

The beauty of butterfly wings owes much to just two genes, researchers revealed this month. They used the CRISPR gene-editing system to turn off the genes, called *WntA* and *optix*, to show how their absence dulls the colours

of these fleeting flyers. Left are the wings of an unmodified Sara longwing (*Heliconius sara sara*) from the study; right is a gene-edited version.

Inside Xenon

Image Slideshow

1. 

   Winner of a gold award in the 2017 International Images for Science competition, this picture by Enrico Sacchetti shows the interior of the Xenon1T experiment at Italy's Gran Sasso Laboratory, which hunts for dark matter.

   Enrico Sacchetti/Royal Photographic Society

2. 

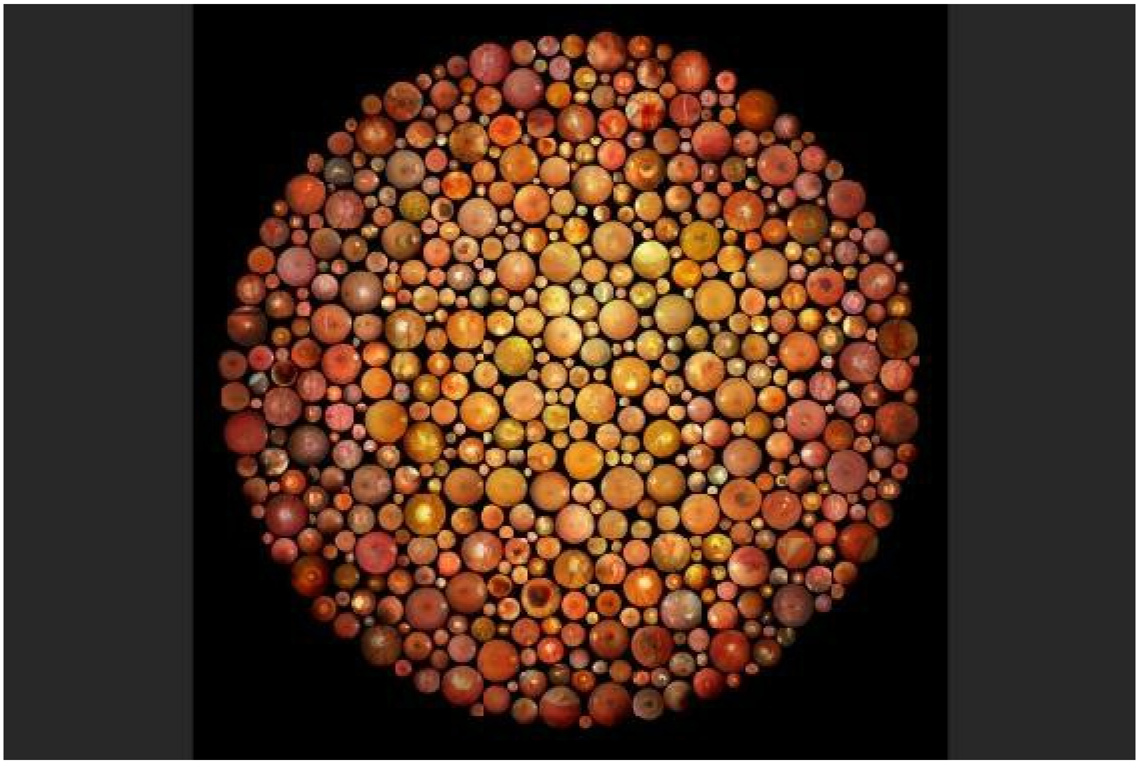
Another gold-award winner, this one taken by Teresa Zgoda. What looks like a frightening visage is actually a close-up of a pork tapeworm (*Taenia solium*), showing in detail the suckers that allow it to stick to the inside of humans and grow — and grow, and grow.

Teresa Zgoda /Royal Photographic Society

3. 

These legs belong to impalas (*Aepyceros melampus*); the black patches are glands used for scent marking. This image from Morgan Trimble won a bronze award in this year’s competition.

Morgan Trimble/Royal Photographic Society

4. 

This shot is a combination of hundreds of images of retinas shot by Jonathan Brett, and assembled to mimic a colour-vision test chart. The eyes took a silver award.

Jonathan Brett/Royal Photographic Society

Coming down…

Bill Ingalls/NASA

At the start of the month, this Soyuz capsule brought back three astronauts to Earth, landing near Zhezkazgan in Kazakhstan. Among them was Peggy Whitson, who spent 288 days in space aboard the International Space Station.

… and going up

Bill Ingalls/NASA

Ten days after Whitson and her colleagues returned to this planet, another three people left it when this Soyuz left for the space station from Baikonur Cosmodrome.

A complex cloud

Artem Mironov

This nebula — called the Rho Ophiuchi cloud complex — is 140 parsecs (460 light years) from Earth. Photographer Artem Mironov took three nights to capture this image of it, which went on to win this year's Insight Astronomy Photographer of the Year award.

Seamount squid

NOAA Office of Ocean Exploration and Research

On 17 September, the crew of the US National Oceanic and Atmospheric Administration's ship *Okeanos Explorer* were exploring the Musicians Seamounts, a formation of undersea mountains in the Pacific Ocean, with remotely operated submersibles when they spotted this cranchiid squid. You can see more pictures of weird and wonderful deep-sea denizens on their diary site.

Bee bounty

Image Slideshow

1. 

The USGS Bee Inventory and Monitoring Lab in Laurel, Maryland has long been among our favourite purveyors of online insect images. Among the latest additions to its catalogue is this *Hoplitis fulgida*.

Anders Croft/USGS Bee Inventory and Monitoring Lab

2. 

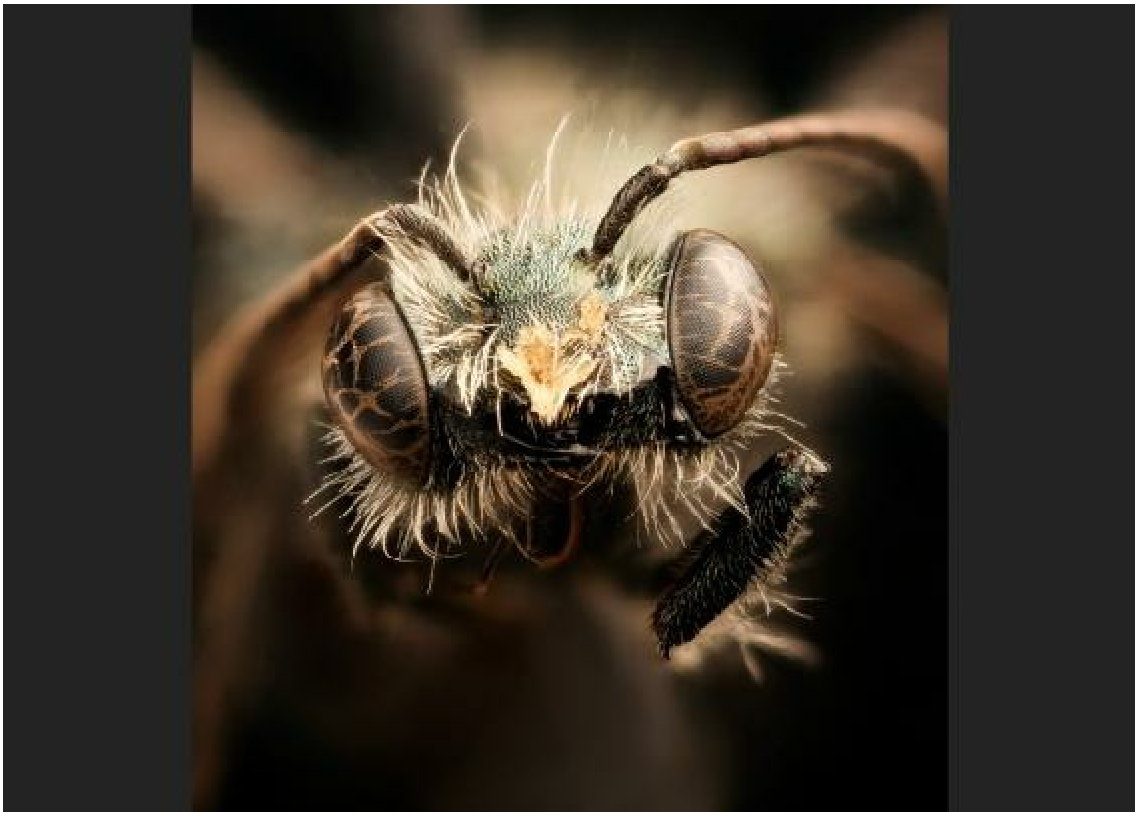
Another shot of *H. fulgida*, collected in Yosemite National Park, California.

USGS Bee Inventory and Monitoring Lab

3. 

Dianthidium singulare glues rocks together to make little houses for its eggs. The lab calls it a “boss looking bee”, and it’s hard to disagree.

USGS Bee Inventory and Monitoring Lab

4. 

The lab says this mason bee *Osmia subarctica* is a terrible specimen, but it has photographed beautifully.

USGS Bee Inventory and Monitoring Lab

Cassini comedown

NASA/Joel Kowsky

It is finally over. The Cassini mission this month dived into Saturn’s atmosphere, destroying itself. In this photo, Cassini programme manager Earl Maize packs up his workspace at mission control in the Jet Propulsion Laboratory in Pasadena, California. on 15 September.

They grow up so fast

Online Tracking of Arabidopsis Root

Arabidopsis thaliana, or thale cress, is widely used as a model organism in labs. Daniel von Wangenheim of the Institute of Science and Technology Austria in Klosterneuburg won first place in the Nikon Small World in Motion Photomicrography Competition for this remarkable time-lapse video of the root tip of one *A. thaliana* plant growing.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22741

Comments

Comments

There are currently no comments.

Europe’s Joint Research Centre, although improving, must think bigger

External report criticizes lack of exploratory research.

03 October 2017

Sean Gallup/Getty

Europe’s Joint Research Centre first raised awkward questions about diesel car emissions.

The European Union’s Joint Research Centre (JRC) uses the label EU Science Hub now. Whether the rebranding will increase its profile is one

question. What science gets done inside this hub is another. In response to that query, there is some positive news. It is doing what it should be, and doing it well: collecting scientific and technical evidence in support of EU policies. That's according to the report of an external evaluation released this week. Furthermore, EU research commissioner Carlos Moedas praised the JRC at its annual public meeting on 26 September for contributing to the interminable struggle to counter false information and communicate science effectively to a sceptical public.

The JRC employs more than 2,000 scientists, who generate or collate a constant feed of information for authorities and politicians. In theory, this helps to support evidence-based policies — from the old chestnuts of genetically modified (GM) crops and nuclear safety to the ongoing refugee crisis, for which it holds a repository of relevant information and reliable statistics. Yet most of this work fails to reach public attention. For example, staff in the JRC transport section had worked out and published evidence that car makers were manipulating diesel-emission data years before the public scandal over Volkswagen finally broke in 2015.

The JRC celebrates its 60th anniversary this year. It has become a complex beast, operating at six sites in five EU countries, with a budget this year of €372 million (US$437 million). It was originally set up as a nuclear research organization, but widened its remit over the decades, adding institutes. Twenty years ago, it morphed into a centre with an explicit mission to provide support for a wide range of EU policies. But by that time it had lost its way, and tough reforms were introduced. A 2009 evaluation led by former UK government science adviser David King concluded that it was carrying out its new remit well, but criticized it for doing too little independent research of the type required to attract and keep the best scientists.

The new report, headed by the former Irish government science adviser Patrick Cunningham, echoes this call. It acknowledges how rapidly the centre has broken out of its much-criticized institute-based silos to restructure thematically into cross-site departments, such as energy and health, which more directly mirror policy areas. It also notes that the JRC has significantly increased its presence in the world's top-cited literature. But it says that the centre still does too little exploratory research — such research engages only

3.5% of JRC staff, well below the target of 10% that it set itself in 2015.

Why has it struggled? Although it has established partnerships with European universities and research institutes, and aided the exchange of scientists, many JRC researchers have different motivations from those of colleagues in universities. There is much satisfaction in contributing to policies that influence the lives of people in the EU. But officials and staff must look again at their priorities. As well as keeping the JRC relevant, a wider focus on the cutting edge would allow it to flag up hot topics to policymakers earlier.

But what policymakers do with the information they receive from their science service is another matter entirely. EU policy on GM crops is notoriously weak — scientific evidence for their safety has failed to convince some countries, whose citizens viscerally reject the technology. And sometimes the EU’s intrinsic political weakness can block the implementation of its science-based policies. After all, the European Commission and EU member states ignored the findings on diesel emissions, and acted only after regulators in the United States cracked down.

Journal name:
Nature
Volume:
550,
Pages:
8
Date published:
(05 October 2017)
DOI:
doi:10.1038/550008a

Comments

Comments

There are currently no comments.

| 章节菜单 | 主菜单 |

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Make plans to eliminate cholera outbreaks

Governments must stop denying the occurrence of cholera and unite in long-term prevention strategies, says Anita Zaidi[1].

03 October 2017

As a medical student in Karachi in the 1980s, I saw cholera all the time. We had a dedicated diarrhoea ward in the hospital, and if there was an increase in diarrhoea cases in children aged over 3, we knew we had a cholera outbreak. Over the past decades, the world has become much better equipped to fight cholera, yet the disease continues to spread across sub-Saharan Africa, Asia and the Caribbean.

In Yemen, cholera has killed more than 2,000 people and infected nearly 700,000 in the past 5 months alone, eclipsing the post-earthquake outbreak in Haiti. Haiti still battles with the disease 7 years after its reintroduction. Meanwhile, Somalia is experiencing its worst outbreak in five years. South Sudan continues to fight its worst outbreak since it gained independence in

2011. If nothing changes, cholera will continue to claim some 100,000 lives a year and afflict around 3 million people, many of them children.

This week, the World Health Organization (WHO) launches a campaign to eliminate cholera outbreaks by 2030. The plan could move countries beyond ad hoc reactions, to sustainable prevention.

The disease is caused by the bacterium *Vibrio cholerae* and spreads mainly through contaminated water. Infection usually causes no or mild symptoms, but in approximately one-tenth of cases it swiftly leads to watery diarrhoea, vomiting and cramps. Rapid loss of fluid can result in dehydration and death within hours. An oral rehydration solution that costs cents can reduce fatality from a high of 50% to under 1%. Every year, it still fails to reach tens of thousands of victims in time.

Clean water, improved sanitation and better access to treatment have been game-changing for much of the world, but cholera is still thought to be endemic in 69 countries, including most of sub-Saharan Africa.

In the twenty-first century, no one should die from this disease. We have treatments and prevention strategies that work, including sufficient cholera-vaccine stocks. We know where outbreaks are most likely to start. To spread, cholera needs estuaries, rivers or coastal waters that are contaminated with faeces, and susceptible people living nearby; it has clear patterns of recurrence. What we need to do is get there first.

What’s stopping us? One barrier is stigma. Many national and regional governments don’t want to admit that their territory harbours cholera. Rather than controlling it, they hide it. The stigma goes back hundreds of years, to when ships with sick passengers were not allowed to dock and people feared being put in quarantine. Now the fears are public anger and loss of economic opportunities. Many countries with known endemic cholera in Asia and Africa report to the WHO that they have no cases, and in the face of an outbreak do not request cholera vaccines. In 2010, during the massive floods in Pakistan, my colleagues and I saw hundreds of cases of acute watery diarrhoea in Sindh that we confirmed to be cholera in our laboratory, but national health officials told us to keep it quiet.

Too many countries act only after a crisis has emerged: then they request vaccine campaigns, set up makeshift cholera clinics and urgently mobilize supplies.

These tactics can quell an outbreak and dampen transmission in the short term, but they don't stop outbreaks from happening again. For that, governments must intervene preemptively to control cholera in places where it recurs frequently. Since the WHO cholera-vaccine stockpile was established in 2013, almost 13 million doses have been delivered. Millions more doses should have been requested.

To truly stop cholera outbreaks, countries must do two things: deploy vaccines where cholera is endemic and strengthen the infrastructure that provides clean water and good sanitation.

Events in Malawi give reason for optimism. In April this year, the country adopted a national plan to control and prevent cholera that directs vaccines to affected communities identified by geo-spatial mapping. More than 2 million citizens have been vaccinated ad hoc since 2015. The new plan, made possible by strong political commitment at the Ministry of Health, collates two decades' worth of information to better estimate cholera burden, identify hotspots and support early intervention. At the same time, Malawi is planning to strengthen water and sanitation infrastructure. Experts are hopeful that this will reduce the country's cholera burden to its lowest level in years.

Similarly, the WHO Global Task Force on Cholera Control is launching a renewed strategy to eliminate cholera outbreaks worldwide. Unlike past efforts, this plan goes beyond responding to cholera flare-ups: it encourages countries to invest in protecting people from cholera over the short and long term.

The success of the WHO's plan ultimately depends on the commitment of governments worldwide. All governments, whether or not they are directly affected by cholera, must unite and increase their political and financial investment in cholera prevention and control.

The first cholera pandemic, in 1817, swept across South Asia, East Africa, the Middle East and Europe, claiming hundreds of thousands of lives. Back

then, we had no vaccine and a limited understanding of transmission. It is unacceptable that, now, in that pandemic's 200th anniversary year, a disease we know how to fight remains out of control.

Journal name:
Nature
Volume:
550,
Pages:
9
Date published:
(05 October 2017)
DOI:
doi:10.1038/550009a

Comments

Comments

There are currently no comments.

Ethics of Internet research trigger scrutiny

Concern over the use of public data spurs guideline update.

03 October 2017

Matt Cardy/Getty

A Banksy artwork in Cheltenham, UK. Scientists tried to find the artist’s true identity using public data.

British graffiti artist Banksy is renowned for his anonymity. But that status was dented last year when researchers published a paper that cross-referenced the locations of Banksy’s street art with public information about people’s

addresses and likely movements ([M. V. Hauge *et al. J. Spatial Sci.* **61,** 185–190; 2016]). The team, led by academics at Queen Mary University of London, concluded that someone previously suspected to be Banksy probably was the secretive artist.

Because the study used public data, a university ethics committee said that the work was exempt from formal review — and informally advised academics that it would do no harm because a UK national newspaper had already identified the person in question as Banksy. But for some ethicists, the paper highlights growing concerns about the potential hazards of research that uses public data. “I think this study should never have been done,” says Jake Metcalf, a technology ethicist at the think tank Data & Society in New York City.

Metcalf is one of several academics calling for new guidelines to steer scientists through ethical quandaries in Internet research. The unprecedented availability of online data — together with tools to draw patterns from it, such as machine learning — is opening up research possibilities that outpace existing ethics frameworks around privacy, consent and harm, says Charles Ess, a research ethicist at the University of Oslo and a member of the Association of Internet Researchers. The association will discuss how to update its guidelines at its annual meeting on 19 October in Tartu, Estonia.

A flurry of similar initiatives is under way. Earlier this year, the SATORI project, funded by the European Commission, published recommendations on Internet research as part of an effort to standardize and update research-ethics guidelines. In September, the US National Science Foundation funded a US$3-million, 4-year study called PERVADE — of which Metcalf is a part — that aims to chart attitudes to data-research ethics, produce best-practice guidelines and create tools to assess the potential harms of such work. And some British universities are preparing their first guidelines on the ethics of Internet research, after the UK Research Integrity Office, a national advisory body, published non-binding recommendations about it last December.

Common themes among these efforts include rethinking what counts as ‘public’ data, the ethical use of social media and the need to consider a study’s potential harm to wider society, as well as to individuals. Many

countries have long-standing ethical checks for research that intervenes in human lives. But those principles, set up for medical and psychological studies, apply to research on human subjects, the definition of which often excludes Internet research, says Metcalf.

In the United States, for instance, studies using public data (which includes that purchased from a third party) generally do not count as human-subjects research because they don't access private, identifiable information about people. They don't need to be checked by an institutional review board (IRB) or require informed consent. Guidelines issued in 2013 add that researchers should sometimes consider seeking review — if a person incorrectly assumed that access to his or her public information was restricted, for example. But IRBs have no obligation to adopt these proposals, and different committees may come to different verdicts, says Metcalf.

Peter Hedges, head of the research-operations office at the University of Cambridge, UK, argues that even researchers who use information that is undeniably public, such as Twitter data, should review the ethics of their work. The SATORI guidelines advise that regulators and researchers should carefully consider whether publicly available information is actually private, and not fall back on simple classifications.

If someone's data are considered private and identifiable, that would usually mean obtaining their informed consent. But, in practice, such consent is often impossible to acquire for large-scale data studies, says Ess. And anonymizing data is difficult, because search engines can easily identify individuals from even small snippets of anonymized text or by cross-referencing them in multiple data sources. The SATORI guidelines recommend that researchers take precautions to ensure the anonymity of study participants, and Ess suggests that scientists can still, without too much effort, seek consent from anyone they explicitly quote in research papers.

When ethics committees do assess data studies, their viewpoint might be too narrow, says Ansgar Koene, an engineer and ethicist at the University of Nottingham, UK. They tend to consider the direct damage to an individual involved in research, rather than a project's potential to do widespread harm to society. That debate flared up in September when artificial-intelligence researchers at Stanford University in California posted a preprint of research

that predicted whether someone is gay from their photo; it used pictures sourced from an online dating site (see https://osf.io/zn79k). The study was approved by Stanford's IRB, but provoked condemnation from some advocacy groups for lesbian, gay, bisexual, transgender and queer (LGBTQ) people, which branded it dangerous. The study's lead author, Michal Kosinski, said the work aimed to protect people by exposing an existing threat from widely used technology. Kosinski and his colleague, Yilun Wang, discussed their results afterwards with representatives of the LGBTQ community, but Koene says that the discussion should have happened beforehand and the paper should have addressed their comments.

Computer science is a flashpoint for Internet-research ethics. Researchers in this field are not used to working with human study participants and often don't consider the ethical impact of their work, says Koene, who has surveyed approaches to ethics in different disciplines. A major concern, academics agree, is how companies use online data for research — much of which they have proprietary access to. In 2014, for example, Facebook altered users' newsfeeds without telling them, to study how this affected their emotions. A public backlash prompted Facebook to publish some details of its internal review process (M. Jackman and L. Kanerva *Wash. Lee Law Rev. Online* **72,** 442; 2016) — but there is little transparency overall about how this works, says Koene.

Researchers may not want to see their science slowed by formal ethical review, which can be time-consuming and opaque. Better ethics training is one solution, says Koene. But a failure to align data science with public perceptions of what is acceptable could generate a severe reaction, he warns. "The public will see us as no different from corporate or other special-interest groups pursuing a hidden agenda," he says.

Journal name:
Nature
Volume:
550,
Pages:
16–17
Date published:

(05 October 2017)
DOI:
doi:10.1038/550016a

Comments

Commenting is currently unavailable.

Gravitational wave detection wins physics Nobel

Rainer Weiss, Barry Barish and Kip Thorne share the 2017 prize for their work at LIGO to detect ripples in space-time.

03 October 2017

Left: Bryce Vickmark/MIT. Centre: Caltech. Right: Caltech Alumni Assoc.

Rainer Weiss (left), Barry Barish (centre), and Kip Thorne (right), who led work to detect gravitational waves.

Three physicists who had leading roles in the first direct detection of gravitational waves have won the 2017 Nobel Prize in Physics.

Rainer Weiss, at the Massachusetts Institute of Technology (MIT) in Cambridge and Barry Barish and Kip Thorne, both at the California Institute

of Technology in Pasadena, share the 9 million Swedish krona (US$1.1-million) award for their work at the US-based Laser Interferometer Gravitational-Wave Observatory (LIGO). In September 2015, LIGO picked up the deformations in space-time caused by the collision of two distant black holes.

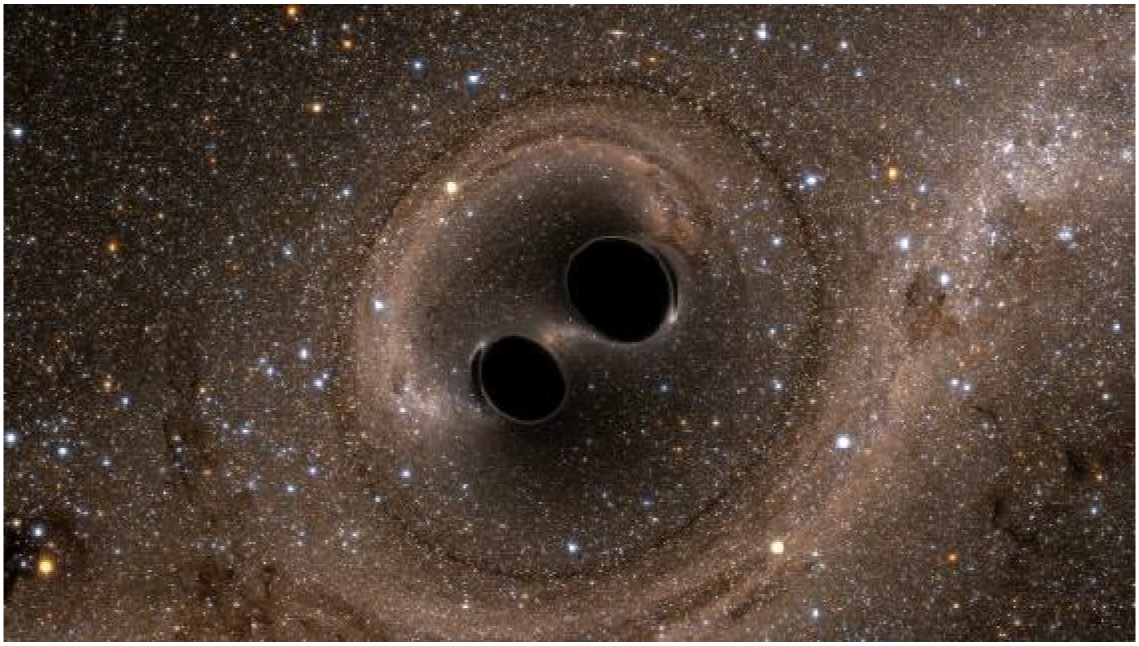
That discovery, which was announced in February 2016, opened up a new field of astronomy, in which scientists listen to the space-time vibrations emitted by some of the Universe's most cataclysmic events. And it confirmed the existence of gravitational waves, which Albert Einstein had predicted a century before.

Weiss and Thorne are two of three physicists known as the Troika — the founders of LIGO's giant twin detectors in Livingston, Louisiana, and in Hanford, Washington. The third troika member, Ronald Drever, died on 7 March this year. And Barish, who was LIGO director from 1997 to 2005, is widely credited with having transformed the collaboration from a chaotic endeavour to a well-oiled machine.

"I view this more as a thing that recognizes the work of about 1,000 people, a really dedicated effort that's been going on for — I hate to tell you — as long as 40 years," said Weiss in an interview with the Nobel Committee just after winning the prize.

"We were all very happy for them to be recognized. They worked on this for decades," says Gabriela Gonzalez, a physicist at Louisiana State University in Baton Rouge, and a LIGO team member and former spokesperson for the collaboration. The Nobel prize can be awarded only to a maximum of three people, but the Nobel Committee noted the huge numbers of people who worked on LIGO in its press release.

Researchers had been widely expecting the committee to reward the team since last year's detection announcement. "I'm very happy that they got the right people," says Charles Misner, a general relativity theorist at the University of Maryland in College Park. Half of the Nobel prize has been awarded to Weiss, with the other half split between Barish and Thorne.



The SXS Project

A computer simulation of two black holes colliding, which generates gravitational waves.

Unimpeded motion

Few physicists doubted the existence of gravitational waves before the LIGO discovery. The distortions in space-time are an inevitable consequence of Einstein’s general theory of relativity, and propagate across the Universe almost unimpeded. In 1974, they were confirmed indirectly when researchers examined the radio flashes emitted by a pair of merging neutron stars; the shifts in the flashes' timing matched predictions of how gravitational waves would carry energy away from the event. That discovery was rewarded with the 1993 Nobel Prize in Physics.

But sensing the waves themselves was a monumental task. Even the most powerful deformations — those produced by collapsing stars or colliding black holes — would typically be tiny by the time they reached Earth. The waves detected in 2015 stretched and squeezed LIGO’s perpendicular 4-kilometre vacuum pipes by a fraction of a proton’s width, but that was

enough to noticeably shift out of sync the laser beams bouncing inside the pipes.

Physicists in the United States and the then-Soviet Union first proposed using laser interferometers to detect gravitational waves in the 1960s. Weiss made the first detailed calculations for how an interferometer would work in 1972. The idea seemed so far-fetched that even he was not sure it would work. “It might come to a junction in a year or so when we will decide it ain’t worth it,” he told science sociologist Harry Collins at the time[1].

Weiss, who was born in Germany in 1932, emigrated with his family to the United States in 1938 to escape from Nazism. He built his first prototype interferometer in the mid-1970s, soon followed by researchers in Europe — among them, Drever and his collaborators at the University of Glasgow, UK, and another group in Munich, Germany.

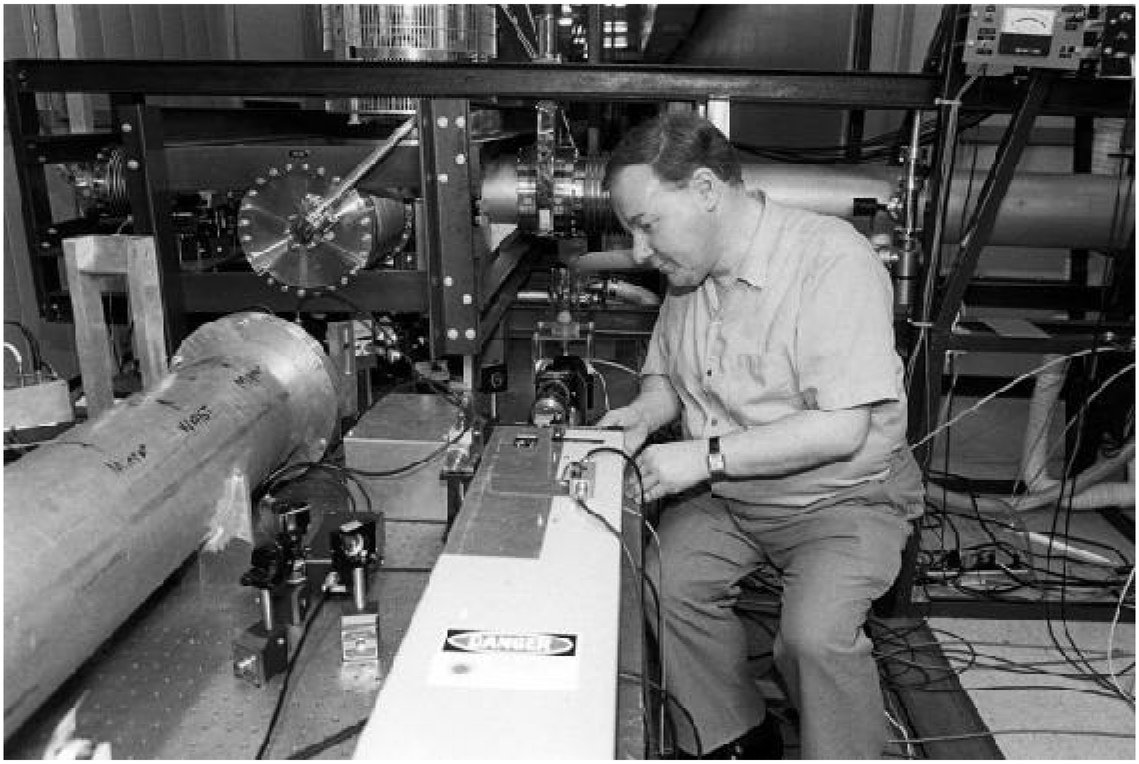
Thorne, born in Utah in 1940 to Mormon parents, specialized in general relativity and had also been developing ideas on the waves. At a conference in Washington DC in 1975, Thorne and Weiss shared a room in an over-booked hotel. During their conversations, Weiss convinced Thorne that interferometers were the right approach. Thorne, Weiss and Drever joined forces in the early 1980s, when it became clear that the US National Science Foundation would not fund two separate efforts, and the LIGO collaboration was born.

Dramatic turn-around

The troika did not always work smoothly and, at their own admission, did not possess the right skills for managing what was quickly becoming a vast operation. Things improved dramatically after Barish, who had been LIGO’s principal investigator since 1994, became director in 1997. Collins, who has closely studied the collaboration for decades, says that Barish turned LIGO into a ‘big science’ organization. “Without Barish turning things around, it would have collapsed,” he says.

LIGO initially struggled to get funded, but ended up being the largest and

most expensive experiment in the history of the US National Science Foundation. Its two nearly identical detectors first opened in 2002, with an admittedly scant chance of detecting anything during their first phase of data collection. The observatory shut down in 2010 for a major overhaul, and restarted in September 2015, three times more sensitive than before.



Bob Paz/Caltech Archives

Ronald Drever was one of the original co-founders of the LIGO project; he died in March 2017.

Researchers were cautiously optimistic of a discovery within a few years. But the Universe was kind to LIGO, providing a dramatic event for it to record on 14 September, while the interferometers were still being calibrated, days before their official science run was due to start. Since then, LIGO has detected at least three other gravitational-wave events — the most recent [also spotted by Virgo, a similar interferometer near Pisa, Italy].

The LIGO team benefited from significant research efforts in other countries.

Germany and the United Kingdom have contributed funding and research, and GEO600, a smaller interferometer near Hannover, Germany, is the main test-bed for technologies that are implemented on its larger cousins in the United States.

The three winners have other strings to their bows: as well as working on LIGO, Weiss was a leading scientist in the Cosmic Background Explorer (COBE), a NASA probe that in the 1990s produced the first map of the cosmic microwave background, the 'afterglow' of the Big Bang. (Two other COBE researchers shared the physics Nobel in 2006.)

Thorne, who has spearheaded theoretical studies of gravitational waves, also helped to conceive the original idea for the plot of the 2014 film *Interstellar*, on which he was an executive producer. And before joining LIGO, Barish worked on neutrino experiments at the Fermi National Laboratory in Batavia, Illinois and elsewhere. He has also led the design of a proposed International Linear Collider.

Thorne and Weiss were generally considered shoo-ins for the Nobel. Before Drever's passing last March, the troika raked up almost every prize there was for them to win, including the $3-million Special Breakthrough Prize in Fundamental Physics; the $500,000 Gruber Foundation Cosmology Prize; the $1.2-million Shaw Prize in Astronomy; and the $1-million Kavli Prize in Astrophysics.

Journal name:
Nature
Volume:
550,
Pages:
19
Date published:
(05 October 2017)
DOI:
doi:10.1038/nature.2017.22737

Comments

Commenting is currently unavailable.

| 章节菜单 | 主菜单 |

Nature News

周三, 18 10月 2017

Nature News

[周三, 18 10月 2017]

- **Nature News**

Nature News

Nature is a weekly international journal publishing the finest peer-reviewed research in all fields of science and technology on the basis of its originality, importance, interdisciplinary interest, timeliness, accessibility, elegance and surprising conclusions. Nature also provides rapid, authoritative, insightful and arresting news and interpretation of topical and coming trends affecting science, scientists and the wider public.

- **Mysterious particles spotted in Saturn's atmosphere** [周三, 18 10月 08:00]
  Source may be dust shed by planet's iconic rings, according to data from NASA's doomed Cassini probe.
- **Japanese research leaders warn about national science decline** [周二, 17 10月 08:00]
  Concern mounts over budget cuts and other changes that undermine basic science.
- **Brazilian Amazon still plagued by illegal use of natural resources** [周二, 17 10月 08:00]
  Practices such as poaching and illegal logging are concentrated near inhabited areas and along rivers, study finds.
- **Give researchers a lifetime word limit** [周二, 17 10月 08:00]
  Brian C. Martinson imagines how rationing the number of publications a scientist could put out might improve the scientific literature.
- **Reboot for the AI revolution** [周二, 17 10月 08:00]
  As artificial intelligence puts many out of work, we must forge new economic, social and educational systems, argues Yuval Noah Harari.
- **Colliding stars spark rush to solve cosmic mysteries** [周一, 16 10月 08:00]
  Stellar collision confirms theoretical predictions about the periodic table.
- **Eye in the sky offers clearest vision of Earth** [周一, 16 10月 08:00]
  The world's latest carbon-monitoring satellite has advanced our understanding of how the planet functions. US politicians should take note.
- **Prepare for larger, longer wildfires** [周五, 13 10月 08:00]
  Climate change makes land management more urgent than ever, says Kathie Dello.
- **Global networks of small telescopes will chase companion signals of gravitational waves** [周五, 13 10月 08:00]
  Seeing cosmic events is one thing, but what if you could hear them and taste them, too?
- **Weather-company chief is Trump's pick to lead climate**

agency [周四, 12 10月 08:00]
Barry Myers would bring private weather-forecasting experience to the National Oceanic and Atmospheric Administration.

- **European drug regulation at risk of stalling as agency prepares to leave London** [周四, 12 10月 08:00]
Post-Brexit plans to relocate the European Medicines Agency could trigger severe staff losses, its head has warned.
- **European Medicines Agency chief raises alarm at forced relocation** [周四, 12 10月 08:00]
Guido Rasi says that ensuring the safety of drugs could be compromised.
- **FDA advisers back gene therapy for rare form of blindness** [周四, 12 10月 08:00]
Therapy that targets disease-causing mutations could become the first of its kind approved for use in the United States.
- **Male scientists share more — but only with other men** [周四, 12 10月 08:00]
Evolutionary differences blamed for squeezing out female researchers.
- **South African researchers bemoan slashed funds** [周三, 11 10月 08:00]
Plans to cut funding to a programme that recognizes and rewards excellence in research have met with criticism.
- **A more personal view of human-gene regulation** [周三, 11 10月 08:00]
A long-planned effort to examine gene expression and gene regulation in all the major tissues in the human body across many people comes to fruition.
- **Marine snow falls heaviest at the Equator** [周三, 11 10月 08:00]
Organic matter drifts down to the equatorial ocean floor in distinct patterns.
- **ResearchGate lawsuit, walrus spat and a Second World War shipwreck** [周三, 11 10月 08:00]
The week in science: 6–12 October 2017.
- **The ambitious effort to document California's changing deserts** [周三, 11 10月 08:00]
Ecologists catalogue bird and mammal populations as warming transforms Death Valley.
- **Gene-expression study raises thorny ethical issues** [周三, 11 10月 08:00]
Project obtains tissues from recently deceased individuals to look for the origins of disease.
- **The rise and fall and rise again of 23andMe** [周三, 11 10月 08:00]
How Anne Wojcicki led her company from the brink of failure to scientific pre-eminence.
- **The future of DNA sequencing** [周三, 11 10月 08:00]
Eric D. Green, Edward M. Rubin and Maynard V. Olson speculate on the next forty years of the applications, from policing to data storage.

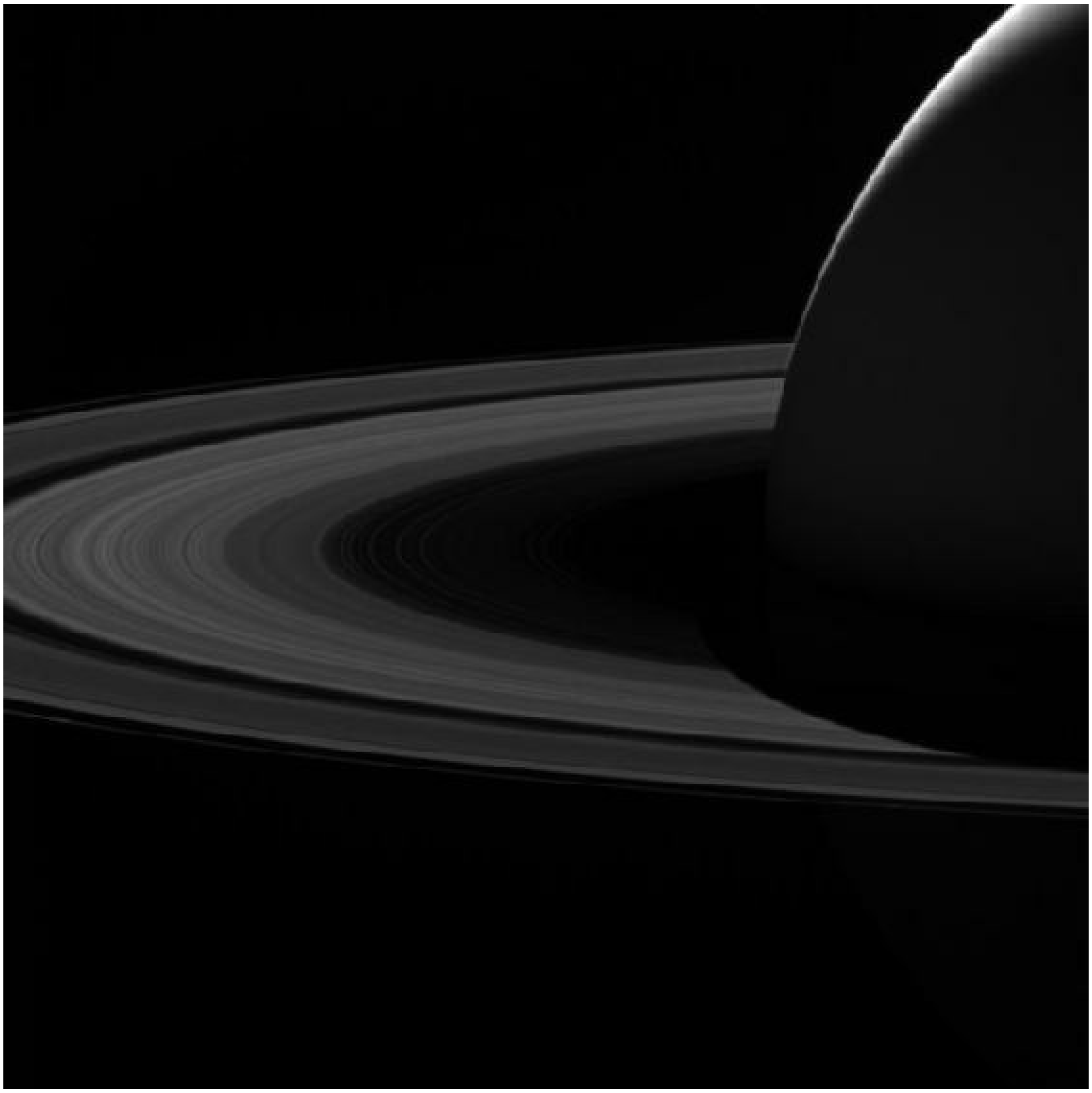
- **[Chemistry: Explosive moments in the laboratory]** [周三, 11 10月 08:00]
  Mark Peplow surveys a gorgeous gala of reactions in Theodore Gray's new book.
- **[Cancer care: Tap latent source of frugal cancer ideas]** [周三, 11 10月 08:00]
- **[Natural hazards: Risk assessments face legal scrutiny]** [周三, 11 10月 08:00]
- **[Countries: Avoid glib terms of development status]** [周三, 11 10月 08:00]
- **[Brain modelling: Does the brain control foraging?]** [周三, 11 10月 08:00]
- **[Predatory journals: Research that isn't read doesn't exist]** [周三, 11 10月 08:00]
- **[Runes transcribed from Dig Site 401A in Ladysmith, Wisconsin]** [周三, 11 10月 08:00]
  Postcards from the past.
- **[Publishers threaten to remove millions of papers from ResearchGate]** [周二, 10 10月 08:00]
  Take-down notices “imminent” as lawsuit is filed alleging widespread copyright infringement.
- **[Trump EPA begins push to overturn Obama-era climate regulation]** [周二, 10 10月 08:00]
  The agency's plan to reverse limits on greenhouse-gas emissions is likely to draw legal challenges.
- **[Climate meetings pose serious test in the Trump era]** [周二, 10 10月 08:00]
  Annual jamborees fail to ignite public passion but are crucial to progress on global-warming.
- **[Developing nations need more than just money]** [周二, 10 10月 08:00]
  Grants from big science funders can be hard to use without better administration and mutual understanding, says Rana Dajani.
- **[How the United States plans to trap its biggest stash of nuclear-weapons waste in glass]** [周二, 10 10月 08:00]
  After decades of delays, a challenging clean-up project is gaining ground.

Mysterious particles spotted in Saturn’s atmosphere

Source may be dust shed by planet’s iconic rings, according to data from NASA's doomed Cassini probe.

18 October 2017

Provo, Utah



NASA/JPL-Caltech/SSI

Saturn's rings are made of whirling bands of ice and dust.

NASA's Cassini spacecraft continues to yield surprising discoveries, more than a month after it burned up on its mission-ending dive into Saturn. New data from the probe suggest that Saturn's majestic rings are showering tiny dust particles into the planet's upper atmosphere, where they form a complicated and unexpected chemical mix.

A mass spectrometer aboard Cassini detected the strange chemistry as the

probe spent its final five months looping between Saturn and its rings.

“We really hit the jackpot,” said Mark Perry, a planetary scientist at the Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland. He reported the findings on 17 October at a meeting of the American Astronomical Society’s Division for Planetary Sciences in Provo, Utah.

Mission scientists had expected Cassini's mass spectrometer to spot the signature of water molecules as the spacecraft slipped between the planet and its rings. In the 1970s and 1980s, NASA's Pioneer and Voyager missions found fewer charged particles than expected in Saturn’s uppermost atmosphere. Based on that data, researchers proposed in 1984 that water molecules coming off the rings — mostly in the form of ice — acted as a catalyst to strip charged particles from the atmosphere[1]. Cassini's final months gave scientists their first opportunity to test this idea directly.

But instead of water, Cassini found a witch’s brew of chemicals, including methane, a molecule that could be carbon monoxide and more-complex molecules. The concentrations of these chemicals are highest around Saturn’s equator and at high altitudes, which suggests that the material is shedding off the planet’s rings.

The deeper the probe went into the atmosphere, the stranger the measurements got. Its closest swings past Saturn's surface revealed a panopoly of heavy molecules, Perry told the conference. The scientists have not yet pinpointed each type of molecule, but clearly there is far more than just water around.

By analyzing the types of materials that could be coming off the rings, Perry’s team concluded that they must be fragments of tiny dust particles, which measure just 1 to 10 nanometres across but are relatively heavy. When these particles spiralled off the rings and slammed into Cassini’s mass spectrometer, they shattered into smaller pieces.

Exactly how those particles make that journey from the rings to the atmosphere remains to be seen. “We have a lot of work to do to understand how they are getting in there,” Perry said. “None of the models predict this.”

On these final plunges, pulled along by Saturn’s gravity, Cassini was zooming along at more than 30 kilometres per second — a speed more than four times greater than the mass spectrometer was designed to withstand. “These are higher speeds than anything it has ever seen,” noted Linda Spilker, a planetary scientist at the Jet Propulsion Laboratory in Pasadena, California, and Cassini’s project scientist.

At such enormous speeds, anything Cassini rammed into would have splintered into bits.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22838

Comments

Comments

There are currently no comments.

Japanese research leaders warn about national science decline

Concern mounts over budget cuts and other changes that undermine basic science.

17 October 2017

Toru Hanai/Reuters

People gather for a rally in Fukushima, Japan, for Prime Minister Shinzo Abe and the Liberal Democratic Party.

As Japan heads towards a national election on 22 October, scientific leaders worry that the outcome will do little to address long-standing concerns about

the country’s deteriorating research landscape. They say that a decline in funding and a shift away from basic research has undermined Japan’s capacity to compete against both established scientific powerhouses and emerging ones such as China.

Since 25 September, when Prime Minister Shinzo Abe called for a snap election, science has barely featured in the campaign. Debate has focused on the government’s plan to amend the constitution and increase taxes. The latest polls suggest that Abe’s conservative Liberal Democratic Party could lose some seats, but will retain enough to lead a coalition government.

If Abe is re-elected, he says, his government will pursue an innovation agenda. At a meeting of global science leaders in Kyoto on 1 October, Abe reaffirmed his pledge to turn Japan into “a cradle of innovation” by cutting regulations that impede new technologies.

Despite Abe’s lofty ambitions, the ruling party coalition has decreased the science and technology budget by more than 5% overall since it came to power in 2012. And the budget for universities has dropped by about 1% a year for a decade. “This has been pointed out as the major cause of the deterioration of research performance and, eventually, the global rank of Japanese universities,” says Takashi Onishi, president of Toyohashi University of Technology and a former president of the Science Council of Japan, which advises the government. In the past two decades, the country’s share of highly cited papers has stagnated, whereas those of many other leading nations are rising, according to publisher Elsevier’s Scopus database.

In an attempt to elevate Japan’s top research universities, the government has introduced reforms that categorize institutions according to their research or teaching focus, and that allocate funding on the basis of performance. The government wants leading research institutions to compete globally for the best students and faculty.

Atsushi Sunami, a science-policy specialist at the National Graduate Institute for Policy Studies (GRIPS) in Tokyo, agrees with this aim, but says that to succeed, the government will need to increase its research funding. And money alone will not be enough, says Hiroshi Nagano, also a science-policy specialist at GRIPS. For universities to become world class, they need

autonomy to decide their research and teaching focus, he says. “The current policy is oriented in the opposite direction.”

Basic research left behind

Changes to the university system implemented by Abe’s government are designed to make academia more responsive to the needs of society and industry, in the hope that it will boost low private-sector investment in research. Although scientists broadly encourage this increased collaboration, some say that it has compromised support for basic research. “The government should focus on the development of basic research to supply seeds or ideas to applied sciences,” says Onishi.

Science leaders point to other big concerns about the future of Japanese research. Minicharini Hamaguchi, head of the Japan Science and Technology Agency in Kawaguchi, says that the domestic workforce will be insufficient to keep up with changes in science, technology and innovation, given the country’s rapidly ageing population. He says that policies are urgently needed to encourage more women and foreigners into science and to boost the number of students in doctoral courses, which has dropped by 18% since 2003.

Students who pursue research careers are finding it harder to get jobs. Budget cuts have depleted permanent research positions at universities, and fewer younger researchers are securing permanent posts: the number of research associates on short-term contracts more than doubled from 2007 to 2013.

Biologist and 2016 Nobel prizewinner Yoshinori Ohsumi has warned that the situation for young researchers will jeopardize the country’s chances of winning future Nobel prizes. Japan has the second-highest number of science laureates in the twenty-first century after the United States — but, Ohsumi says, that record is unlikely to hold.

Journal name:
Nature
DOI:

doi:10.1038/550310a

Comments

Comments

There are currently no comments.

Brazilian Amazon still plagued by illegal use of natural resources

Practices such as poaching and illegal logging are concentrated near inhabited areas and along rivers, study finds.

17 October 2017

Jeff Hutchens/Getty

An official with Brazil's environmental enforcement agency arrests poachers caught near Manaus.

Despite Brazil’s efforts to safeguard the Amazon rainforest by establishing protected areas and boosting law enforcement, illegal use of the region’s natural resources is still widespread, according to a study[1] published on 10

October in *PeerJ*.

The researchers looked at 4,243 law-enforcement records from between 2010 and 2015, across 118 federally protected areas of the Brazilian Amazon. Although the overall number of citations decreased over those five years, illegal activities still occurred in nearly every protected area. The analysis highlighted the need for improved monitoring and enforcement, says study co-author Érico Kauano, a conservation biologist at the Chico Mendes Institute for Biodiversity Conservation (ICMBio), the Brazilian agency responsible for the management of the federal protected areas.

Kauano and his colleagues grouped illegal activities into ten categories, and found that 37% of the infractions fell into the “suppression and degradation of vegetation” group, which included deforestation, logging of endangered tree species and the unauthorized use of fire. Illegal fishing was the next most common citation at 27%, followed by hunting at 18%. Most of the illegal activity occured in more accessible and densely populated areas.

Roads have a major role in opening up the tropics to colonization and exploitation[2]. Deforestation of the Brazilian Amazon increased after the construction of the Belém–Brasília Highway in the 1960s, and continued with the opening of the Trans-Amazonian Highway in 1970s. A 2014 study[2] using satellite images found that around 95% of the deforestation in Brazil’s Amazon occurred within 5.5 kilometres of a road and within 1 kilometre of a navigable river.

Caught in the act

The availability and use of government data are what sets this study apart from others, says Emilio Bruna, a tropical ecologist at the University of Florida in Gainesville, who was not involved in the study. Past studies, including a paper[3] published last month in *Biotropica* (where Bruna is editor-in-chief), struggled to obtain even the most basic information, such as how many staff members were employed by the agency that manages protected areas, and how much they were paid, Bruna says.

Data from efforts on the ground are important because, although remote-sensing instruments such as satellites can detect deforestation, for example, they fail to identify threats present beneath the forest canopy. Law-enforcement records, when available, can complement remote-sensing data sets, the study authors say.

“You can actually tell what it is they’re writing infractions for, and that’s valuable,” says Bruna. But he points out that, without knowing where law-enforcement efforts are being allocated, it’s only a partial picture. “It could be that the reason certain protected areas have the most infractions is because those are the places that are under the greatest threat,” he says. “Or it could be because that’s where the greatest enforcement is being focused.”

Greater enforcement

“We are still far from having adequate staff in the protected areas,” Kauano says. In 2014, a local news outlet reported that the Brazilian Institute of Environment and Renewable Natural Resources had only 47 agents to monitor environmental crimes in Amazonas, the country’s largest state in the Amazon region, which covers an area of about 1.6 million square kilometres.

Hiring more enforcement officials looks unlikely in the short term, however, owing to Brazil’s ongoing political and economic crisis, says Kauano. “What ICMBio seeks to do to overcome this is to prioritize some regions with greater problems.”

Bruna cautions against jumping to conclusions from the study’s results, however. “Not all infractions are created equal,” he says. It’s important to differentiate between a resident fishing out of season and a fishing charter operator. Bruna worries that some may look at this study and think that the people living near protected areas are the problem. But they aren’t the only ones breaking the law, he says. And the demand for the fruits of this illegal labour comes from all over the world.

Local people can, in fact, be part of the solution. There is some evidence that people living in or near protected areas are helping with conservation, says

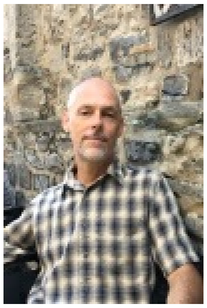
Kauano. But he adds that the government needs to make a greater effort to work with local communities.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22830

Comments

Comments

There are currently no comments.



Ellie R. Martinson

Give researchers a lifetime word limit

Brian C. Martinson[1] imagines how rationing the number of publications a scientist could put out might improve the scientific literature.

17 October 2017

A dirty truth pervades academic publishing: we write papers to gain credit in an academic marketplace. Almost a quarter of a century ago, academic worthies lamented that scholarly publications had become “the coins academics must use to get through the tollgates on their way to academic promotion” (D. Rennie and A. Flanagin *J. Am. Med. Assoc.* **271**, 469–471; 1994). In some cases, papers in flashy journals truly do bring in hard cash — reportedly more than US$40,000 at some universities in China. And plenty of people reading this will have felt they’d better squeeze a paper or two out soon to have any chance of getting their next grant proposal funded.

The purpose of authorship has shifted. Once, its primary role was to share knowledge. Now it is to get a publication — ‘pubcoin’ if you will. Authorship has become a valuable commodity. And as with all valuable commodities, it is bought, sold, traded and stolen. Marketplaces allow

unscrupulous researchers to purchase authorship on a paper they had nothing to do with, or even to commission a paper on the topic of their choice. ‘Predatory publishers’ strive to collect fees without ensuring quality.

I have spent much of my career studying how academic and clinical workplaces influence how carefully researchers conduct their studies. The commodification of authorship encourages all manner of corner-cutting, sloppiness in research, and other degradations in the quality of publications, not to mention an obvious motive for plagiarism. A quest for high-profile papers leads researchers to favour a spectacular result, even if it is specious. Authors cite themselves to boost the impact of publications, and cite colleagues to curry favour.

At this point, it is hard even to envisage a world in which the communication of knowledge could return to its rightful place as the focus of academic authorship. But if we cannot imagine something, we cannot attain it. So let me try. Imagine a world in which each scientist is allotted a fixed number of words that they can publish over her or his career. I’m not the first person to suggest this: the Australian writer Michael McGirr has proposed a word limit for every person.

What would happen? Might authorship regain its original purpose?

Lifetime limits would create a natural incentive to do research that matters. Researchers would have to ask themselves, “Is this project I’m pursuing worth the words it will cost me?” I see several articles in my own CV that did not contribute much knowledge to the world. I cannot help but think that I might have pursued better questions had a word limit been in place.

Ideally, limits would encourage researchers to ensure that research is conducted with the utmost care. (Imagine losing part of your allotment of words to a paper that is discredited or even retracted.) This would provide a counterweight to the pressure to publish quickly for priority. It would also lead to increased value being placed on concision and clarity, improving readability and efficiency. Honorary authorship would become much less attractive.

With less time needing to be spent on papers of low quality or containing

little new information, readers and editors would be able to give the smaller number of articles more attention. Editorial workload would be reduced by virtue of the lower volume and the higher quality of material. This might reduce editorial costs, enhance quality, and quite possibly enhance the job satisfaction and quality of life of editors and readers. Predatory publishers would vanish.

With a boost in the quality of scientific papers, the communal work of peer review would get easier. Individual researchers would be asked to carry out fewer reviews. Reviewing invitations would be for work of higher quality, making the job more enjoyable and less aggravating. And knowing the stakes for the authors in expending their precious words, reviewers themselves might be inclined to put more time and effort into their reviews, further improving quality.

The task of evaluating candidates for jobs, advancement and prizes would become less scattershot. With fewer publications per candidate, promotion and tenure committees could become less reliant on tallying counts of first-authored publications, and devote time to reading and critiquing the published work. This, in turn, should reduce their use of journal impact factors as proxies for quality.

Limits would of course bring a new set of problems: if we don't also address our own cognitive biases and penchant for compelling narratives, word limits could exacerbate tendencies to publish only positive findings, leading researchers to explore blind alleys that others' negative results could have illuminated. Researchers might skimp on a full description of caveats, previous work and methods. Some subjects and pursuits might be inherently wordier than others. Exceptions might have to be made for experts such as statisticians and bioinformaticians whose skills are required on many papers — but perhaps this would boost the quality of collaborations. Perhaps researchers could apply for word bonuses for careful reproductions, cautious interpretations and meticulously described methods.

Would these drawbacks be worse than the current incentives to publish as much as you can? We have lost sight of information sharing as the primary reason for publishing. Perhaps my flight of fancy is a rose-tinted remembrance of times past. Or perhaps it can serve as a guide to restore the

exchange of ideas to its rightful, pithy, place.

Journal name:
Nature
Volume:
550,
Pages:
303
Date published:
(19 October 2017)
DOI:
doi:10.1038/550303a

Comments

Commenting is currently unavailable.

Reboot for the AI revolution

17 October 2017

As artificial intelligence puts many out of work, we must forge new economic, social and educational systems, argues Yuval Noah Harari.

Laura Lezza/Getty

A robot conducts the Orchestra Filarmonica di Lucca at Teatro Verdi in Pisa, Italy, this September.

The ongoing artificial-intelligence revolution will change almost every line of work, creating enormous social and economic opportunities — and challenges. Some believe that intelligent computers will push humans out of the job market and create a new 'useless class'; others maintain that

automation will generate a wide range of new human jobs and greater prosperity for all. Almost everybody agrees that we should take action to prevent the worst-case scenarios.

The automation revolution is emerging from the confluence of two scientific tidal waves. Computer scientists are developing artificial intelligence (AI) algorithms that can learn, analyse massive amounts of data and recognize patterns with superhuman efficiency. At the same time, biologists and social scientists are deciphering human emotions, desires and intuitions. The merger of infotech and biotech is giving rise to algorithms that can successfully analyse us and communicate with us, and that may soon outperform human doctors, drivers, soldiers and bankers in such tasks. These algorithms could eventually push hundreds of millions out of the job market.

Governments might decide to deliberately slow down the pace of automation, to lessen the resulting shocks and allow time for readjustments. But it will probably be both impossible and undesirable to prevent automation and job loss completely. That would mean giving up the immense positive potential of AI and robotics. If self-driving vehicles drive more safely and cheaply than humans, it would be counterproductive to ban them just to protect the jobs of taxi and lorry drivers.

A more sensible strategy is to create new jobs. In particular, as routine jobs are automated, opportunities for new non-routine jobs will mushroom. For example, general physicians who focus on diagnosing known diseases and administering familiar treatments will probably be replaced by AI doctors. Precisely because of that, there will be more money to pay human experts to do groundbreaking medical research, develop new medications and pioneer innovative surgical techniques.

This calls for economic entrepreneurship and legal dexterity. Above all, it necessitates a revolution in education.

Lifelong learning

To make use of the new opportunities, people will need radical, lifelong

retraining. The AI revolution won't be a single event after which the job market and the educational system will settle into a new equilibrium. Rather, it will be a cascade of ever-bigger disruptions. Even today, few employees expect to work in the same job for their entire life (see go.nature.com/2ymdvjs). By 2050, not just the idea of 'a job for life', but even the idea of 'a profession for life' might seem antediluvian. It will become increasingly difficult to know what to teach schoolchildren and university students.

Predicting the future was never easy. If you lived in China 1,000 years ago, there were many things you didn't know: the empire might collapse in 50 years; the Khitans might invade, or a new plague might kill millions. Nevertheless, you did know that most people would still work as farmers and weavers, rulers would still need men to fight in their armies and administer their taxes, women would still have few opportunities beyond marriage and life expectancy would still be about 40 years.

Hence, in 1017, poor Chinese parents taught their children how to plant rice or weave silk, and wealthier parents taught their boys how to read and write, or to fight on horseback, and their girls to be modest and obedient housewives. It was obvious that these skills would still be needed. In 2017, by contrast, we have no such certainties about the future of jobs, gender, economics or even death.

Human psychology, too, might turn out to be a key hurdle. Change is always stressful. Already we face an epidemic of stress and anxiety (see go.nature.com/2z96s57). As the volatility of the job market and of individual careers increases, we may wonder whether everyone will have the emotional stamina necessary for a life of constant flux. We may need more-effective stress-reduction techniques — ranging from drugs through neurofeedback to meditation — to cope.

Creating new jobs might prove easier than retraining people to fill them. A huge useless class might appear, owing to both an absolute lack of jobs and a lack of relevant education and mental flexibility.

Test cases

It is particularly important to identify as early as possible the potential winners and losers from new technologies. Rosy overall statistics can hide growing gaps between disparate groups. Automation might have a very different impact on men and women, on 40-somethings and 20-somethings, on the university-educated and the illiterate.

The winners and losers are not the usual suspects. In the clinic, for example, automation might prove more of a threat to doctors than to nurses. Many physicians focus almost exclusively on processing information: they absorb medical data, analyse them and produce a diagnosis. Nurses also need good motor and emotional skills, to give a painful injection, replace a bandage and listen with care. We will probably have an AI family doctor on our smartphone years before we have a reliable nurse robot[1].

Exploring the relationship between intelligence and consciousness will also be crucial to understanding the economic, professional and ethical rapport between future computers and humans. We are seeing a tremendous development in computer intelligence, but zero development in computer consciousness. Just as aeroplanes fly faster than birds without ever developing feathers, so computers could come to solve problems and even to analyse human feelings much better than humans, without ever developing feelings. Studying these differences will help us to predict what AI can and cannot do, and to decide what should be kept out of its control.

There are a few areas in which AI has already made significant strides that, in my view, offer test cases for the impact of modern automation on the world of work.

In chess, it has been 20 years since IBM's Deep Blue computer thrashed Gary Kasparov. Yet humans still play chess, and 'centaur' teams of humans-plus-AIs can outperform both. This seems at first to bode well for the future: the job market could nurture people who can leverage, rather than compete with, AI. Yet the balance of power in centaur teams is constantly shifting. Computers are becoming so good at chess that the humans are gradually losing value, and could soon become irrelevant. The same thing might happen in other human–AI teams[2].

Laura Lezza/Getty

A woman with a robot at an Italian nursing home in 2015.

Self-driving vehicles are another important test case. The race to produce self-driving vehicles now pits old steel giants such as Mercedes-Benz against new silicon giants such as Google. Transport leverages one of the core advantages of AI: connectivity. Even if a single computer-driven car is less competent than a good human driver, a network of computer-driven cars is still likely to be much safer and more efficient than the chaos of fallible human drivers that currently dominates the roads.

Today, about 1.25 million people are killed annually in car accidents[3], more than 90% of which are estimated to be caused by human errors[4]. When two human drivers approach the same junction, they might miscommunicate and collide. But computer-driven vehicles can be connected — the chances that they might miscommunicate and collide are therefore much smaller. Similarly, it is easier to ensure that automated vehicles comply with rules such as speed limits (not to mention the ban on drink driving), even as those rules change[5, 6, 7].

Self-driving vehicles illustrate two important points. First, that in some fields it might make sense to replace all humans with robots and computers, even if individually some humans do a better job. Second, that when change comes to some realms, it might do so suddenly, not step-wise.

The military is another important bellwether, because armies are early adopters of much technology. Human soldiers carry a very high economic and political price tag, so replacing people with computers on the battlefield has proved attractive. The most advanced armies now increasingly rely on relatively small numbers of experts coupled with sophisticated and autonomous technologies, such as drones, robots, smart bombs, cyberworms and algorithms that sift through a mass of data[8, 9].

This shift has produced new classes of military jobs in maintenance, remote control, programming and cybersecurity. The US armed forces need 30 people to operate every Predator or Reaper drone flying over Syria, and analysing the harvest of information occupies at least 80 more. A careful study of the military job market might tell us a lot about potential future developments in the civilian economy.

New order

With insights gleaned from early warning signs and test cases, scholars should strive to develop new socio-economic models. The old ones no longer hold. For example, twentieth-century socialism assumed that the working class was crucial to the economy, and socialist thinkers tried to teach the proletariat how to translate its immense economic power into political clout. In the twenty-first century, if the masses lose their economic value they might have to struggle against irrelevance rather than exploitation.

One new model has been gaining increasing attention and popularity: universal basic income (UBI). UBI suggests that the government should tax the rich and big corporations to provide every person with a stipend covering his or her basic needs. This will cushion the poor against job loss and economic dislocation, and protect the rich from populist rage. It will also free the masses to engage in more creative forms of work that might not currently have economic value, or to pursue further education.

In January 2017, Finland began a 2-year experiment, providing 2,000 unemployed citizens with €560 (US$657) per month, irrespective of whether they work. Similar experiments are under way in the Canadian province of Ontario, in the Italian city of Livorno and in several Dutch cities[10].

Of course, such national and municipal schemes might not solve the worst problems. Globalization has made people in one country utterly dependent on markets in others, and automation might unravel large parts of this global trade network with disastrous consequences for the weakest links. AI might generate immense wealth in hi-tech hubs such as Silicon Valley and Bangalore, while devastating the economies of underdeveloped countries that rely on cheap labour, such as Honduras and Bangladesh.

US voters might conceivably agree that taxes paid by tech giants Amazon and Google for their US business should be used to give stipends to unemployed coalminers in Pennsylvania or jobless taxi-drivers in New York. But they are unlikely to send their taxes to Honduras. We are still far from having any feasible models for a post-work economy, society or political system, and we don't have much time to formulate them.

In the nineteenth century, the Industrial Revolution created new conditions and problems that none of the existing social, economic and political models could cope with. Consequently, humankind had to develop completely new models — liberal democracies, communist dictatorships and fascist regimes. It took more than a century of terrible wars and revolutions to experiment with these, separate the wheat from the chaff and implement the best solutions.

The challenges posed in the twenty-first century by the merger of infotech and biotech are arguably bigger than those thrown up by steam engines, railways, electricity and fossil fuels. Given the immense destructive power of our modern civilization, we cannot afford more failed models, world wars and bloody revolutions. We have to do better this time.

Journal name:
Nature
Volume:
550,
Pages:
324–327
Date published:
(19 October 2017)
DOI:
doi:10.1038/550324a

Comments

Comments

There are currently no comments.

Colliding stars spark rush to solve cosmic mysteries

Stellar collision confirms theoretical predictions about the periodic table.

16 October 2017

Cosmic furnace

A simulation of the merger of two neutron stars, leading to the formation of a black hole. About 2% of the stars' mass gets ejected at high speed, producing radioactive, heavy atoms.

Credit: W. Kastaun/T. Kawamura/B. Giacomazzo/R. Ciolfi/A. Endrizzi via Caltech

Gold, platinum, uranium and many of the rare-earth elements that are crucial to today’s high-tech gadgets are generated during the formation of black holes, astronomers have said. The collision of two small but dense stars simultaneously solved several cosmic mysteries, researchers announced at a press conference in Washington DC on 16 October. More than 30 papers have been published so far in five journals — *Physical Review Letters, Science*, *Nature*, *Nature Astronomy* and *Astrophysical Journal Letters.*

Astronomers watched as two neutron stars — small but very dense objects formed after the collapse of stars bigger than the Sun — collided and merged, forming a black hole, in a galaxy 40 million parsecs (130 million light years) away, according to two dozen researchers interviewed by *Nature*’s News team.

The collision generated the strongest and longest-lasting gravitational-wave signal ever seen on Earth. And the visible-light signal generated during the

collision closely matches predictions made in recent years by theoretical astrophysicists, who hold that many elements of the periodic table that are heavier than iron are formed as a result of such stellar collisions.

Neutron-star mergers are also thought to trigger previously mysterious short γ-ray bursts, a hypothesis that now also seems to have been confirmed.

Astronomers have good reasons to believe that they are looking at the same source of both the gravitational waves and the short γ-ray bursts, says Cole Miller, an astronomer at the University of Maryland in College Park, who was not involved in the research but who has seen some of the papers ahead of their publication.

Bright object

The event was detected on Earth on 17 August, and triggered weeks of febrile, round-the-clock activity on all 7 continents, as more than 70 teams of researchers scrambled to observe the aftermath.

The collision was felt first as a space-time tremor by the Laser Interferometer Gravitational-wave Observatory (LIGO) in the United States and by its Italy-based counterpart Virgo, and seen seconds afterwards as a smattering of high-energy photons by NASA's Fermi Gamma-ray Space Telescope.

Alerted by the LIGO–Virgo team, astronomers then raced to find and study what was seen as a bright object in the sky using telescopes big and small, famous and obscure, on land and in orbit, and spanning the spectrum of electromagnetic radiation, from radio waves to X-rays.

Cody Messick was at his home at 08:41 local time (12:41 UT) on 17 August when he first found out about the event. "I remember standing on my stairs and looking at my phone, thinking: 'Wow!" he says. Messick, who is a physicist at Pennsylvania State University in University Park, belongs to a small team of LIGO first-responders who receive frequent automated alerts from the two interferometers, which are based in Livingston, Louisiana, and Hanford, Washington. Normally, LIGO's algorithms flag a potential signal in real time only if both interferometers detect it. Messick was surprised,

because the message on his smartphone mentioned a strong signal — but one seen only at the Hanford site.

Messick quickly got on a conference call with his team leader, Chad Hanna, also at Pennsylvania State, and other colleagues. Together, they examined the data online. The Hanford signal looked like a textbook example of the waveform of the gravitational waves emitted by two compact objects, each slightly more massive than the Sun, as they spiral into each other, he says. In particular, the waves lasted much longer — about 100 seconds — and had a higher pitch than the signals from the much more massive black-hole mergers that LIGO had previously detected.

When they looked at the data stream coming from Livingston, the LIGO researchers found a similar signal there as well, but one with a loud, spurious glitch towards the end. It was that anomaly that had caused the real-time-analysis software to ignore the signal, says David Shoemaker, a physicist at the Massachusetts Institute of Technology in Cambridge who is LIGO's spokesperson.

Meanwhile, researchers received another alert: Fermi had detected a short γ-ray burst that had occurred 1.7 seconds after the gravitational waves had ended. Called GRB170817A, it was unusually faint for such a burst.

Second signal

In Italy, another technical glitch had suspended the continuous stream of data normally sent out by Virgo. So it took another 40 minutes for researchers to realize that they, too, had a signal — albeit a faint one. It transpired that the waves had travelled close to one of the interferometer's four blind spots, says Jo van den Brand, a physicist at the Vrije Universiteit Amsterdam and spokesperson for the Virgo Collaboration.

By 13:21 UT, 40 minutes after the event, the LIGO–Virgo team had decided to notify its roughly 70 follow-up partners — teams of astronomers on standby to look for related events using conventional telescopes.

Four and a half hours later, the team sent a second, much more useful alert.

The timing of Virgo's feeble signal had been sufficient for the LIGO-Virgo team to identify the source of the waves. It pointed to a region of the sky spanning an angle of just a few degrees, in the southern sky. They called the event GW170817, after the date it was detected.

Virgo had joined LIGO's observation campaign only on 1 August, after a five-year shutdown for upgrades. And just three days before the event's detection, on 14 August, LIGO and Virgo had made their first joint detection. It enabled them to rehearse the more precise identification of the patch of sky of interest. The event on 17 August enabled them to narrow it down even further. And the estimated distance was ten times closer to Earth than in the previous events. They could tell this because of how loud and persistent the waves were: it was the strongest signal LIGO had ever sensed. After the fact, Hanna's team was able to extract a signal that lasted a full six minutes.

Together, the alerts from LIGO–Virgo and Fermi sent astronomers into a frenzied rush. Each team wanted to be first to spot the fireworks produced by a neutron-star merger. It was daytime on most of the world's land mass, so teams began to formulate strategies for their nocturnal observations. They knew that, at that time of the year, the region to search was not far from the Sun. That left a window of observation of a couple of hours after dusk, before the region of sky would set below the horizon.

"We had a complicated, choreographed dance of telescopes that night," says Iair Arcavi, an astrophysicist at the University of California, Santa Barbara, whose team made non-stop observations using the Las Cumbres Observatory, a worldwide network of robotic telescopes. It began by activating a number of telescopes in Chile.

Three messengers

The first person to see the event may have been Charles Kilpatrick, an astronomer at the University of California, Santa Cruz. He was part of a team that was scanning the sky with the more modest means of the single one-metre Swope Telescope in Chile. Like his competitors, Kilpatrick was closely watching the exposures one by one as they came out, comparing them with

archival images of the same patch of sky. By the ninth exposure, he saw something very conspicuous in a galaxy called NGC 4993. “It looked exactly like a point source in this image that wasn’t in the reference image,” Kilpatrick says. The team named it SSS17a.

At least two other groups say they spotted the bright dot independently. They and other teams also made sure that there were no other plausible candidates within the search region. GW170817, GRB170817A and SSS17a really seemed to be three different messengers from the same source.

LIGO and Virgo lacked a sufficiently detailed signal of the final instants of the collision to be certain that the objects were neutron stars, Shoemaker says. From gravitational-wave data alone, they could have been two unusually small black holes. But the presence of visible light strongly suggested that at least one of the objects in the merger was a neutron star, he and other researchers say.

The group at the University of California, Santa Cruz, was also the first to measure the optical spectrum of SSS17a. On the first night, the dot was bright blue, says astronomer Ryan Foley, who led that effort. NASA’s Swift telescope also detected blue, as well as ultraviolet, light. But during the next few nights of observation, those colours faded away, and the object became more red, according to multiple teams.

Colliding neutron stars should spread debris — a mix of neutrons, but also some protons — in three ways, says Brian Metzger, a theoretical astrophysicist at Columbia University in New York City. First, they fling matter out from their outer layers during the final orbits. Then some matter gets squeezed out in the actual collision. Finally, as the two stars begin to collapse into a black hole, it forms an accretion disk of matter, some of which flies out instead of falling in.

Over the past decade or so, astrophysicists had come to believe that this was the most plausible mechanism to explain the abundance of the heavier elements of the periodic table[1]. The theory held that, overall, about 2% of the combined mass of the stars would escape the fate of the rest. Within one second of the collision, this material would have expanded to become a cloud tens of thousands of kilometres across, but still about as dense as the Sun. In

this cauldron, protons and neutrons would immediately clump together to form neutron-heavy nuclei, which would then begin to decay radioactively. This radioactivity would keep the cloud glowing hot for several days, even as it reached the size of the Solar System. Within a million years, it would spread across an entire galaxy.

As predicted

Metzger says that the switch from blue to red was just what he expected to see. His models suggest that nuclei in this early cloud would reach the masses of many of the elements beyond iron, although not the heaviest ones. This chemical composition would cause the cloud to glow blue.

But the real smoking gun for this model, the signatures of the formation of the heaviest elements, would be a cloud that glowed in the red and infrared. These would be elements forged in a separate wave of the explosion, probably the one coming from the accretion disk, says Metzger.

“We had predicted exactly what kind of red,” says Daniel Kasen, a theoretical astrophysicist at the University of California in Berkeley. Jennifer Barnes, another theorist then in Kasen’s team who is now at Columbia University, had run the supercomputer simulations that predicted the experimental signatures in 2013[2]. “I had just finished my PhD thesis predicting what these things would look like,” she says.

Eleonora Troja, an astronomer at NASA Goddard Space Flight Center in Greenbelt, Maryland, was part of one of the first teams to use the Hubble Space Telescope to view the event. “The spectra were phenomenal,” she adds, and almost indistinguishable from the theoretical predictions. “You could clearly see the fingerprints of the metals that had formed.”

But Troja and other observers were also puzzled, because they couldn't find any signal in the X-ray and radio regions of the spectrum. These would be expected during the formation of a black hole, which is thought to shoot jets of out of its poles at close to the speed of light. Nine days later, Troja’s team was the first to find the X-rays.

Alessandra Corsi, an astronomer at Texas Tech University in Lubbock, and her collaborators kept looking for radio emissions using the Very Large Array in New Mexico. Day after day, the dishes recorded nothing. “It turned out we had to wait 16 very long days in order to see the first radio glow,” she says.

The late onset of the radio and X-ray signals, together with the weakness of the initial γ-rays, suggest that the jets were pointed away from the line of sight to Earth. Gamma-ray bursts that happen to be pointed in the right direction can look very bright even from billions of parsecs away.

After a few weeks, most observatories had to stop looking at the object, because that part of the sky had got too close to the Sun. But radio telescopes are still tracking it to this day, Corsi says. More discoveries might yet be made.

“The idea that all this stuff has happened, it’s too much. It is just hard to process,” says Daniel Holz at the University of Chicago in Illinois. “It’s unreasonable that we have done so much with just one event of its kind.”

“All our hopes and dreams have basically come true,” says Jocelyn Read, an astrophysicist at California State University, Fullerton. “All this time we have been saying, look at this amazing thing we are going to be able to see. And it is still hard to believe when it actually happens.”

Journal name:
Nature
DOI:
doi:10.1038/550309a

Comments

5 comments

1. *Pentcho Valev* • 2017-10-17 06:54 AM
"Rethinking Einstein: The end of space-time. It was a speech that changed the way we think of space and time. The year was 1908,

and the German mathematician Hermann Minkowski had been trying to make sense of Albert Einstein's hot new idea - what we now know as special relativity - describing how things shrink as they move faster and time becomes distorted. "Henceforth space by itself and time by itself are doomed to fade into the mere shadows," Minkowski proclaimed, "and only a union of the two will preserve an independent reality." And so space-time - the malleable fabric whose geometry can be changed by the gravity of stars, planets and matter - was born. It is a concept that has served us well, but if physicist Petr Horava is right, it may be no more than a mirage. Horava, who is at the University of California, Berkeley, wants to rip this fabric apart and set time and space free from one another in order to come up with a unified theory that reconciles the disparate worlds of quantum mechanics and gravity - one the most pressing challenges to modern physics." https://www.newscientist.com/article/mg20727721-200-rethinking-einstein-the-end-of-space-time/ To "rip this fabric apart and set time and space free from one another" means to declare two things: 1. The premise from which spacetime has been derived, Einstein's constant-speed-of-light postulate, is false. 2. Gravitational waves (ripples in spacetime) don't exist - LIGO folks are fraudsters. Petr Horava is not so brave. Perhaps he doesn't want to rip spacetime apart anymore and sings dithyrambs to LIGO's victorious godfathers. His brother string theorist Steve Giddings once wanted to retire spacetime but now believes that the ripples in spacetime are worth living for: What scientific idea is ready for retirement? Steve Giddings: "Spacetime. Physics has always been regarded as playing out on an underlying stage of space and time. Special relativity joined these into spacetime... [...] The apparent need to retire classical spacetime as a fundamental concept is profound..." https://www.edge.org/response-detail/25477 "In celebration of Einstein's birthday, physicists reflect on the German-born scientist's work and its impact on the field and on everyday life. "We have good reason to believe general relativity is not a complete theory and, in particular, that it's going to break down in the context of describing black holes," said UCSB physics professor Steve Giddings. "That's very much an important problem in physics

today. "The direct observation of gravitational waves from colliding black holes really constrains the possible departures from general relativity that we know are there and limits where modifications can be made," he continued. "But the discovery is still spectacular and its announcement was one of those moments in science that you live for."
http://www.news.ucsb.edu/2016/016562/einstein-revolution
Pentcho Valev

2. *Pentcho Valev* • 2017-10-16 11:17 PM

   Since Einstein's 1905 constant-speed-of-light postulate is false, it is incompatible with any relevant experiment. Einsteinians overcome the difficulty by introducing idiotic ad hoc assumptions analogous to Lorentz's 1889 length contraction. So in the interpretation of the Doppler effect they assume that pulses (or wavecrests) bunch up in front of the moving light source: Albert Einstein Institute: "We will start with a very simple set-up, which you can see in the following animation. On the right-hand side, drawn in green, there is a sender that emits pulses in regular succession. On the left-hand side there is a receiver, drawn in blue. The pulses themselves are drawn in red, and they all travel at the same speed from right to left. Everytime the sender emits a new pulse, a yellow indicator light flashes once. Likewise, a flashing light indicates when a pulse has reached the receiver: http://www.einstein-online.info/images/spotlights/doppler/doppler_static.gif Next, let us look at a slightly different situation, where the source is moving towards the detector. We assume that the motion of the sender does not influence the speed at which the pulses travel, and that the pulses are sent with the same frequency as before. Still, as we can see in the following animation, the motion influences the pulse pattern: http://www.einstein-online.info/images/spotlights/doppler/doppler_source_blue.gif The distance between successive pulses is now smaller than when both sender and receiver were at rest. Consequently, the pulses arrive at the receiver in quicker succession. If we compare the rates at which the indicator lights at the receiver and at the sender are flashing, we find that the indicator light at the receiver is flashing faster." [END OF QUOTATION] http://www.einstein-online.info/spotlights/doppler Einsteinians make the following assumption above, which is essentially identical to Einstein's 1905 constant-speed-of-light postulate: Assumption 1: "The motion of the sender does not influence the speed at which the pulses travel." Assumption 1 goes hand in hand with another assumption: Assumption 2: "The distance between successive pulses is now smaller than when both sender and receiver were at rest." Assumption 2 is false - the pulses do not bunch up when the source (sender) is moving. If they did, by measuring the (variable) distance between the pulses, an observer associated with the source would know whether he is moving or at rest, which contradicts the principle of relativity. Since Assumption 2 is false, Assumption 1 is false as well. If the speed of the moving source is v, the speed of the light relative to the receiver is c'=c+v, in violation of Einstein's relativity. Pentcho Valev

3. *Pentcho Valev* • 2017-10-17 07:36 AM

    In 1887 the calculations of Michelson and Morley showed that the two beams should arrive at different times but the experiment demonstrated no time difference at all - the two beams arrived at the same time. The calculations were based on a false assumption - Michelson and Morley had assumed that the speed of light was independent of the speed of the emitter. So the first thing the Michelson-Morley experiment refuted was this assumption. If Michelson and Morley had assumed that the speed of light VARIED with the speed of the emitter, as predicted by Newton's emission theory, the experimental result would have matched the calculations: "Emission theory, also called emitter theory or ballistic theory of light, was a competing theory for the special theory of relativity, explaining the results of the Michelson–Morley experiment of 1887. [...] The name most often associated with emission theory is Isaac Newton. In his corpuscular theory Newton visualized light "corpuscles" being thrown off from hot bodies at a nominal speed of c with respect to the emitting object, and obeying the usual laws of Newtonian mechanics, and we then expect light to be moving towards us with a speed that is offset by the speed of the distant emitter (c ± v)." https://en.wikipedia.org/wiki/Emission_theory Since the refuted assumption, "the speed of light is independent of the speed of the emitter", became one of Einstein's postulates in 1905, it is correct to say that Einstein's relativity was experimentally refuted before it was created. Pentcho Valev

4. *Pentcho Valev* • 2017-10-16 04:53 PM

   Synopsis of the spacetime story. Here is a schematic presentation of Einstein's initial argument: Postulate 1: The principle of relativity is correct. Postulate 2: The speed of light is independent of the speed of the source (emitter). Conclusion: The speed of light is independent of the speed of the observer. Actually that was a reductio ad absurdum argument - the conclusion was nonsense: John Stachel: "But this seems to be nonsense. How can it happen that the speed of light relative to an observer cannot be increased or decreased if that observer moves towards or away from a light beam? Einstein states that he wrestled with this problem over a lengthy period of time, to the point of despair." http://www.aip.org/history/exhibits/einstein/essay-einstein-relativity.htm The reductio-ad-absurdum procedure should have forced Einstein to abandon the false Postulate 2. Instead, he camouflaged the nonsense by introducing more nonsense now known as "spacetime": Peter Galison: "Only by criticizing the foundational notions of time and space could one bring the pieces of the theory - that the laws of physics were the same in all constantly moving frames; that light traveled at the same speed regardless of its source - into harmony." https://www.aip.org/history/exhibits/einstein/essay-einsteins-time.htm "Special relativity is based on the observation that the speed of light is always the same, independently of who measures it, or how fast the source of the light is moving with respect to the observer. Einstein demonstrated that as an immediate consequence, space and time can no longer be independent, but should rather be considered a new joint entity called "spacetime." http://community.bowdoin.edu/news/2015/04/professor-baumgarte-describes-100-years-of-gravity/ The false Postulate 2, like a typical malignancy, quickly overwhelmed the body of physics and killed this branch of science: "The speaker Joao Magueijo, is a Reader in Theoretical Physics at Imperial College, London and author of

Faster Than the Speed of Light: The Story of a Scientific Speculation. He opened by explaining how Einstein's theory of relativity is the foundation of every other theory in modern physics and that the assumption that the speed of light is constant is the foundation of that theory. Thus a constant speed of light is embedded in all of modern physics and to propose a varying speed of light (VSL) is worse than swearing! It is like proposing a language without vowels." http://www.thegreatdebate.org.uk/VSLRevPrnt.html "...Dr. Magueijo said. "We need to drop a postulate, perhaps the constancy of the speed of light." http://www.nytimes.com/2002/12/31/science/e-and-mc2-equality-it-seems-is-relative.html "But the researchers said they spent a lot of time working on a theory that wouldn't destabilise our understanding of physics. "The whole of physics is predicated on the constancy of the speed of light," Joao Magueijo told Motherboard. "So we had to find ways to change the speed of light without wrecking the whole thing too much." http://www.telegraph.co.uk/technology/2016/12/06/speed-light-discovered/ Joao Magueijo, Faster Than the Speed of Light, p. 250: "Lee [Smolin] and I discussed these paradoxes at great length for many months, starting in January 2001. We would meet in cafés in South Kensington or Holland Park to mull over the problem. THE ROOT OF ALL THE EVIL WAS CLEARLY SPECIAL RELATIVITY. All these paradoxes resulted from well known effects such as length contraction, time dilation, or E=mc^2, all basic predictions of special relativity. And all denied the possibility of establishing a well-defined border, common to all observers, capable of containing new quantum gravitational effects." http://www.amazon.com/Faster-Than-Speed-Light-Speculation/dp/0738205257 Pentcho Valev

5. *Pentcho Valev* • 2017-10-16 03:14 PM

   LIGO and Fermi already tried this particular hoax - optical confirmation of LIGO's "discovery" - but then Integral exposed the fraud: "Integral is sensitive to transient sources of high-energy emission over the whole sky, and thus a team of scientists searched through its data, seeking signs of a sudden burst of hard X-rays or gamma rays that might have been recorded at the same time as the gravitational waves were detected. "We searched through all the available Integral data, but did not find any indication of high-energy emission associated with the LIGO detection," says Volodymyr Savchenko of the François Arago Centre in Paris, France. Volodymyr is the lead author of a paper reporting the results, published today in Astrophysical Journal Letters. [...] Subsequent analysis of the LIGO data has shown that the gravitational waves were produced by a pair of coalescing black holes, each with a mass roughly 30 times that of our Sun, located about 1.3 billion light years away. Scientists do not expect to see any significant emission of light at any wavelength from such events, and thus Integral's null detection is consistent with this scenario. [...] The only exception was the Gamma-Ray Burst Monitor on NASA's Fermi Gamma-Ray Space Telescope, which observed what appears to be a sudden burst of gamma rays about 0.4 seconds after the gravitational waves were detected. The burst lasted about one second and came from a region of the sky that overlaps with the strip identified by LIGO. This detection sparked a bounty of theoretical investigations, proposing possible scenarios in which two merging black holes of stellar mass could indeed have released gamma rays along with the gravitational waves. However, if this gamma-ray flare had had a cosmic origin, either linked to the LIGO gravitational wave source or to any other astrophysical phenomenon in the Universe, it should have been detected by Integral as well. The absence of any such detection by both instruments on Integral suggests that the measurement from Fermi could be unrelated to the gravitational wave detection." http://www.esa.int/Our_Activities/Space_Science/Integral_sets_limi Now Integral is neutralized but still LIGO conspiracy is doomed. Theoreticians know that spacetime doesn't exist (LIGO's "ripples in spacetime" are like the Cheshire cat smile): Nima Arkani-Hamed (06:09): "Almost all of us believe that space-time doesn't really exist, space-time is doomed and has to be replaced by some more primitive building blocks." https://www.youtube.com/watch?v=U47kyV4TMnE Nobel Laureate David Gross observed, "Everyone in string theory is convinced...that spacetime is doomed.

But we don't know what it's replaced by." https://www.edge.org/response-detail/26563 What scientific idea is ready for retirement? Steve Giddings: "Spacetime. Physics has always been regarded as playing out on an underlying stage of space and time. Special relativity joined these into spacetime... [...] The apparent need to retire classical spacetime as a fundamental concept is profound..." https://www.edge.org/response-detail/25477 "Splitting Time from Space - New Quantum Theory Topples Einstein's Spacetime. Buzz about a quantum gravity theory that sends space and time back to their Newtonian roots." https://www.scientificamerican.com/article/splitting-time-from-space/ Joao Magueijo, Faster Than the Speed of Light, p. 250: "Lee [Smolin] and I discussed these paradoxes at great length for many months, starting in January 2001. We would meet in cafés in South Kensington or Holland Park to mull over the problem. THE ROOT OF ALL THE EVIL WAS CLEARLY SPECIAL RELATIVITY. All these paradoxes resulted from well known effects such as length contraction, time dilation, or E=mc^2, all basic predictions of special relativity. And all denied the possibility of establishing a well-defined border, common to all observers, capable of containing new quantum gravitational effects." http://www.amazon.com/Faster-Than-Speed-Light-Speculation/dp/0738205257 "And by making the clock's tick relative - what happens simultaneously for one observer might seem sequential to another - Einstein's theory of special relativity not only destroyed any notion of absolute time but made time equivalent to a dimension in space: the future is already out there waiting for us; we just can't see it until we get there. This view is a logical and metaphysical dead end, says Smolin." http://www.guardian.co.uk/books/2013/jun/10/time-reborn-farewell-reality-review "Was Einstein wrong? At least in his understanding of time, Smolin argues, the great theorist of relativity was dead wrong. What is worse, by firmly enshrining his error in scientific orthodoxy, Einstein trapped his successors in insoluble dilemmas..." https://www.amazon.com/Time-Reborn-Crisis-Physics-Universe-ebook/dp/B00AEGQPFE "[George] Ellis is up against one of the most successful theories in physics: special relativity. It revealed that there's no such thing as objective simultaneity. [...] Rescuing an objective "now" is a daunting task." https://www.newscientist.com/article/mg22730370-600-why-do-we-move-forwards-in-time/ "...says John Norton, a philosopher based at the University of Pittsburgh, Pennsylvania. Norton is hesitant to express it, but his instinct - and the consensus in physics - seems to be that space and time exist on their own. The trouble with this idea, though, is that it doesn't sit well with relativity, which describes space-time as a malleable fabric whose geometry can be changed by the gravity of stars, planets and matter." https://www.newscientist.com/article/mg20026831.500-what-makes-the-universe-tick Perimeter Institute: "Quantum mechanics has one thing, time, which is absolute. But general relativity tells us that space and time are both dynamical so there is a big contradiction there. So the question is, can quantum gravity be formulated in a context where quantum mechanics still has absolute time?" https://www.perimeterinstitute.ca/research/conferences/convergence discussion-questions/what-are-lessons-quantum Pentcho Valev

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Eye in the sky offers clearest vision of Earth

The world’s latest carbon-monitoring satellite has advanced our understanding of how the planet functions. US politicians should take note.

16 October 2017

Bill Ingalls/NASA

Launched in 2014, the OCO-2 satellite has offered unprecedented views of carbon flow on Earth.

When a rocket failure saw NASA’s first carbon-monitoring satellite plunge

into the ocean in 2009, it was a major blow for climate scientists. Space-based greenhouse-gas monitoring was a promising new frontier — and perhaps an eventual tool for monitoring international climate commitments. It took several years to get a replacement into space, but the Orbiting Carbon Observatory-2 (OCO-2) began taking measurements in 2014. The first major scientific results were published last week in *Science*[1–5], and there can be no doubt that the mission is delivering. No doubts, either, that the US government should launch a successor.

The results give an unprecedented insight into one of the most important planetary phenomena: El Niño, the subtle but massively influential gathering of warm waters in the tropical Pacific Ocean. The 2015–16 El Niño was a monster, changing weather patterns and driving the largest and longest coral-reef-bleaching event on record. Through it all, scientists used OCO-2 to watch carbon move through oceans and ecosystems.

The overall trend came as little surprise — a massive increase in global atmospheric carbon levels. Scientists have measured similar rises in carbon dioxide during past El Niños. But the precise mechanism was elusive. OCO-2 helped clarify the matter by producing detailed maps. Researchers saw an initial decrease in the amount of CO_2 coming out of the tropical Pacific Ocean, a dip later swamped by CO_2 originating from Africa, South America and southeast Asia as the event wore on.

Tracking carbon is just the first step. Those data feed into atmospheric models that can provide a more comprehensive explanation for the origin — and destination — of any given CO_2 molecule. Fortunately, sensors on board OCO-2 can assess the amount of photosynthesis using methods other than measuring carbon flux. They detect a photosynthesis-linked signal called solar-induced chlorophyll fluorescence, which gives an independent measure of how much CO_2 plants are taking up.

With this suite of tools, scientists have managed to paint a finer picture of how the 2015–16 El Niño affected individual regions. Heat and drought set the stage for the massive wildfires that ravaged Indonesia during the event, whereas drought-stricken trees in the Amazon rainforest took up less carbon than usual. In Africa, the higher temperatures probably boosted plant

respiration. All three mechanisms for increasing atmospheric CO_2 have been proposed in the past, but it was a surprise to see all play out on different continents simultaneously.

Plenty of questions remain. The satellite measurements are not as precise as scientists would like, and they don’t always align perfectly with data from the ground. And getting the models right is a never-ending challenge. It will be some time before satellites are able to provide the precision needed to quantify the natural carbon cycle, let alone to separate out human emissions with enough confidence to verify whether countries are meeting their obligations to cut greenhouse-gas emissions. But OCO-2 is further validation that the effort is worth pursuing.

US politicians should take note. President Donald Trump has proposed scrapping a follow-on mission, OCO-3, presumably because it falls under the rubric of climate — a topic that is anathema to this administration. That would be a self-defeating and damaging move. The bulk of the budget for OCO-3 — which was built from the spare parts of its predecessor — has already been spent; all that’s left is the expense of launch and operation. Killing the mission now would waste time and money. But more importantly, as these latest studies show, humanity can learn from the measurements that it will make.

OCO-2 is an affirmation of climate science that everybody should be able to appreciate, regardless of political leanings. Trump might not like talking about climate. But surely his administration — and the lawmakers on Capitol Hill who will decide whether OCO-3 survives — cares about the weather.

El Niño has an impact on weather systems around the world. It raises the likelihood of heavy rainfall from California to the Gulf of Mexico, while increasing the chances of drought and extreme heat in areas farther north. El Niño and its opposite sister system La Niña factor heavily in longer-term seasonal forecasts, which can help governments prepare for fires like those tearing through California at the moment. The more we understand this system, the better we will be at forecasting changes in the weather, the climate — and the economy. A 2014 report from the International Monetary Fund argued that effects of El Niño should be taken into account when

nations plan their finances. This has nothing to do with politics, and everything to do with understanding the world in which we live.

Journal name:
Nature
Volume:
550,
Pages:
301
Date published:
(19 October 2017)
DOI:
doi:10.1038/550301a

Comments

Comments

There are currently no comments.

Prepare for larger, longer wildfires

Climate change makes land management more urgent than ever, says Kathie Dello[1].

13 October 2017

Neighbourhoods burned this week in northern California, with more than 30 people reported dead and 2,000 buildings destroyed. Downtown San Francisco is hazy with smoke from wildfires covering 465 square kilometres, more than 30 kilometres north of the Golden Gate Bridge.

Whatever the proximate cause, these should serve as reminders that climate change is not a future problem, nor a hazard just for tiny island nations. It is a problem now, and our land-management plans need to do a better job of incorporating it.

Scientists must walk a careful line when attributing specific events to climate change. Wildfires are part of a healthy ecosystem and a fact of life in the western United States. Many aspects of a landscape affect them, including past fire suppression, land use and human carelessness.

But climate change increases the threat: fires that do start are larger and last longer. Warmer summer temperatures mean more evaporation. Overall, that means drier forests during the fire season. Ironically, California’s past wet winter ended a long drought, but meant that there was more vegetation to become tinder. A 2016 study showed that the fire area attributed to human-

caused climate change has doubled since 1984, largely because vegetation has dried out more. Another 2016 study found that the average area of burnt forest in the northwest United States each year from 2003 to 2012 was almost 5,000% larger than in the years 1972 to 1983, and that the fire season grew from an average of 23 days to 116 days over the same periods. Four other forest areas studied — the Northern Rockies, Southern Rockies, Sierra Nevada and Southwest — also saw increases in both the area burnt and the length of the fire seasons.

Talk about climate change can focus exclusively on avoiding temperature increases in the vague future. The US government's moves to pull out of the Paris climate accord and the home-grown Clean Power Plan are short-sighted, and states' and municipalities' efforts to cut their own emissions are laudable. But it's not enough. We have to manage the effects of climate change that are already here. That means recognizing that threats are increasing.

The cost of fighting US wildfires this year exceeded a staggering US$2 billion, more than half the US Forest Service's budget. The agency has to use funds to fight fires that would otherwise go towards prevention and forest management. It needs more resources so that plans for prevention can become bolder and more expansive.

In fact, the Forest Service is incorporating some climatic adaptation into its regional plans. These include planting seedlings less densely, for instance. But we need many more plans in place, and we need to make sure that goals are met.

What does adaptation mean for wildfires? We have to manage risk even more aggressively than we have done, and incorporate greater uncertainty. We are likely to need an expansion of the areas considered to be at risk. We should avoid building in the urban–wildland interface and mandate the use of materials that are less likely to catch fire. We can boost attempts to thin woody growth and remove brush.

A public-education component is needed as well. At the end of August, a wildfire ravaged the breathtakingly beautiful Columbia River Gorge near Corvallis, Oregon, where I live. It was probably caused by a teenager

throwing a firework off a cliff during one of the hottest summers on record in the Pacific Northwest. Everyone has to realize that the consequences of foolish behaviour or bad luck (many wildfires are started by lightning) are getting worse, so prevention and mitigation are even more important.

Let’s face it — adapting to a changing climate makes the already difficult task of land management even tougher. The aspects we need to manage aren’t isolated — for instance, the burn scars left by the fires will be prone to landslides in the rainy season and dust storms in the summer.

Those living far from fire hazards also need to adapt. The 2014 US National Climate Assessment counts only 15 states with climate-adaptation plans, mainly concerned with flooding and saltwater hazards. The Georgetown Climate Center in Washington DC, which has been tracking progress, says that most states have completed only a few of their goals, many set nearly a decade ago, although work on others is in progress.

The irony is that catastrophes can make for better planning. We should not be afraid to talk about them. Recent events — such as the fires this summer, and the crippling five-year drought that ended in 2015 — motivate us to account for more of these events in the future. Part of my job is talking to policymakers, natural-resource managers and the general public about climate change. Contrary to stereotypes, people in rural areas in the US West are ready to discuss it.

Approaches to climate change that start off in an atmosphere of blame and aggressive policy proposals rarely stick. Instead, discussions about the land that people know provide a common ground that images of lonely polar bears on ice floes do not. There’s always an entry point, and it’s around shared values and solutions. That’s as true in Pocatello, Idaho, as it is in Portland, Oregon.

The wildfires in northern California are horrendous. There is much to mourn. And we can bet that these and other disasters will get worse. Our planning needs to take that into account. We need to protect our livelihoods now, to help ensure better prospects for future generations.

Journal name:

Nature
DOI:
doi:10.1038/nature.2017.22821

Comments

Commenting is currently unavailable.

Global networks of small telescopes will chase companion signals of gravitational waves

Seeing cosmic events is one thing, but what if you could hear them and taste them, too?

13 October 2017

Krzysztof Ulaczyk/University of Warwick

The Gravitational-wave Optical Transient Observer (GOTO) in La Palma, Spain, will look for flares of light coming from the same spot as any gravitational waves.

A cottage industry of small observatories is springing up around the globe to take advantage of astronomers' new ability to capture the gravitational waves from major cosmic events. These new facilities will enable researchers to match up those gravitational waves with electromagnetic signals and perhaps one day even particles of matter from some of the cataclysms that send measurable ripples through space-time.

The main goal is to look for flares of light originating from the same spot as any gravitational waves detected by the US-based Advanced Laser Interferometer Gravitational-Wave Observatory (LIGO), or the Virgo observatory near Pisa, Italy. These smaller telescopes, often built on a shoestring budget, will serve as first-line responders, filling the gap between gravitational-wave detectors and the major facilities of conventional astronomy. “Once you know where to look, you can swing the whole world’s telescopes at it,” says Danny Steeghs, an astronomer at the University of Warwick, UK.

Moving quickly is key. It’s tricky to pinpoint the source of gravitational waves — astronomers can typically narrow it down to a region of the Universe that could contain thousands of galaxies — and observatories may have only a few days before any promising flares of light dissipate. “You need to look at a lot of sky,” says Steeghs, “and you don’t have a lot of time for it.”

Robots of the sky

Steeghs leads a small UK–Australian collaboration that built the Gravitational wave Optical Transient Observer (GOTO) in La Palma, Spain. It is an array of four small robotic telescopes that will eventually grow to 8 telescopes, and perhaps 16. So far, it has cost just £800,000 (around US$1 million).

Alan Watson of the National Autonomous University of Mexico (UNAM) in Mexico City and his collaborators spent even less. They built the Deca-Degree Optical Transient Imager (DDOTI), currently consisting of a pair of robotic telescopes at Sierra San Pedro Martir, Mexico, for a mere

US$350,000, largely by using off-the-shelf components, he says. They plan eventually to have six telescopes, perhaps followed by more facilities in France and Australia.

Some of the facilities, including GOTO, are being designed and built specifically to follow up on gravitational-wave signals. Most of these will be robotic, using machine-learning algorithms to alert each other to point at particular regions of sky and search for interesting flares without the need for human intervention.

Other projects have grown out of existing collaborations that are familiar with looking for visible-light counterparts to the γ-ray bursts spotted by space observatories, or tracking other transient phenomena, such as supernovae explosions or asteroids that are potentially Earth-bound. And some venerable telescopes, including one of those once used by Edwin Hubble in Palomar, California, have been retrofitted. The 1.2-metre telescope is now part of GROWTH (Global Relay of Observatories Watching Transients Happen), a network of 17 facilities around the globe that can track an object seamlessly as the Earth spins. “The idea is, basically, to beat sunrise,” says Mansi Kasliwal, an astronomer at the California Institute of Technology in Pasadena, who is part of GROWTH.

Twan Bekkers

Engineers install a prototype of the BlackGEM telescopes at the South African Astronomical Observatory in Sutherland.

Astrophysicist Paul Groot of Radboud University in Nijmegen, the Netherlands, whose group is part of the Virgo collaboration itself, is leading a Dutch-funded project called BlackGEM. It will initially consist of three telescopes in La Silla, Chile, costing about €6 million (US$7.1 million), that will continuously map the southern sky to build up a database of archived images. If news of a gravitational-wave detection arrives, BlackGEM will scan the relevant patch of sky within hours, and automatically compare that to its archived images to search for anything new.

Neutrino chasers

Similar efforts are already following up on detections of notable particles from space, such as unusually energetic neutrinos or cosmic rays. The

Astrophysical Multimessenger Observatory Network (AMON), started in 2016, got its first interesting hint on 22 September, when it responded to a high-energy neutrino detected by IceCube, the world's largest neutrino observatory, at the South Pole.

When AMON researchers looked towards the source of the neutrino, they saw that a known quasar — an entity consisting of heated matter orbiting a supermassive black hole at the centre of a distant galaxy — was flaring up. This is the type of heightened activity that theorists think could produce an excess of neutrinos, but so far, no high-energy neutrinos have been traced conclusively back to their sources.

In the future, researchers hope that they might detect all three types of emission together: electromagnetic radiation, gravitational waves and particles of matter. Some compare that to seeing, hearing and tasting an astrophysical event at once.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22828

Comments

Commenting is currently unavailable.

Weather-company chief is Trump's pick to lead climate agency

Barry Myers would bring private weather-forecasting experience to the National Oceanic and Atmospheric Administration.

12 October 2017 Updated:

1. 12 October 2017

Mandel Ngan/AFP/Getty

Barry Myers has been nominated to lead the US National Oceanic and Atmospheric Administration.

Barry Myers, the chief executive of weather-forecasting firm AccuWeather, is US President Donald Trump's pick to head the National Oceanic and Atmospheric Administration (NOAA), the White House said on 11 October.

Myers, an attorney by training, has led AccuWeather — based in State College, Pennsylvania — since 2007. This experience could prove useful if the US Senate confirms Myers as NOAA's chief, given that the agency includes the US National Weather Service. But some scientists worry that Myers's ties to AccuWeather could present conflicts of interest, and note that Myers has no direct experience with the agency's broader research portfolio, which includes the climate, oceans and fisheries.

"I think the science community has real cause for concern," says Andrew Rosenberg, head of the Center for Science and Democracy at the Union of Concerned Scientists in Cambridge, Massachusetts.

Rosenberg notes that Myers was an early proponent of carving out a larger role for the private sector in providing weather services. And in 2005, while Myers served as executive vice-president and general counsel, AccuWeather lobbied for legislation to prevent the National Weather Service from competing with private firms in providing products including basic weather forecasting. "Is he going to recuse himself from decisions which might potentially be of interest to his company down the road?" asks Rosenberg.

A different perspective

Myers will probably advance efforts to bring commercial weather data into the national weather-forecasting system, says Bill Gail, chief technology officer for the Global Weather Corporation in Boulder, Colorado. Still, Gail says, Myers respects the importance of the public sector in such activities. "I've got a lot of respect for him, and I think he could do a pretty good job," adds Gail, the co-chair of a decadal survey of US Earth-science satellites being conducted by the National Academies of Sciences, Engineering, and Medicine.

The chief executive's views on climate change are a little harder to parse,

because Myers hasn’t taken any strong public positions on global warming. But in a position statement on the Accuweather website, the company says there is “little doubt” that human activities influence the planet’s climate. “At the same time, our knowledge of the extent, progress, mechanisms and results of global climate change is still incomplete,” the statement says. The company says it encourages its scientists to express their own views, and it publishes a blog featuring posts about climate research.

If Myers ascends to NOAA’s top job, he will lead an agency facing an uncertain financial future. Trump has proposed slashing NOAA’s budget by 17% in fiscal year 2018, compared to the 2017 level of US$5.7 billion. Although Congress has so far rebuffed Trump’s attempts to cut funding for several key science agencies, funding for the 2018 budget year — which began on 1 October — is still up the air. The government is currently running on a stopgap spending bill that will expire on 8 December, prompting another round of budget negotiations.

Ultimately, Myers will need to build a solid team to handle the full NOAA portfolio, says Antonio Busalacchi, president of the University Corporation for Atmospheric Research in Boulder. “He’s going to face a lot of challenges, but the bottom line is that Barry does bring a lot of relevant experience to the table.”

Whoever ends up leading the agency will have help. On 5 October, the Senate confirmed oceanographer Timothy Gallaudet as assistant secretary of commerce for oceans and atmosphere, the number-two position at NOAA. Gallaudet, a 32-year veteran of the US Navy, has experience ranging from weather and ocean forecasting to developing policies to counter illegal fishing and assessing the national-security implications of global warming, according to the White House.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22311

Updates

Updated:

> This story has been updated with information about Myers' views on climate change and the recently confirmed assistant secretary of commerce for oceans and atmosphere, Timothy Gallaudet.

Comments

Comments

There are currently no comments.

European drug regulation at risk of stalling as agency prepares to leave London

Post-Brexit plans to relocate the European Medicines Agency could trigger severe staff losses, its head has warned.

12 October 2017

Chris Ratcliffe/Bloomberg via Getty Images

The European Medicines Agency in London

Drug regulation in Europe could temporarily freeze if the European Medicines Agency (EMA) loses staff during its post-Brexit move from

London. Up to 70 per cent of its 900 staff have said they would quit if the agency relocated to some of the cities bidding to host the organisation.

According to a battle plan drawn up by agency management, failure to retain enough staff would result in a shutdown of essential operations until more people could be hired. If fewer than 30% of the staff move with the agency to its new destination — to be decided next month — it would cease operation, Guido Rasi, the agency's executive director, told *Nature*.

The EMA, an agency of the European Union, needs to leave London — where it has been headquartered since 1995 — as a result of Brexit. In addition to its permanent staff, the agency hires many other experts on a short-term basis. Following an internal staff survey undertaken in September, the agency urged European heads of state to pick a location to which at least 65% of staff would relocate.

Bids for a home

Some 19 cities across Europe have applied to host the prestigious organization. Last week, the EMA released its own assessment of the applications, and warned that several locations are entirely unsuitable for the agency's location. Proposals for Sofia, Malta and Warsaw met almost none of the requirements put forward by the agency and could result in huge staff losses, Rasi warned. Amsterdam was the most popular alternative to London.

"The best case is, of course, a continuum of our activities, with only about 20% staff loss," he says. "The worst case scenario we have come up with is 94% staff loss. For our business-continuity plan, we found three levels of activities we can delay, put on hold or stop completely."

According to Rasi, the agency's core mission — the regulation and monitoring of innovative drugs across Europe — would be the last thing to stop. But even with 50% staff loss, the agency would have to reduce advisory support to new research projects, which could stall work on innovative medicines, he says (see 'European Medicines Agency chief raises alarm at forced relocation').

The agency assesses all medicines, including veterinary products, to be sold on the European market, and passes on recommendations to the European Commission for authorization. It evaluates reports of adverse reactions and, if necessary, works with national agencies to ban medicines that are suspected of being dangerous. The EMA also has in-house scientists who provide advice to drug developers on which criteria they need to fulfil to get a product passed.

In 2016, the agency recommended 81 new medicines for authorization and answered more than 450 requests for scientific advice.

Medication mediation

The European Federation of Pharmaceutical Industries and Associations, headquartered in Brussels, has called on member states to put the agency's well-being first when choosing a location. "There are many cities that could have the right criteria for the agency to settle," said a spokesman. "There is a potential for disruption, but also a potential for harmony. It all depends on what you choose."

In the United Kingdom, pharmaceutical companies worry about how they will get their medicines approved after Brexit. The BioIndustry Association, a group of British life-sciences companies, has backed a UK government proposal to maintain authorizations for medicines granted before Brexit and the continuation of work with the agency during a transition period.

"The alternative — organizing and delivering a wholesale change — would be a gargantuan task for companies and regulators across the UK and Europe," says Steve Bates, the association's chief executive officer. "It would be extremely challenging to successfully deliver in the short amount of time left until Brexit in March 2019."

Meanwhile, the uncertainty about the agency's future is already causing problems. The agency has been unable to fill a position as head of veterinary medicine; all three potential candidates said that they would wait for the final location to be announced before deciding whether or not to take the job, according to Rasi.

Europe's heads of state will meet on 18–20 October to begin hammering out an agreement. A decision is due to be announced on 20 November, at the next EU General Affairs Council meeting.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22817

Comments

Comments

There are currently no comments.

European Medicines Agency chief raises alarm at forced relocation

Guido Rasi says that ensuring the safety of drugs could be compromised.

12 October 2017

Finbarr O'Reilly/REUTERS

The European Medicines Agency (EMA), which oversees drug safety in the 28 countries that are members of the European Union, must move out of London because the United Kingdom is leaving the EU. Nineteen cities have bid to host it and a decision on its new home is expected in November. But EMA staff – and its executive director, Guido Rasi – are worried that the move could severely disrupt the agency’s functions. On 26 September, the agency revealed an internal staff survey which suggested that more than 70%

of current staff would quit, rather than move country, in the case of eight candidate cities. Rasi says he fears that the EMA – which licenses drugs for use in the EU, monitors adverse reactions to medicines and sets standards – could find itself hobbled by the wrong choice of city. *Nature* talked to him about how this might affect European researchers and public health. The interview has been edited for length and clarity.

What kind of activities would stop first if you lost staff?

Initiatives for the elderly, initiatives for tailoring medicine to male and female patients, engagement with patients, efforts to increase transparency, our communication — all these are for the improvement of our work, but they can be stopped if we need to focus on more essential activities. We must ring-fence the approval process, monitoring and inspections. So the second layer would be to decrease our engagement with scientists. The third layer would be to stop scientific advice and abandon early engagement during the research process.

What is the worst-case scenario?

If we retained less than 30% of our staff, we simply could not operate. We could see the collapse of entire services. For example, think of clinical-trials assessment. If we lose all the statisticians, all the experts, we'll sink. We might maintain some activities that are not so relevant, because we have people there, but might have to cancel core activities because those people are gone. In other words, we cannot replace plumbers with blacksmiths. The best case is, of course, a continuum of our activities, with only about 20% staff loss.

How would this affect the average European?

In the worst-case scenario, there would be no approval of medicines and no management of adverse reactions at the central level. Member states would urgently have to make provisions to approve new medicines and decide what standards they want to see. Many innovative medicines would be delayed or simply not be known, because there are no assessors. Innovation would be available only at the cost of uncertainty. Monitoring would rely on local efficiency, and there would be 28, sorry, 27 different approaches and standards.

And what does it mean for researchers?

We would cease the many activities we are doing to support research and development. For example, we get involved at the EU level to define strategy, such as planning for big EU funding programmes or its Innovative Medicines Initiative. We also provide scientific advice, innovation passports for drugs, protocol assistance and advice around clinical trials. For example, we are working with the commission to reduce the regulatory pool around clinical trials while maintaining the standards. This would stop completely for about two years or so. The impact would be huge, because without staff, we cannot engage with researchers and listen to their needs.

How did you react to the results of the staff survey?

We were surprised by the possible severity of staff loss. This is the worst thing that has happened during my experience here. Now, we feel the imperative responsibility to highlight the consequences of the choice of location. What is at stake now is not where to put the agency; it’s about where you can maintain its activities.

How likely is it that people will leave the agency?

You have to consider that people made a choice to come to London. They competed hard to get here. It's not their choice to go away. In 14 months, from November 2017 to April 2019, they will have to recast their lives, give up their houses, their mortgages, the plans they had for the future of their children, the jobs of their partners, their cultural lives. These people are the crème de la crème of Europe. It will not be difficult for most of them to find a job elsewhere, and the headhunters are already around.

But wherever the agency goes, can't you find experts there?

I am sure there are smart people in each country. But to train someone into an expert takes five or six years. It is unlikely that the local environment in any single member state can give us back the knowledge that we are losing.

Would you consider leaving the agency?

You know, the captain is the last to abandon his ship. I will go along with the agency, and I will do whatever will be in my capacity and power to retain as many people as I can.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22818

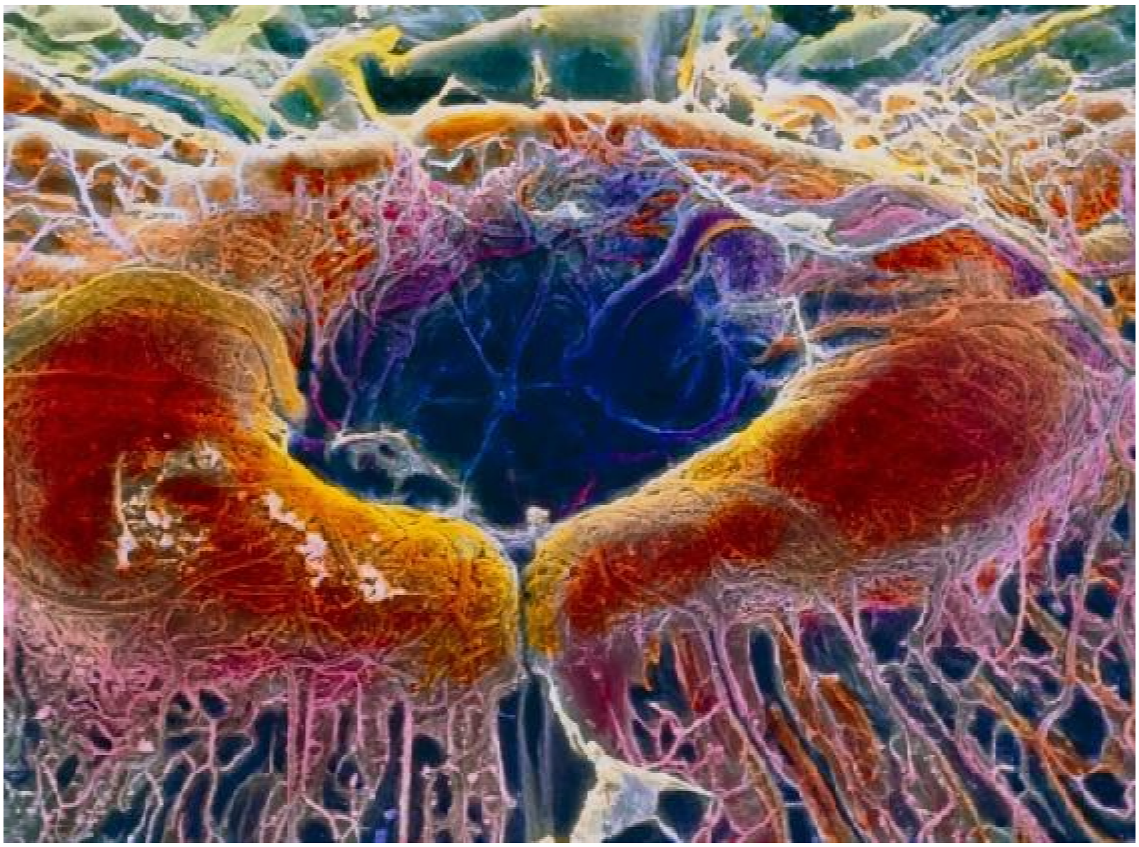
Comments

Commenting is currently unavailable.

FDA advisers back gene therapy for rare form of blindness

Therapy that targets disease-causing mutations could become the first of its kind approved for use in the United States.

12 October 2017



P. Motta/Dept. of Anatomy/University “La Sapienza”, Rome/SPL

The US government is considering whether to approve a gene therapy to prevent the degradation of cells in the retina (shown here in an image from a scanning electron microscope).

Advisers to the US Food and Drug Administration (FDA) have paved the way for the agency's first approval of a gene therapy to treat a disease caused by a genetic mutation.

On 12 October, a panel of external experts unanimously voted that the benefits of the therapy, which treats a form of hereditary blindness, outweigh its risks. The FDA is not required to follow the guidance of its advisers, but it often does. A final decision on the treatment, called voretigene neparvovec (Luxturna), is expected by 12 January.

An approval in the lucrative US drug market would be a validation that gene-therapy researchers have awaited for decades. "It's the first of its kind," says geneticist Mark Kay of Stanford University in California, of the treatment. "Things are beginning to look more promising for gene therapy."

Gene replacement

Luxturna is made by Spark Therapeutics of Philadelphia, Pennsylvania, and is designed to treat individuals who have two mutated copies of a gene called *RPE65*. The mutations impair the eye's ability to respond to light, and ultimately lead to the destruction of photoreceptors in the retina.

The treatment consists of a virus loaded with a normal copy of the *RPE65* gene. The virus is injected into the eye, where the gene is expressed and supplies a normal copy of the RPE65 protein.

In a randomized controlled trial that enrolled 31 people, Spark showed that, on average, patients who received the treatment improved their ability to navigate a special obstacle course[1]. This improvement was sustained for the full year during which the company gathered data. The control group, however, showed no improvement overall. This was enough to convince the FDA advisory committee that the benefits of the therapy outweigh the risks.

Long road

That endorsement is an important vote of confidence for a field that has struggled over the past 20 years. In the early 1990s, gene therapy was red hot, says David Williams, chief scientific officer at Boston Children's Hospital in Massachusetts. "You couldn't keep young people out of the field," he says. "Everyone wanted in." Then came the death of a young patient enrolled in a gene-therapy clinical trial, and the realization that a gene therapy used to treat children with an immune disorder could cause leukaemia.

Investors backed away from gene therapy, and some academics grew scornful of it. Although European regulators approved one such therapy in 2012, for a condition that causes severe pancreatitis, many doubted that it worked. (The company that makes it has announced that it will not renew its licence to market the drug when it expires on 25 October.) "You're too smart to work in this field," a colleague told Kay. "It's a pseudoscience."

But some researchers kept plugging away at the problem, improving the vectors that shuttle genes into human cells. Over time, new clinical trials began to show promise, and pharmaceutical companies became more interested in developing treatments for rare genetic diseases. Gradually, investors returned.

Now, demand for gene-therapy vectors is so high that suppliers are oversubscribed, and researchers have to wait between 18 months and 2 years to get some of the reagents that they need for clinical studies, says Williams.

Measured expectations

In the past few years, gene therapies have shown promise in clinical trials for a range of diseases — including haemophilia, sickle cell disease and an immune disorder called Wiskott–Aldrich syndrome. On 4 October, Williams and his colleagues published results of a gene-therapy trial to treat cerebral adrenoleukodystrophy (ALD), a devastating and sometimes fatal disorder that affects the nervous system and adrenal glands[2]. Disease progression was halted for the roughly 2-year duration of the study in 15 of 17 boys who were treated.

The FDA approved its first gene therapy, a treatment in which immune cells are engineered to combat cancer, on 30 August. Unlike Spark’s therapy, the cancer treatment does not target a specific disease-causing mutation, and is administered to immune cells that are removed from the body, engineered and then reinfused.

That is why researchers say that an FDA approval for voretigene neparvovec would be a landmark. “The general concept of gene therapy is replacing or compensating for a missing gene, and that’s what this does,” says Matthew Porteus, a paediatric haematologist also at Stanford. “People are so excited.”

But Spark’s treatment also highlights the limitations of this generation of gene therapies. Although the treatment seems to improve vision, it is still unclear how long the virus will continue to express the normal *RPE65* gene — and thus how long its effects will last. “It isn’t a cure,” says Kay.

Similarly, the cerebral ALD therapy seemed to slow the effects of the disease in the brain, but is not expected to treat symptoms in other parts of the body, which can emerge later in life.

“I think we still need to have major improvements in the technology before we’re going to be able to cure these diseases,” says Kay. “But along the way there may be treatments that help make improvements.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22819

Comments

Commenting is currently unavailable.

Male scientists share more — but only with other men

Evolutionary differences blamed for squeezing out female researchers.

12 October 2017

Old Visuals/Everett Coll./Mary Evans Picture Library

Male scientists are more likely to collaborate with other men than with women, says a study.

Male scientists are more likely to share their published work than are women — but only with other men, a study of hundreds of researchers has found.

Humans are generally considered to be a highly cooperative species, says

Jorg Massen, a cognitive biologist at the University of Vienna. But most of the evidence for that assumption comes from artificial situations such as computerized cooperation tasks. “I wanted to test human prosociality in an everyday situation,” he says. So he chose one of the most competitive situations he could think of: his own field of research psychology.

To investigate cooperation among psychologists, Massen turned his fellow researchers into guinea pigs. He and his colleagues e-mailed nearly 300 researchers and asked them to share either a PDF of one of their latest papers, or some raw data (pretending that they wanted to include it in a meta-analysis). The results were published in *Scientific Reports* on 10 October[1]. In general, the scientists contacted were highly cooperative, with almost 80% willing to share a PDF and almost 60% willing to send raw data. “I was surprised,” says Massen. “Humans are prosocial even in this competitive field.”

Even more unexpected, however, was a strong gender difference in how the scientists responded to the request for help. Massen and his colleagues had wondered whether men might respond more favourably to women, or vice versa. In fact, men were more likely to share, but only with other men. A male–male request was 15% more likely to be granted than any other gender combination.

Evolution at work?

Massen and his colleagues say that one possible explanation for their results “may be that among male academics there is a network at play, in which they favor each other much like 'Old Boy' networks”. They also suggest that this imbalance might have evolutionary roots and point to an idea called the male-warrior hypothesis, which states that men have evolved to form strong bonds with other males in their group because in the past this enabled them to defend territory from hostile attackers.

“Men are more ready to cooperate with genetic-stranger males to form these fighting coalitions,” says Mark van Vugt, an evolutionary psychologist at the Free University of Amsterdam who first suggested the theory in 2007[2]. Some

of the evidence for this idea comes from lab-based tasks such as public-goods games (in which volunteers choose how many tokens to keep or share), but there are some real-world hints too, he says. Boys tend to play in larger groups than girls, van Vugt says, and in sports such as tennis and boxing, men make more effort to bond with their opponent after a match or fight than women do. However cultural factors are also thought to be at work.

Massen's results “sit very well” with these previous findings, says van Vugt, who suggests that such gender differences might affect professional situations beyond psychology research. Any roles that involve teaming up with strangers — such as business, politics, law and economics — could end up favouring men, he predicts. “Men are always on the lookout to find coalition partners,” he says, whereas women tend to be more cautious about cooperating with strangers. “That's an obstacle to building up the same networks that men have.”

Many factors, including cultural ones, contribute to gender bias at work. “It is very clear that in science and many other professions, women are discriminated against,” says Massen. “Something needs to change.” But he suggests that an increased awareness of differences in cooperation might encourage both men and women — in science and other fields — to look at their own behaviour and consider how they might respond differently. “I hope people read it and think about it,” he says.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22820

Comments

Commenting is currently unavailable.

South African researchers bemoan slashed funds

Plans to cut funding to a programme that recognizes and rewards excellence in research have met with criticism.

11 October 2017

Academics in South Africa are in uproar after a government research agency announced plans to cut the budget of a prestigious grant programme that rewards the country’s best researchers.

The initiative aims to foster academic excellence by awarding grants to individual researchers who volunteer to be rated, with higher-rated academics attracting more money than lower-rated ones. But the National Research Foundation (NRF) said last week that, in an effort to contain costs, it would cut funds to the programme. Some rated researchers will lose up to 90% of their cash.

The move is “catastrophic”, according to George Ellis, a top-rated mathematician at the University of Cape Town who receives funding from the programme. He said it would “leave many of the best researchers in the country high and dry”.

South Africa’s research and higher education system has long struggled with chronic underfunding, exacerbated in recent years by economic and political turmoil. The budget of the government's science and technology department, the NRF's parent body, has increased slightly over the past few years but decreased in real terms owing to rising inflation. And in August 2016, academics wrote an open letter to the government, warning that the system was on the brink of collapse because of systemic underfunding.

The rating system, introduced in 2008, aims to benchmark South Africa's researchers against those in the rest of the world and improve the country's competitiveness. The number of researchers who have been rated has since more than doubled to 3,689.

South Africa's research system is "subject to the availability of resources, and we are being asked to do more with less", says Gansen Pillay, deputy chief executive of the NRF. "The question was sustainability into the future. It hasn't been terminated, but the funding model has been revised."

The system, known as the Incentive Funding for Rated Researchers programme, has five ratings: A (for international leaders in their field), B (for researchers who are internationally acclaimed), C (for established researchers), P (for young researchers, normally aged under 35, who have received prestigious awards and are expected to become international leaders in their subjects), and Y (for emerging young researcher). Ratings were awarded for a period of five years, and came with cash rewards that researchers were free to spend on research of their choice.

The NRF's plans will cut funding across all rating categories, but top-rated researchers will be hit hardest; Y- and C-rated researchers will see comparatively moderate declines. In 2018, newly A-rated researchers will see their funding decline from up to 100,000 South African rands (£5,500) a year over five years to a one-off payment of 50,000 rands in the first year of their rating. Newly Y-rated emerging researchers will receive 100,000 rands from the NRF over two years, instead of 40,000 rands a year over five years.

From 2019, only P-rated researchers will get an annual sum of 50,000 rands. Those in other categories will receive a one-off payment of 30,000 rands if they retain their rating. If they are newly rated or improve their rating, they will receive a one-off payment of 50,000 rands.

"When you are an A-rated researcher, which means you're world renowned, you should be able to access funding from other sources," says Pillay. However, many of the NRF's largest grants programmes are available only to experienced researchers, he says. "It is incentive funding, not a grant. It was just to acknowledge and affirm excellence."

Ellis says that, in practice, many researchers use the incentive funding to supplement their main research grants, to support students or visitors and to travel for conferences. "In practice, it is a termination of this excellent programme and a huge slap in the face for South Africa's top level scientific researchers."

"The incentive grants funding was good: it encouraged researchers to get themselves rated," says Michael Davies-Coleman, dean of science at the University of the Western Cape. "It will become increasingly difficult to convince colleagues to apply for rating in the future, despite the important contribution which increasing numbers of rated researchers make to a university's national research profile." Cutting incentive cash would also have a major effect on the number of students entering research, he says.

An A-rated researcher who spoke on condition of anonymity says that the NRF "were victims of their own success" because of the growth in the number of rated researchers. "In an environment where the budgets are being reduced in real terms, they're desperate to save a bit of money. But from an academic point of view, it's a bit of a disaster."

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22816

Comments

Comments

There are currently no comments.

A more personal view of human-gene regulation

A long-planned effort to examine gene expression and gene regulation in all the major tissues in the human body across many people comes to fruition.

11 October 2017

Dung Vo Trung/Eurelios/Look at Sciences/SPL

Hundreds of post-mortem tissue samples have been analysed for gene expression.

“The observation of and the search for similarities and differences are the basis of all human knowledge,” Alfred Nobel once said. From external events to spiritual influence, each culture and time has found its own way to explain

how we differ from each other and what we have in common. Today, much biological effort focuses on the similarities and differences between people’s DNA, and probing the myriad ways that these can combine, for good or ill, is at the cutting edge of genetics.

This week, geneticists announce the results of one such project. The researchers describe how they have analysed the regulatory code in our genomes. This should help scientists to unpick how genetic variants associated with disease function in different tissues of the body.

The project is called GTEx (genotype-tissue expression) and it catalogues genetic variation and its influence on gene expression in 44 tissues across the human body. The results — published in four papers (see pages 204, 239, 244 and 249) and discussed in an accompanying News and Views article — show how most of these critical regulatory regions are located close to the gene they affect. And they report important differences in gene regulation between tissues and between individuals. These results build on the findings of a pilot study that were announced in 2015.

The project results were a long time coming and were widely anticipated. The GTEx study was first proposed back in 2008. Its goal was to establish a resource database and an associated biobank (holding all major human tissues from 1,000 deceased individuals) that could be used by scientists to study the relationship between genetic variation and gene expression.

That seemed so far beyond technical capabilities at the time that many dismissed the idea as unrealistic. How could that many tissues be sampled from a single donor? How could so many individuals be recruited and be appropriately consented? How could high-quality samples be taken within the required post-mortem interval (different for various tissues)? And would the data even reflect living biology and replicate known findings on gene regulation?

LISTEN

Reporter Shamini Bundell learns about the grieving families contributing to a

huge genetics project.

You may need a more recent browser or to install the latest version of the Adobe Flash Plugin.
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What was not questioned was the scientific need to reach for those goals. Following the Human Genome Project in the early 2000s, the genomics community had continued to establish reference catalogues for human genomes. These characterized genetic variation within and between individuals in populations worldwide, and made it possible to begin to identify functional elements in different cell and tissue types. Geneticists also identified genetic variation associated with a wide range of human diseases, a large proportion of which is found in non-coding regions, suggesting a role for gene regulation.

The GTEx Consortium investigates this link. To do so, project scientists needed a framework to consider ethical, legal and social issues that surround post-mortem donation (as discussed in a News story on page 169). Research on samples from deceased donors is not covered by rules on using humans as experimental subjects, and so does not need consent in the United States, where the project was based. But the GTEx scientists decided to include only samples from people for whom consent had been obtained from next of kin. This is commendable. Presumed consent — a sensible policy for organ donation for transplantation — seems less appropriate for basic research, where the benefits are not as immediate and clear-cut. It is good, too, that some researchers kept in touch with donor families, many of whom have attended project meetings to hear about the ongoing contribution of their loved one to science.

Nearly all donor families have said that they would like some genetic results returned, especially information relevant to treatable diseases. The GTEx study was not designed to do this. Nevertheless, project organizers and other researchers should consider in future studies whether and how they could return results to tissue donors' families.

Why rely on deceased donors? Previous studies were largely limited to cell lines or blood, but the GTEx project wanted to assess other tissues relevant to

disease, for example the heart and kidneys. Combined with the desire to study materials that are not available from living donors, such as the brain, and the need to sample multiple tissues from the same individual, it was clear that the project would have to find a way to source and quickly sample tissue post-mortem. To identify potential donors, the project made use of a network of existing programmes, such as autopsies carried out soon after death, and organ- and tissue-transplantation registers.

In reaching this point, and by providing an open-access database and tissue biobank that is already being widely used in biomedical research, the GTEx project has provided clear guidelines and procedures that are already informing, and providing the groundwork for, a next generation of studies.

These should include, for example, continued expansion of projects such as GTEx to include larger numbers of donors and sampling across different populations to further our understanding of the impact of genetic variation and regulatory differences. Complementary to these studies are projects such as the proposed Human Cell Atlas, which aims to use single-cell sequencing to better resolve cell types and their relationships.

For now, all biomedical researchers should welcome the wealth of data that continues to be released by the GTEx project, and the insights it provides into the regulatory code of our genomes. It is an important step towards the ultimate and ambitious goal of being able to characterize genetic variation and gene regulation in all cells of the human body.

Journal name:
Nature
Volume:
550,
Pages:
157
Date published:
(12 October 2017)
DOI:
doi:10.1038/550157a

Comments

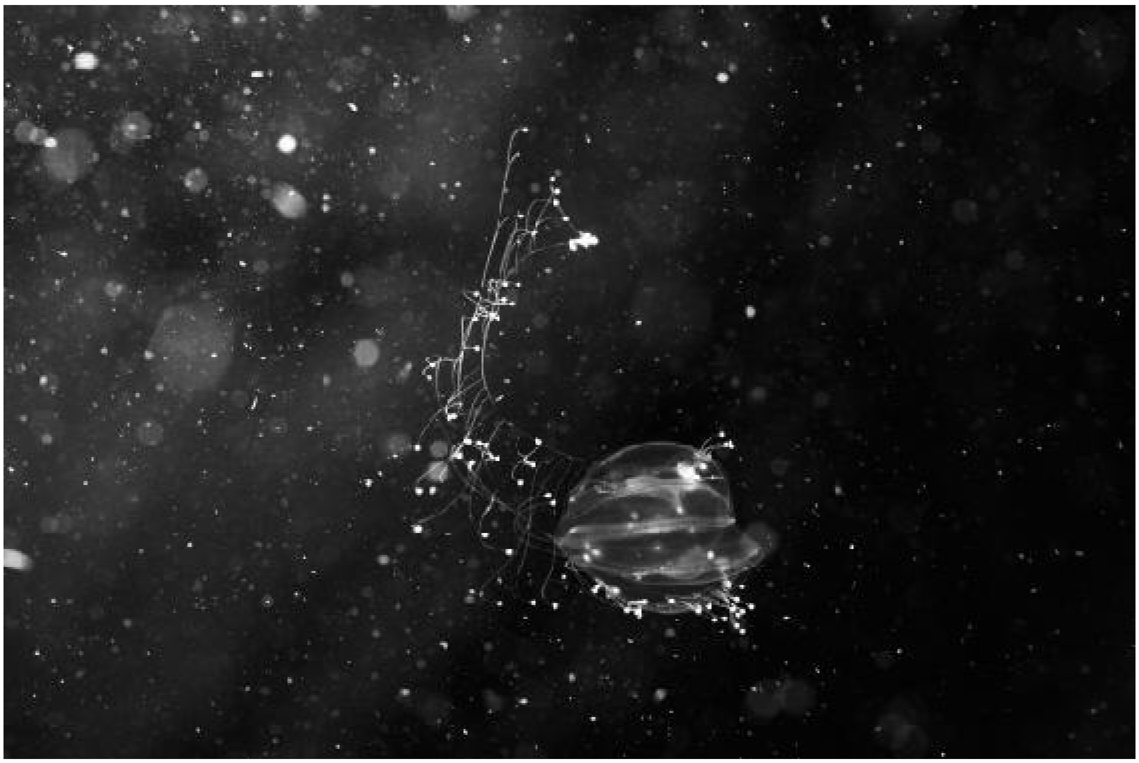
Commenting is currently unavailable.

| 章节菜单 | 主菜单 |

Marine snow falls heaviest at the Equator

Organic matter drifts down to the equatorial ocean floor in distinct patterns.

11 October 2017



Flip Nicklin/Minden Pictures/Getty

Scientists have mapped heavy marine snow fall in the equatorial ocean.

According to the Renaissance mathematician Evangelista Torricelli, who discovered atmospheric pressure, “We live submerged at the bottom of an ocean of air.” If the atmosphere is an ocean, then the ocean is also an atmosphere, with its own turbulence and microclimates. And the parallels between these two great fluid environments of our planet go further. When

Japanese scientists took a dive into the ocean in a submersible in 1952 and their lamp revealed a flurry of shining white flakes falling towards the depths, they were going to name it only one thing.

This week, scientists report the most in-depth (and at-depth) analysis of this 'marine snow' — in the region that experiences the heaviest falls. For it is more than a mesmeric curiosity. The origins and fate of these oceanic snowflakes — in reality various forms of organic matter ranging from dead plankton to plant and animal detritus — help to determine what happens to carbon in the deep ocean. Carbon that makes it all the way to the depths without being released on its journey is effectively sequestered from the atmosphere for hundreds of years.

Writing in *Nature Geoscience* (R. Kiko *et al. Nature Geosci.* http://doi.org/cdz6; 2017), the scientists describe how they scanned the avalanche of marine snow that makes slow and steady progress towards the depths of the equatorial Atlantic and Pacific oceans. They discovered particularly heavy clouds of the material at depths of between 300 and 600 metres. This is where zooplankton (drifters) and nekton (swimmers) head from the surface during the daytime. The snowy scene, the scientists conclude, is largely made up of the faeces released by these organisms.

The study overturned one common assumption that is included in many models of ocean carbon transport. The researchers found that most of the organic matter that reaches the bottom arrives as a veil of relatively slow-moving small particles, rather than the assumed faster-falling and larger aggregates, which seem to disintegrate steadily as they sink.

The scientists also noted another fascinating effect. Strong and deep equatorial currents stop the snow drifting north or south towards the poles. Instead, it falls as a narrow curtain of flakes drifting down the darkness of the marine sky.

Journal name:
Nature
Volume:
550,
Pages:

158
Date published:
(12 October 2017)
DOI:
doi:10.1038/550158b

Comments

Comments

There are currently no comments.

ResearchGate lawsuit, walrus spat and a Second World War shipwreck

The week in science: 6–12 October 2017.

11 October 2017

Policy | Awards | Publishing | Universities | People | Events | Space | Trend watch

POLICY

Walrus left off threatened-species list The US government will not list the Pacific walrus (*Odobenus rosmarus divergens*) as a threatened species, despite the dwindling of its Arctic sea-ice habitat, the Fish and Wildlife Service (FWS) announced on 4 October. The decision reverses a 2011 FWS finding that the walrus should be listed. Now, officials say that the population seems to be adapting to the changing environmental conditions. They say that although the walrus's sea-ice habitat may shift, the animal should still be around in the near future, which the FWS defines as the year 2060. The Center for Biological Diversity, based in Tucson, Arizona, filed the original petition to force a decision. It called the announcement "disgraceful".

Mike Korostelev/Biosphoto/FLPA

Drug applications China is overhauling its drug-registration system in a bid to fast-track new medicines to market. The powerful State Council announced rules on 8 October that will allow data from clinical trials in other countries to be used to support drug-approval applications in China. That will make it faster and cheaper for companies to introduce medicines — a boon for multinational pharmaceutical companies hungry for a piece of the Chinese market. After the announcement, shares in China's drug-makers jumped in anticipation of higher profits. The move is the government's latest attempt to clear the way for innovative drugs, reduce the backlog of applications and crack down on fraudulent or otherwise-faulty drug applications. The rules will also help research institutions to conduct clinical trials.

Endocrine row The European Parliament has vetoed draft criteria proposed by the European Commission to identify chemicals known as endocrine disruptors: substances such as bisphenol A that may interfere with hormone systems and cause health problems. Under a 2012 law, the commission had been asked to come up with scientific criteria for defining the chemicals by

the end of 2013 as a step towards restricting the substances. But it failed to do so. Experts from 28 European Union member states finally agreed on criteria in July, but Parliament members rejected them in a 4 October vote. They said that the commission exceeded its mandate in exempting from its definition some chemicals that are designed to attack pests' endocrine systems. The Commission must now draft fresh proposals.

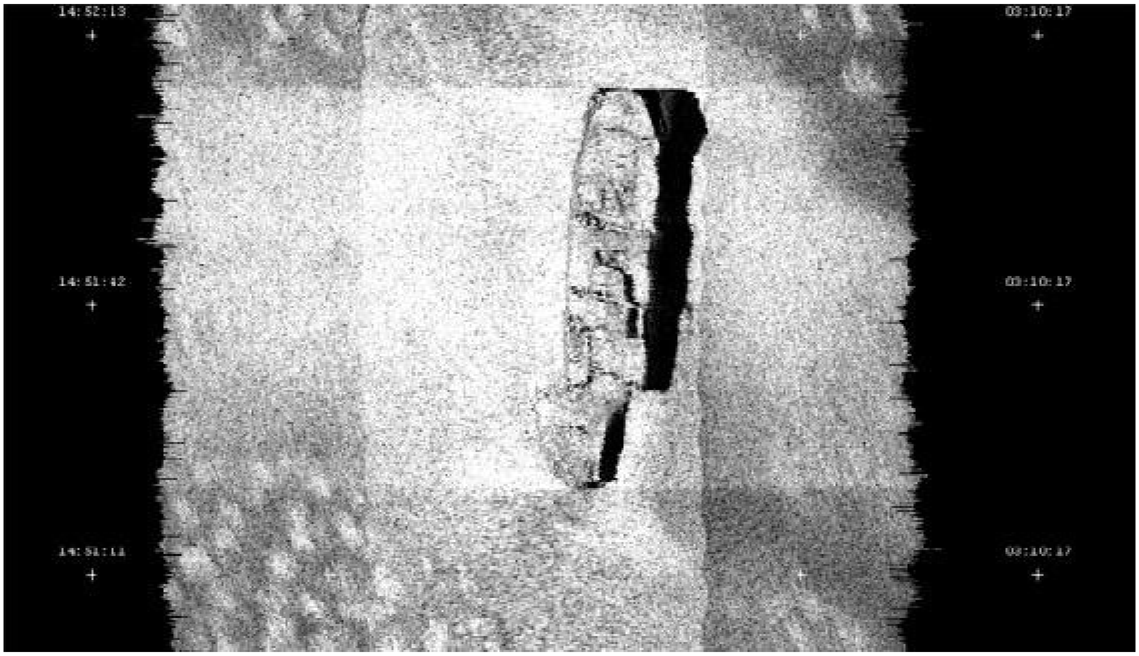
Zika screen On 5 October, the US Food and Drug Administration (FDA) approved a test to detect Zika virus in blood and organ donations. During last year's outbreaks in the US territories of Puerto Rico, the US Virgin Islands and American Samoa, the FDA permitted blood-donation centres to screen blood using the 'cobas' Zika test on an experimental basis, to ensure that people would not be infected through transfusions. The test, manufactured by Roche of Basel, Switzerland, detects Zika virus RNA in blood plasma. The FDA has not yet approved a Zika treatment, vaccine or commercially available diagnostic test.

EVENTS

Climate lawsuit An environmental group is suing the US National Oceanic and Atmospheric Administration (NOAA) to gain access to public records related to the August disbanding of a federal climate-advisory committee. The panel was providing input into the next national climate assessment, a congressionally mandated report on the effects of climate change in the United States, due in 2018. On 18 August, NOAA announced that it would not renew the committee's charter, and on 31 August the Center for Biological Diversity in Tucson, Arizona, asked the agency for documents related to that decision. NOAA failed to respond to that request, and on 3 October the environmental group filed a lawsuit in federal district court, demanding access to the files.

Shipwreck spotted Scientists on board Australia's national deep-water research ship have discovered the wreck of a merchant ship sunk during the Second World War. The wreck of the SS *Macumba* (**pictured**) was found in the Arafura Sea off the coast of the Northern Territory on 4 October during a government-sponsored search by the RV *Investigator*. *Investigator*'s

multibeam sonar located the wreck, which is sitting upright in 40 metres of water. Japanese aircraft sank the *Macumba* on 6 August 1943, killing three crew members.



Marine National Facility, CSIRO

AWARDS

Nobel prizes The 2017 Nobel Prize in Chemistry was awarded on 4 October to Jacques Dubochet, Joachim Frank and Richard Henderson for their development of cryo-electron microscopy, which has transformed the imaging of biomolecules. The Nobel Peace Prize, announced two days later, went to the International Campaign to Abolish Nuclear Weapons in Geneva, Switzerland, for its efforts to achieve a “treaty-based prohibition” of the weapons. The economics prize was awarded on 9 October to Richard Thaler at the University of Chicago, Illinois, in recognition of his work on behavioural economics, which incorporates elements of psychology.

PUBLISHING

Copyright suit Two large scientific publishers, Elsevier and the American Chemical Society, have filed a lawsuit against the scholarly social network ResearchGate to prevent copyrighted material appearing on its site. The publishers are two of five that on 5 October announced they had formed a coalition to start ordering ResearchGate to take down from its site papers that breach copyright. Up to 7 million papers may be affected, the coalition statement said. ResearchGate, based in Berlin, declined to comment on the lawsuit, which was filed in a German court.

UNIVERSITIES

Budapest battle The prestigious Central European University (CEU) in Budapest seems to have dodged a law change that many see as a deliberate attempt to close it down. In April, the Hungarian government sparked mass protests by rushing through a law that requires international universities in the country to also operate as higher-education institutes in their countries of origin. Only the CEU, registered in New York state after being founded in 1991 by Hungarian-born philanthropist George Soros, was seriously affected. The revised law comes into effect on 11 October; the CEU announced on 3 October that it had agreed with Bard College in Annandale-on-Hudson, New York, to provide educational activities in the state.

PEOPLE

WHO leaders Clinical scientist Soumya Swaminathan will be the new deputy director-general for programmes at the World Health Organization (WHO), making the post the most senior in the organization to be held by an Indian national. Swaminathan, a paediatrician and researcher specializing in tuberculosis, is the secretary of India’s department of health research and director-general of the Indian Council of Medical Research. Former UK public-health minister Jane Ellison has been appointed as the WHO’s deputy director-general for corporate operations. Swaminathan and Ellison are two of 13 new WHO leaders announced by director-general Tedros Adhanom Ghebreyesus on 3 October.

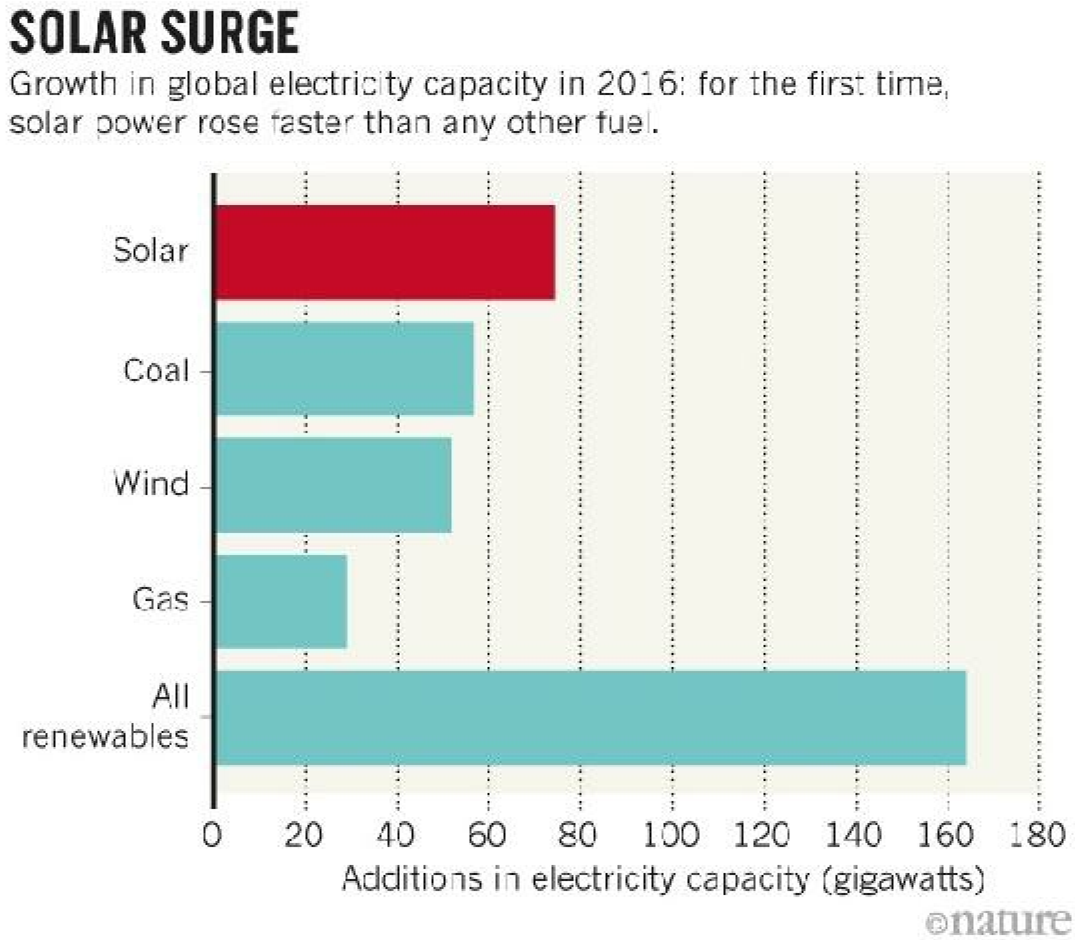
Whistle-blower quits A senior executive who turned whistle-blower at the US Department of the Interior resigned on 4 October, accusing President Donald Trump’s administration of advancing fossil-fuel interests ahead of the agency’s conservation mission. Joel Clement, who had been at the department for nearly seven years, was director of the office of policy analysis before he was abruptly reassigned to an accounting division in June. Clement has filed a whistle-blower claim against the agency, arguing that his reassignment was in retaliation for speaking out about the threat of climate change to Native Alaskan communities.

SPACE

Plutonium problem NASA’s plutonium supply could be threatened if production issues are not addressed soon, according to a report from the US Government Accountability Office (GAO). The space agency uses plutonium-238 to power long-term missions such as some Mars rovers. The review, released on 4 October, found that current stockpiles, along with 100 grams of new ^{238}Pu manufactured by the Department of Energy (DOE), will last NASA until the 2020s. But without fixing one of the two US reactors capable of producing the isotope, the DOE will have trouble producing enough to meet demand. The space agency originally sourced its ^{238}Pu from nuclear-weapons programmes, but the DOE phased them out in the 1980s. NASA began paying the energy agency to manufacture ^{238}Pu in 2011.

TREND WATCH

The solar sector grew faster than any other energy market in 2016, according to the *Renewables 2017* report published on 4 October by the International Energy Agency in Paris. New electricity capacity provided by solar photovoltaics grew by 50% last year — faster than for any other fuel — to more than 74 gigawatts worldwide. China accounted for almost half of this expansion. The surge, driven by government policies and falling costs, opens “a new era for solar power”, says the report.



Source: Renewables 2017, IEA

Journal name:
Nature
Volume:
550,
Pages:
162–163
Date published:
(12 October 2017)
DOI:
doi:10.1038/550162a

Comments

1 comment

1. *Phil Sandine* • 2017-10-15 02:35 AM
   In Walrus left off threatened-species list it was reported that The Center for Biological Diversity called the announcement “disgraceful”. However, if the Center had kept up with the information available on walrus population dynamics (see links below), it is reasonable to conclude that they would have recognized that the FWS finding was reasonable (of course they would have had one less reason to ask for donations if they had changed their opinion).
   https://polarbearscience.com/2016/08/02/usgs-report-on-history-of-walrus-haulouts-leaves-out-correlation-with-population-size/
   http://www.thegwpf.org/content/uploads/2014/10/walrus-fuss.pdf

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The ambitious effort to document California’s changing deserts

Ecologists catalogue bird and mammal populations as warming transforms Death Valley.

11 October 2017

Death Valley, California

Jason Ogulnik for Nature

Jim and Carol Patton hunt for kangaroo rats and other desert rodents in Death Valley, California.

Jim Patton brushes a packrat's furry white belly with a vibrant green marker as his wife, Carol, croons over the animal. "We're making you beautiful — punk mice!"

Patton, a retired mammologist, is trapping and releasing desert wildlife as part of an ambitious project to repeat surveys conducted by renowned ecologist Joseph Grinnell from 1908 to 1939. Known as the 'father of field notes', Grinnell criss-crossed California in his Ford Model T to catalogue its birds and mammals. His descriptions are so complete that researchers today can compare the density and distribution of animal populations then and now.

Grinnell's records provide an unparalleled baseline for researchers to explore how urbanization, farming, mining and climate change are reshaping the state's ecosystems. The Grinnell Resurvey Project, run by the University of California, Berkeley, has sought over the past 14 years to capture current conditions, with an eye to quantifying future ecological shifts. The latest phase of the work, which began last month, is focused on cataloguing small mammals in California's rapidly changing deserts.

"The only way to get a sense of what is happening under climate change, and what to expect in the future, is the kind of work going on in the Grinnell research project," says Josh Tewksbury, a sustainability scientist at Future Earth, an environmental-research group in Boulder, Colorado. "It's hard to see how the water boils when you're in the pot."

When Grinnell began his project in the early twentieth century, he was struck by California's varied geography, from snowy mountains to blazing deserts to rocky coasts. Anticipating the state's inevitable transformation as Americans moved west, he documented the distribution of species in about 700 locations. His team deposited more than 100,000 specimens in natural-history museums, including the skull from one of California's last grizzly bears (*Ursos arctos californicus*), as well as 74,000 pages of field notes and 10,000 images.

"The student of the future will have access to the original record of faunal conditions in California," Grinnell wrote in 1910, two years after he became the first director of Berkeley's Museum of Vertebrate Zoology. "This value

will not, however, be realized until the lapse of many years, maybe a century.”

Image Slideshow

1. 

   Jim and Carol Patton have trapped rodents around the world for more than 40 years. They began a new season of fieldwork in Death Valley in September, as part of the Grinnell Resurvey Project.

   Jason Ogulnik for Nature

2. 

Jim Patton marks a rodent so that he can tell if the same animal shows up again in a trap.

Jason Ogulnik for Nature

3.

Joseph Grinnell, the first director of the Museum of Vertebrate Zoology at the University of California, Berkeley, documented the state's flora and fauna in unparalleled detail from 1908 to 1939.

With permission of the Museum of Vertebrate Zoology, UC Berkeley

4. 

Grinnell and a colleague collected these bushy-tailed woodrats (*Neotoma cinere*a) near Death Valley, but the species is rarely found in the same locations there today.

With permission of the Museum of Vertebrate Zoology, UC Berkeley

In 2003, Grinnell's academic descendants set out to retrace his survey of Yosemite National Park. Five years later, they reported that 14 of the 28 mammal species monitored in Yosemite had migrated to higher elevations since Grinnell's time, averaging a gain of 500 metres (C. Moritz *et al.* *Science* **322,** 261–264; 2008). The animals' climb occurred during a period when winters in the park warmed by about 3 °C. Because Yosemite has been a protected area since 1864, the researchers concluded that land-use changes were not a major factor in the species' shifts.

Steve Beissinger, a conservation biologist at Berkeley and the project's leader, says that recent surveys have yielded less-coherent results. "As we look more broadly across sites in California, we find that responses are much more complicated," he says. "Some species [are] moving to lower elevations in areas that have become rainier, and in some places we see stasis."

But a growing number of studies suggest a dim future for desert dwellers in the coming decades, as they face warmer, drier conditions. Temperatures in Death Valley in July were the hottest for any month anywhere in the world in 2017, averaging 41.9 °C.

Many biologists think that desert organisms are living at the limits of survival — and that cooler regions may be out of reach for slow-moving or short-lived species. Preliminary results from the Grinnell Resurvey Project corroborate this idea. Of the 135 bird species surveyed in the Mojave Desert, only the common raven (*Corvus corax*) has significantly expanded its range since the early twentieth century, Beissinger says. The ranges of 38 other species have contracted.

With permission of the Museum of Vertebrate Zoology, UC Berkeley

Photographs of Vogelsang Lake in Yosemite National Park in 1915 (left) and 2004 show how trees have grown larger as the area has warmed.

A changing landscape

Yet on a cool morning in the Lee Flat area of Death Valley, most of the 160 box traps set out by Patton contain small, furry animals. Within 24 hours, he and Carol mark 90 squirrels, mice and rats belonging to nine species — one more than Grinnell listed in the same area in 1917.

Patton rejects the idea that climate change will soon drive many desert mammals to extinction. Like Grinnell, he is awed by the animals’ ability to adapt to extreme conditions. Kangaroo rats (*Dipodomys* sp.) extract water from seeds, and lose little of it because their kidneys concentrate urine to a crystal-like consistency. The rodents’ oily coats also prevent water loss through sweat.

Still, Patton sees signs of change. He has not yet captured a bushy-tailed woodrat (*Neotoma cinerea*), prominent in Grinnell’s Death Valley accounts. But Patton hesitates to speculate on the species’ absence, because reliable data on its distribution come only from Grinnell’s time and now. The rat’s numbers might have dwindled before desert warming intensified in the 1970s.

Others on the resurvey project are exploring how hotter, drier conditions might harm birds and mammals, by studying species’ metabolisms and how much water they lose through evaporation. Ecological modellers can combine these findings with the latest population data to better project how the desert ecosystem might fare as the planet warms.

Ideally, scientists would revisit these forecasts in a few decades using fresh data. But fieldwork of this sort is falling out of favour. Staring at the blue mountains on the horizon, Patton says that he doesn’t know who will replace him: very few students today train as naturalists, and museums and national parks are chronically underfunded. “Everyone wants to know how nature is changing and why,” he says. “But there’s almost nobody doing this kind of work.”

Journal name:
Nature
Volume:
550,
Pages:
168–169
Date published:
(12 October 2017)
DOI:
doi:10.1038/550168a

Comments

There are currently no comments.

Gene-expression study raises thorny ethical issues

Project obtains tissues from recently deceased individuals to look for the origins of disease.

11 October 2017

Marc Asnin/Redux/eyevine

Tissues are taken from organ donors after consent has been given by their loved ones.

Sharon Napper was getting ready for school one morning five years ago, when her four-year-old daughter said, “Daddy fell off the bed.” Her husband, Ronald, a retired US Marine who worked as a police officer on an army base, was lying on the floor. He had suffered an aneurysm that spread to the

temporal artery in his head.

At the hospital, the only way to relieve the swelling would have been to open Ronald's skull, leaving him unable to eat or breathe on his own. "There was a quality-of-life issue. We had discussed this, and so I let everything kind of take its course," says Napper, who had been planning Ronald's 50th birthday party the evening before.

The couple had previously discussed Ronald's desire to be an organ donor, but another request followed: would Napper also donate his tissues for research after he died?

Ronald's myriad tissues, and those of almost 1,000 other anonymous deceased donors, are now the basis of a first-of-its-kind database. Supported by the US National Institutes of Health, the US$150-million Genotype-Tissue Expression (GTEx) project is amassing data about gene sequences and activity, and other information, across 44 types of tissue, from blood vessels to 10 different brain regions.

"It's creating a 'Google Maps' of the body," says Kristin Ardlie, a geneticist at the Broad Institute of MIT and Harvard in Cambridge, Massachusetts, who is part of the project's data-analysis team. It routinely releases new data, which are freely available to qualified researchers. And in this week's *Nature*, GTEx is publishing its latest and biggest analysis, based on tissue from 449 donors[1–4].

In assembling so much information from such a large number of deceased donors, the project has raised some thorny ethical issues concerning informed consent and scientists' moral obligations to families who donate the tissues of their loved ones for nothing in return.

The study aims to plug a gap in the search for the genetic origins of disease. Scientists have identified thousands of DNA variants linked to different conditions, but most lie in stretches of the genome that are devoid of protein-coding genes and are, instead, likely to alter the activity of other genes. By relating genes active in different tissues to variations in donors' genomes, researchers hope that GTEx can join the dots between non-coding variants and gene expression.

When the project was proposed in 2008, many researchers were sceptical that it could succeed, says Manolis Dermitzakis, a human geneticist at the University of Geneva Medical School in Switzerland and an early proponent of GTEx. That is because RNA molecules (a readout of gene activity) start to decompose after a person dies, and no one had ever attempted to measure gene expression in so many different tissues across so many people.

The challenge of amassing that much human tissue wasn't merely technical. Soon after learning of the deaths of their loved ones, the relatives of GTEx donors, such as Sharon Napper, were asked to donate dozens of tissue samples and to consent to the genome, medical history and other data of their loved ones being made widely available to researchers, albeit with most identifying details removed.

"They are being asked to donate to this strange project about which they have never heard anything like it before," says Laura Siminoff, a bioethicist at Temple University in Philadelphia, Pennsylvania, who led a project on GTEx that involved re-contacting donor families to see how they felt about the entire process. Her team found that the stress of suddenly losing a family member had fogged people's memories of what they had consented to. Most recalled that they had agreed to donate their relatives' tissue for research, but often didn't recall much else.

LISTEN

Reporter Shamini Bundell learns about the grieving families contributing to a huge genetics project.

You may need a more recent browser or to install the latest version of the Adobe Flash Plugin.
[Go to full podcast]

Siminoff suggests that some form of genetic counselling should be made part of the informed-consent process for tissue-donation projects such as GTEx. She also thinks that the project missed an opportunity by seeking tissue donations only from organ donors, because African Americans, Latinos and

other ethnic-minority groups are less likely to register.

Larry Gavan donated his older brother Mark's tissues to GTEx in August 2014, he says, even though he and his family weren't entirely clear how they would be used. Mark, who died of cardiac arrest following a stroke, was born with type 1 diabetes and had lost most of his sight. Gavan says his family saw the donation of Mark's tissues as "an opportunity to make a contribution to future people's lives and be directly related to the diseases my brother suffered from."

Napper, who along with other donor families was part of a GTEx community advisory group, emphasized that altruism motivated her decision to donate her husband's tissues. But Siminoff's research has found[5] that most donor families, including Napper's, want to know the results of tests, such as genome sequencing, conducted on the remains of their loved ones.

The study was not designed to return such findings. But Nicole Lockhart, a programme director at the National Human Genome Research Institute in Bethesda, Maryland, who coordinated the ethical, legal and social aspects of GTEx, says that future tissue-donation studies might consider providing families with medically important results.

"A standing policy of simply 'we will not return results' is becoming less and less common," says Susan Wolf, a lawyer and bioethicist at the University of Minnesota in Minneapolis. Studies such as GTEx should plan to enable families to be identified if researchers discover, for instance, a mutation that dramatically increases the risk of cancer for relatives who inherit it, she says.

GTEx and other tissue-donation studies are likely to offer enormous benefits to scientists and companies (which can also apply for free access to the data), says Siminoff. "We should also think about what we can do for people who are generous and make these kinds of donations that benefit everybody."

Napper, who works as a nurse in cancer and chemotherapy, accepts that her late husband's tissues are now a code in the GTEx database. But, still, she checks the study's website to keep track of new research (191 studies are listed on the project website, and several more appear today in *Nature* and other journals). She sees his participation as an important legacy for their

family, which includes six sons, two daughters and nine grandchildren.

In June, she and other GTEx donor families attended the project's annual meeting in Rockville, Maryland. She met some of the scientists involved, who told her about the research they were doing on tissues such as those from her husband. "To know he's still there is a wonderful thing," she says.

Journal name:
Nature
Volume:
550,
Pages:
169–170
Date published:
(12 October 2017)
DOI:
doi:10.1038/550169a

Comments

1 comment

1. *Manuel Corpas* • 2017-10-12 09:55 AM
   Donating tissues and organs is only the start of the debate of what to do with the remains of deceased relatives. A critical issue still remains undiscussed: what to do with the clinical, genetic and environment data from a person who died? As people get sequenced, their clinical histories made accessible and wearable technology incorporated into clinical care, we need to think about how this data could be used for advancement of research. I am currently exploring this and more with the sequencing of my deceased relative 4.5 years after she passed away: https://personalgenomics.zone/2017/09/01/whole-genome-sequencing-data-from-4-years-deceased-relative-now-in-the-public-domain/

| 章节菜单 | 主菜单 |

The rise and fall and rise again of 23andMe

How Anne Wojcicki led her company from the brink of failure to scientific pre-eminence.

11 October 2017

Credit: Gabriela Hasbun for *Nature*

There's a placard in Anne Wojcicki's office enshrining the attitude that nearly ran her company, 23andme, aground. Tucked behind a toy unicorn, the small, wood-veneered nameplate reads: “I'm CEO, bitch.”

It was with this kind of brashness that Wojcicki set out to disrupt the health-care industry in 2006. Her goal was to put sophisticated DNA analyses into

the hands of consumers, giving them information about health, disease and ancestry, and allowing the company to sell access to the genetic data to fuel research. But in 2013, that vision hit a snag. Wojcicki didn't think she needed regulatory approval to provide information about her customers' health risks. The US Food and Drug Administration (FDA) disagreed, and ordered the company to stop.

The FDA action prompted months of soul-searching and strategizing on how to reorient the company to work with regulators. “You just accept at some point, you're regulated, and there's no Silicon-Valley, 24-hour, easy fix,” Wojcicki says.

After years of effort, the pay-off came in April this year, when the FDA agreed to allow 23andme to tell consumers their risks of developing ten medical conditions, including Parkinson's disease and late-onset Alzheimer's disease. Surfing a wave of positive news, the company has since launched an advertising blitz to dramatically expand its customer base to 10 million people.

23andme has always been the most visible face of direct-to-consumer genetic testing, and it is more formidable now than ever before. In September, the company announced that it had raised US$250 million: more than the total amount of capital raised by the company since its inception. Investors estimate that it is worth more than $1 billion, making it a 'unicorn' in Silicon Valley parlance — a rare and valuable thing to behold. But for scientists, 23andme's real worth is in its data. With more than 2 million customers, the company hosts by far the largest collection of gene-linked health data anywhere. It has racked up 80 publications, signed more than 20 partnerships with pharmaceutical firms and started a therapeutics division of its own.

“They have quietly become the largest genetic study the world has ever known,” says cardiologist Euan Ashley at Stanford University, California.

But as it matures, 23andme faces new challenges. It must sustain customers' trust, fight off competition and prove that it can use genetic data to make new medicines — a notoriously difficult goal. And 23andme still has a long way to go with the FDA, which won't allow it to tell customers many genetic results directly relevant to human health, such as those for the *BRCA* genes,

which are linked to breast cancer.

Still, Wojcicki is undeterred. “I'm very stubborn,” she says.

In the picture

23andme's headquarters in Mountain View, California, have a start-up vibe that belies the company's 11-year history. Pink and green foil balloons float over cubicles to commemorate employees' work anniversaries. The kitchenette is stocked with healthy snacks. And Polaroid photographs of all employees line the wall of the free cafeteria. Each picture is scrawled with a quirky fact about the person. (“Her favorite drink is green tea,” reads one. “Once won a lip-sync contest singing a New Kids on the Block song,” boasts another.) Arranged by the order in which employees joined the company, the photos make clear where everyone fits in.

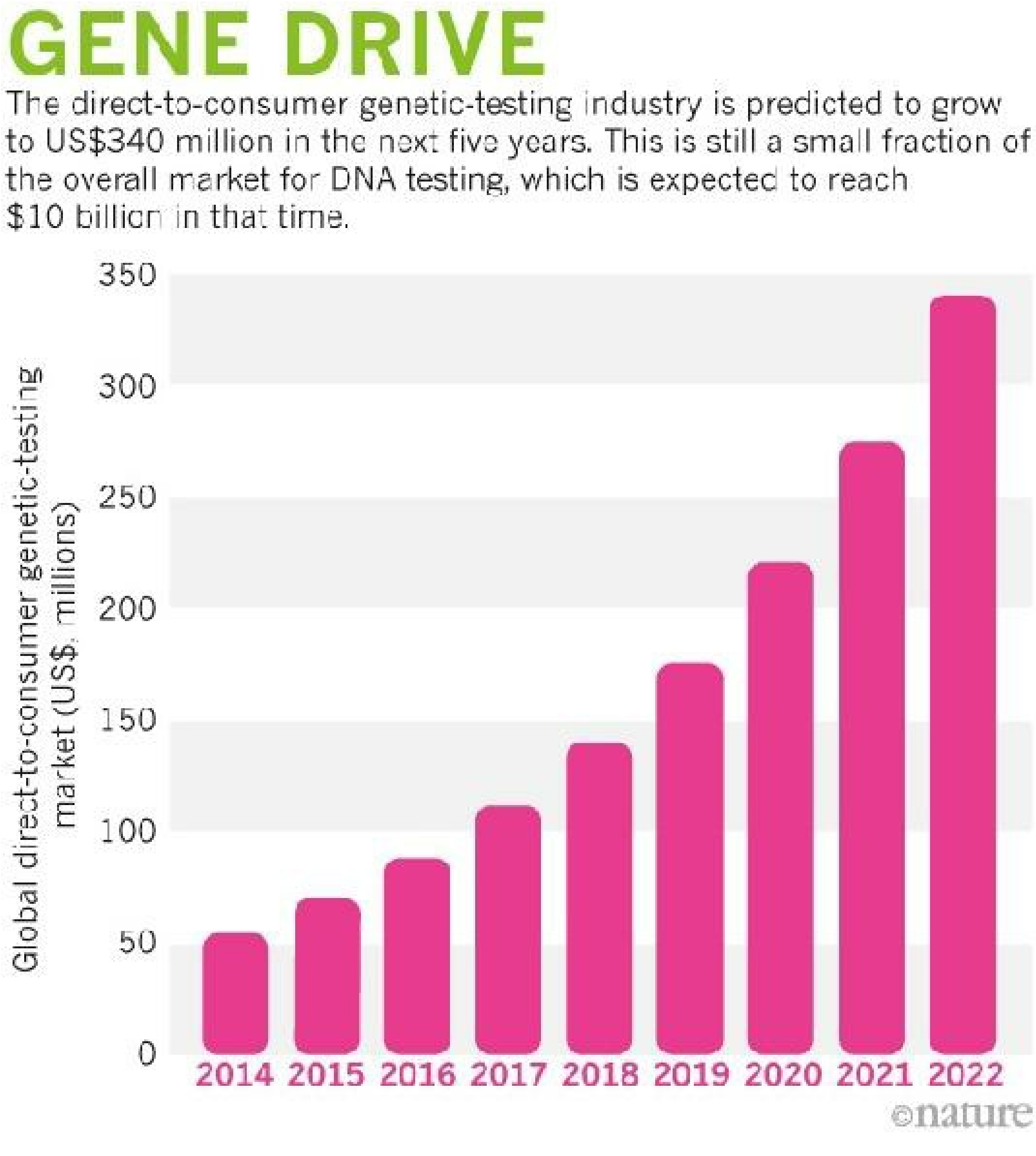
The first photo, of course, is of Wojcicki, who grew up on the campus of Stanford University, the child of a teacher and a physics professor. She majored in biology at Yale University in New Haven, Connecticut, where she played ice hockey. (She's still an avid athlete; the bike she rides to work is often parked in 23andme's lobby.)

In 1996, after graduating, Wojcicki worked for investment companies and hedge funds analysing heath-care ventures. She eventually came to dislike how the industry incentivized the development of expensive products and services that earn maximum insurance payments, rather than treatments and devices that consumers can afford to pay for on their own.

Wojcicki founded 23andme in 2006 with Linda Avey and Paul Cusenza with a goal of upending conventional models of health care. The following year, it received $8.95 million from a number of high-powered investors, including the biotechnology powerhouse Genentech in South San Francisco and Google, whose co-founder Sergey Brin was married to Wojcicki from 2007 to 2015.

Wojcicki aimed to attract millions of customers by selling an inexpensive test that would reveal genetic predispositions for dozens of traits. It would

provide disease risks, but also genetic propensity for baldness, obesity and trivial features such as earwax consistency. Wojcicki wanted to make the genome fun and engaging, the better to attract customers. She hosted celebrity 'spit' parties to get the product in the hands of tastemakers and stir up media interest: after taking one of the company's tests, Ivanka Trump gloated that she had a very low genetic risk of becoming obese. As the tests hit the market in late 2007, Wojcicki and Avey were hailed as visionaries (Cusenza had left in 2007; Avey would depart in 2009).



Source: Credence Research; Grand View Research

Scientists, meanwhile, were dubious. Family history was and is still a more powerful indicator than genes are for predicting the risk of most diseases. “The evidence is increasingly strong that the benefits of direct-to-consumer testing for these kinds of indications are somewhere between small and zero,” says Stanford University lawyer and ethicist Hank Greely, a long-time critic of the company.

There were also questions about 23andme's plan to sell customer data to help develop medicines. Companies have been trying to mine genetic data to design drugs for at least a decade, with little success. Take deCODE genetics, founded in Reykjavik in 1996, which recruited about half of the adult population of Iceland into a genetic study. Although the company's research has provided insights into the genetic mechanisms of disease, it hasn't yet yielded a drug.

Scientists' scepticism didn't deter hundreds of thousands of customers from signing up to 23andme, nor did it stop investors from ploughing $118 million into the company in its first five years — but a problem was emerging in the background. In 2009, the FDA started asking 23andme for evidence that the company's products worked as advertised and wouldn't harm customers. The agency was worried that people might take drastic medical measures on the basis of their test results, such as deciding to change the dosage of their medications without consulting a doctor or undergoing unnecessary surgery, such as a mastectomy, or treatment based on false positives. Regulators demanded evidence that the tests were accurate, and that customers were well informed what the results meant.

The next years were difficult ones for 23andme. It communicated with the agency on a few occasions and promised in January 2013 that data would be forthcoming. According to the FDA, it then ceased communicating with regulators entirely in May, even as it started a new advertising campaign. Fed up, the agency sent Wojcicki a strongly worded warning letter on 22 November 2013 ordering her company to stop marketing its product.

It was a self-inflicted wound for the company. “There was a bit of arrogance,” says Richard Scheller, who was an executive at Genentech at the

time. As a result, 23andme was forced to drastically cut its customer offerings, threatening its viability.

Wojcicki was stunned. “It became clear that we had pissed them off,” she says. “I really didn't know that we had done so many things that angered them.”

Back on track

Soon after the letter arrived, Wojcicki called Kathy Hibbs, a lawyer then working for Genomic Health, a gene-testing company in nearby Redwood City, California.

“Can I get my whole company back in one year?” Wojcicki asked Hibbs.

“You can get it back, but it will take years,” Hibbs replied. And to get there, she counselled, Wojcicki would have to cooperate with regulators.

It was a tough adjustment for Wojcicki; she didn't think that the FDA should be able to stop customers from learning their own genetic information. But Hibbs and others convinced her that capitulating to the FDA's demands was the fastest way to rescue her company.

“It's almost like being in a relationship,” Wojcicki says. “There's things that you might disagree with, but you just have to do them.” Wojcicki hired Hibbs, who began gathering evidence to respond to the FDA's concerns — a formidable task, because the FDA and the company had tussled over many issues over the years. By the end of 2014, Hibbs felt that the company was ready, so she asked the FDA to approve one test, intended to tell customers whether their children might inherit a genetic risk for a disease called Bloom syndrome.

The FDA approved the test in February 2015. The news didn't make a huge public splash: Bloom syndrome is a very rare disorder, affecting about 1 in 50,000 people with Ashkenazi Jewish heritage. But 23andme was now the first company approved to market a direct-to-consumer genetic test for a disease in the United States, although it had already been offering the test

overseas.

But even after the FDA's decision this April, 23andme is still barred from giving customers lots of available information, such as whether they carry gene variants that raise their risk for certain cancers or that predict how well certain medications will work. Before the FDA lockdown, it had been providing information on hundreds of health conditions.

Greely says that the restrictions make sense: there is very strong evidence that genetic variants cause the ten conditions listed in the FDA's approval in April. But the predictive value is much weaker for the variants linked to the vast majority of common health conditions that 23andme would like to tell its customers about.

Paths of discovery

Even as the company confronted resistance at the FDA, it was making moves into drug development. Key to this plan was bringing Scheller aboard. Wojcicki e-mailed him on the day he announced his retirement from Genentech in December 2014. Four months later, Scheller arrived in Mountain View to start 23andme's therapeutics group; by July, Wojcicki had raised $115 million more from investors.

Scheller was attracted not just by the size of 23andme's database, but by its richness. Customers have each answered an average of 300 questions on a huge array of traits, including their medical histories. That enables Scheller's team to try a different approach for gene-driven drug development.

The standard method has been a genome-wide association study, or GWAS, in which scientists gather people with a disease or trait, and then look for gene variants that seem to contribute to it. Scheller's team can do the reverse. They start with a particular gene that known drugs target, and then look for the diseases or health traits — the phenotypes — that are associated most strongly with different variants in the gene. “We just let the database show us what to work on,” Scheller says.

It's a study design called a phenome-wide association study, or PheWAS —

and Erik Karrer, director of drug discovery, calls it the company's “secret sauce”. 23andme is banking that it will speed drug discovery by allowing scientists to select drug targets that are important in human biology, that can be targeted by drugs and that are less likely to cause side effects.

To see if it works, computational biologist Fah Sathirapongsasuti studied whether 23andme's genetic and health data could predict the success of drugs developed over the past few decades. Sathirapongsasuti surveyed a database of thousands of drug compounds, some of which were approved for sale by regulators.

He compiled a list of all the genes encoding proteins targeted by drugs in this database, and compared it against variations in these genes among 23andme's customers, checking to see what medical conditions they had reported to the company. The process helped to validate the genetic basis for some drugs in humans in a way that mouse studies and other preclinical research often can't. Sathirapongsasuti also found instances in which 23andme customer data correctly predicted side effects of approved drugs.

And the data were able to predict which drugs approved for some conditions might work better for others. Isofagomine tartrate, for instance, was initially intended to treat Gaucher's disease, a rare genetic disorder, but it stalled after a failed clinical trial in 2009. Sathirapongsasuti's data suggest that the drug might also affect the processes underlying Parkinson's disease. The compound has been tested for this condition as well.

Sathirapongsasuti's data suggested that the PheWAS approach could be useful in drug development — and helped to convince 23andme that it should invest in its own drug programme. Using the results of additional phenome-wide association studies, Scheller and his team have now decided to focus on seven drug targets in four categories of disease: cancer, cardiovascular disease, skin disease and immune disorders, such as asthma.

Most scientists no longer see 23andme as a frivolous undertaking. The ability to recruit two million customers, and potentially many more, has been a huge draw, and researchers are lining up to collaborate with the company. Other major biobanks can boast no more than half a million people in their ranks. “They have the power of '*N*',” says cardiologist Eric Topol, director of the

Scripps Translational Science Institute in La Jolla, California.

In October, the US National Institutes of Health awarded the company a $1.7-million grant to sequence the genomes of hundreds of thousands of its African American customers who had already bought the company's standard product, which provides an overview of the genome rather than an in-depth analysis. The project — one of several sequencing initiatives that the company has started — is intended to help rectify the paucity of sequencing data on racial and ethnic minorities.

It's still an adjustment for scientists to work with 23andme data, because the company asks its collaborators to follow unusual rules. Its agreement with customers forbids it from sharing their actual data with collaborators, so scientists see only the results of analyses run by the company and never have access to the raw data that inform the studies.

And some scientists are uneasy about the self-reported data resulting from 23andme questionnaires. Neurogeneticist Ashley Winslow, for instance, who led a high-profile collaboration with Pfizer to identify genetic markers associated with depression, says that peer reviewers of the resulting paper were concerned about the veracity of 23andme's customer data. They argued that people who said that they had been diagnosed with clinical depression might just have been feeling low on the day that they took the company's survey. Winslow's team ran internal studies on the validity of the data, such as analyses showing the percentage of people who also reported using selective serotonin re-uptake inhibitors. The analyses were sufficient to get the paper published, but such concerns will probably come up again.

“Some communities might still be more dubious and demand more from the data to prove its relevance,” says Winslow, who is now at the University of Pennsylvania in Philadelphia. But, she adds, the results of a large study such as hers, which has since been validated by another large psychiatric genetics consortium, are encouraging more scientists to work with the company. “There is definitely an openness that didn't used to exist,” Winslow says.

But that doesn't mean that 23andme's model will definitely lead to new drugs. Several high-profile drugs based on human-genetics research have failed to live up to their potential, or have failed entirely. In May, for instance,

pharmaceutical company Amgen, based in Thousand Oaks, California, announced that its genetically targeted osteoporosis drug romosozumab raised the risk of heart disease by as much as 30% in a clinical trial with 4,000 people. “The idea of developing drugs as a result of genetics isn't as straightforward as many of us would like,” Topol says.

The direct-to-consumer genetic testing market has been transformed since 23andme's early years. And although it is a small slice of the gene-testing market, it is expected to grow to $340 million in the next five years (see 'Gene drive').

And a growing crop of genetic-analysis companies are now competing for 23andme's customers. They include firms offering inexpensive, targeted medical sequencing (Color Genomics in Burlingame, California); ancestry testing (Ancestry DNA, based in Salt Lake City, Utah); whole-genome sequencing, either on its own (Veritas, based in Danvers, Massachusetts) or in combination with medical testing (Craig Venter's Human Longevity in San Diego, California) or with apps for interpreting genomic data (Helix of San Carlos, California).

Wojcicki's competitors give her credit for showing that there may be a business in gathering and selling genetic data. “I'm a big admirer of 23andme and what they've done for the entire industry in pioneering both consumer genetics and this difficult regulatory road,” says Mirza Cifric, chief executive of Veritas. 23andme is still the only company offering FDA-approved direct-to-consumer health tests and no competitors have indicated a willingness to go down that path.

Wojcicki, for her part, still wants to stay ahead. “There's all kinds of ways we want to approach genetics,” she says. For instance, 23andme is watching closely as technology companies such as Apple and Google develop sensors and mobile health-data applications, and the company is looking for pilot projects in this space, which could allow it to seamlessly collect continuous data from its users. And she has no doubt that the company will achieve her goal of recruiting 10 million customers. “Just based on natural growth we'll get there,” she says.

In the 23andme company cafeteria, the fun fact on Wojcicki's Polaroid

picture seems at once trivial and telling: “I once ate so many carrots that I turned orange and was told not to eat carrots for a year.”

Wojcicki's colour has come back. She took the advice. But whether her resolve and ability to correct course can also push 23andme from earwax and ancestry to life-saving drugs remains an open question. If she has her way, it's her doubters who will one day become the real unicorns of Silicon Valley — so rare and shy, you'd hardly believe they exist.

Journal name:
Nature
Volume:
550,
Pages:
174–177
Date published:
(12 October 2017)
DOI:
doi:10.1038/550174a

Comments

Commenting is currently unavailable.

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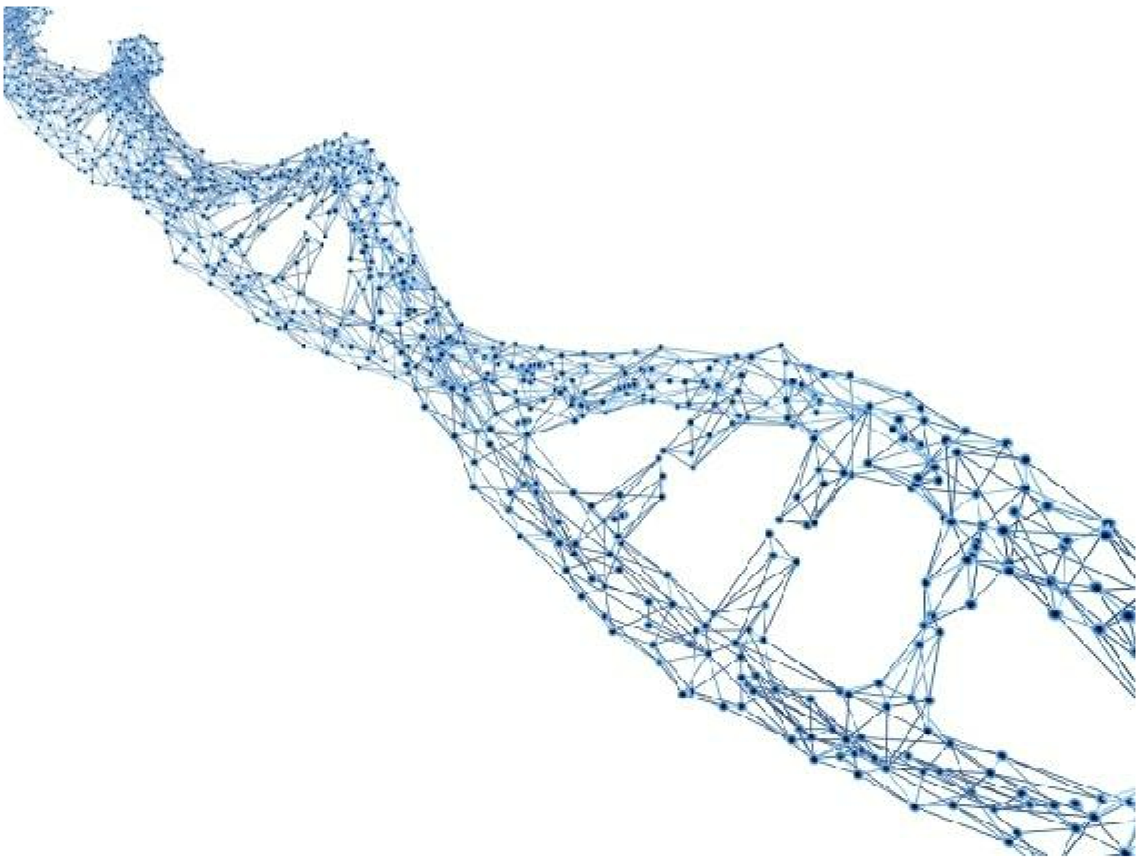
The future of DNA sequencing

11 October 2017

Eric D. Green, Edward M. Rubin and Maynard V. Olson speculate on the next forty years of the applications, from policing to data storage.



Alfred Pasieka/SPL

Researchers have an insatiable appetite for DNA-sequence data.

Forty years ago, two papers[1, 2] described the first tractable methods for determining the order of the chemical bases in stretches of DNA. Before these 1977 publications, molecular biologists had been able to sequence only

snippets.

The evolution of DNA sequencing from these nascent protocols to today's high-throughput technologies has occurred at a breathtaking pace[3]. Nearly 30 years of exponential growth in data generation have given way, in the past decade, to super-exponential growth. And the resultant data have spawned transformative applications in basic biology and beyond — from archaeology and criminal investigation to prenatal diagnostics.

What will the next 40 years bring?

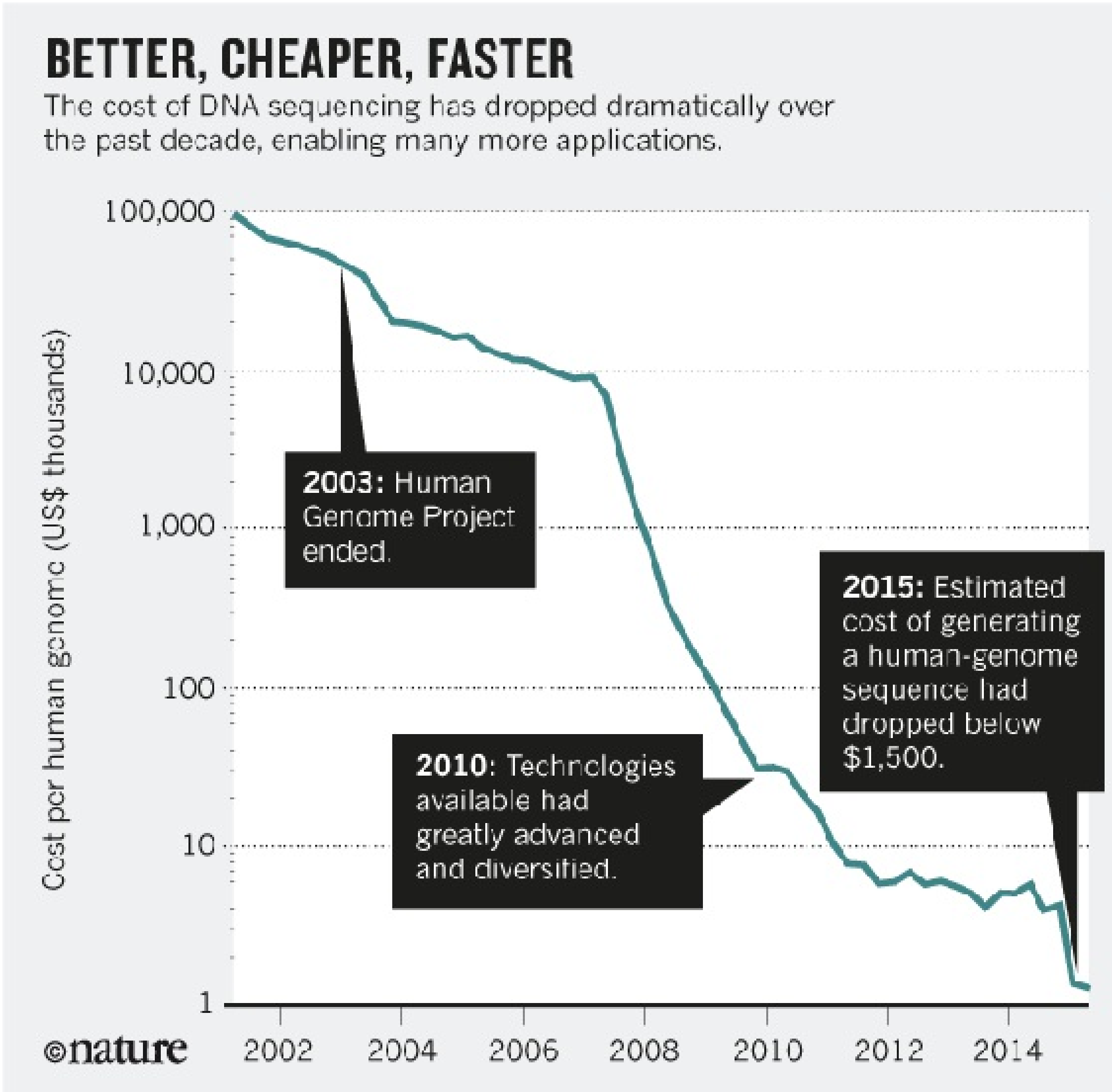
Prognosticators are typically wrong about which technologies — or, more importantly, which applications — will be the most disruptive. In the early days of the Internet, few predicted that e-mail that would achieve staggering popularity. Similarly, traders on Wall Street and investors in Silicon Valley failed to foresee that games, online video streaming and social media would come to dominate the use of today's available processing power and network bandwidth.

We would probably fare no better in predicting the future of DNA sequencing. So instead, we offer a framework for thinking about it. Our central message is that trends in DNA sequencing will be driven by killer applications, not by killer technologies.

In demand

Improvements in a technology can either increase or decrease demand. Microsoft co-founder Bill Gates famously cited radial tyres as an example of the latter: because they were more durable than earlier designs, the need for tyres dropped and the tyre industry shrank.

We think that DNA sequencing will follow the pattern of computing and photography, not of tyres. As it becomes cheaper and more convenient, applications will proliferate, and demand will rise (see 'Better, cheaper, faster'). As DNA sequencing breaks out of the research market and into clinical, consumer and other domains, the rule of 'more supply means more demand' will hold ever more strongly.



SOURCE: National Human genome research Institute

Researchers have an insatiable appetite for DNA-sequence data. In the 1990s, the idea of sequencing a human genome seemed daunting. Now, geneticists would like to have DNA sequences for everyone on Earth, and from every cell in every tissue at every developmental stage (including epigenetic modifications), in health and in disease. They would also like to get comprehensive gene-expression patterns by sequencing the complementary DNA copies of messenger RNA molecules. Meanwhile, archaeologists are beginning to reconstruct the flow of genes through ancestral populations, just as they previously deduced the flow of languages, cultural practices and

material objects. And taxonomists, ecologists, microbiologists and evolutionary biologists are seeking to analyse the genomes of all living (and extinct) species — and even whole ecosystems.

Obviously, a sustained demand for data would require that the vast cataloguing efforts proffer actual understanding. At present, the bottleneck is analysing and interpreting all the DNA-sequence data. But just as new informatics approaches and massive data sets have dramatically improved language translation and image recognition, we predict that massive DNA-sequence data sets coupled with phenotypic information will enable researchers to deduce the biological functions encoded within genome sequences.

LISTEN

Reporter Anand Jagatia speaks with Eric Green about the past and future of DNA sequencing.

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What's more, much of the basic science needed to interpret the data is already in place for a growing repertoire of practical applications (such as high-quality reference sequences of bacterial genomes, or the rules by which certain gene networks operate in healthy people). These range from recognizing microbial DNA sequences in unbiased surveys of environmental or clinical samples to identifying genome changes associated with known biological consequences.

Killer applications

Over the years, the platforms for DNA sequencing have changed dramatically (see 'Many ways to sequence DNA'). Yet the trajectories of other technologies for which there is a seemingly insatiable demand —

smartphones, the Internet, digital photography — suggest that the real disrupters will be the resulting applications, not the new technologies.

Many ways to sequence DNA

Over the past 40 years, the platforms for DNA sequencing have repeatedly been replaced.

By 1985, almost all DNA sequencing was performed with the Sanger or dideoxy chain-termination method[2]; reaction products were labelled with radionucleotides, separated on acrylamide slab gels, and detected with autoradiography (the use of X-ray or photographic film to detect radioactively labelled samples). By 2000, the four-colour-fluorescence method reigned supreme; reaction products were labelled with chain-terminating nucleotide analogues, separated electrophoretically in capillaries filled with a jelly-like media, and detected with energy-transfer fluorescent dyes. By 2010, the techniques had diversified. The dominant instruments were based on massively parallel analyses of DNA 'polonies' (clonal amplifications of a single DNA molecule) and on sequencing-by-synthesis chemistries (these rely on reversible chain-terminators).

From now on, the requirements for each DNA-sequencing platform will depend on what it is to be used for. In oncology and medical genetics, the goal will often be to identify every base correctly and to define every variant of genomic segments that exist in multiple copies. By contrast, when a yes or no 'match' is required — for instance, in species identification — the ability to run tests quickly and easily in the field may be more important than accuracy.

Another factor that will probably change is the relative need for centralized versus decentralized DNA sequencing. An epidemiologist trying to assess in real time what virus has affected a particular village in Sierra Leone might need cheap, portable devices. But for those generating massive data sets, it might be more efficient and cost effective to ship samples to centralized commercial operations, especially when the laboratories are required to meet exacting standards for quality control and sample tracking, as in clinical

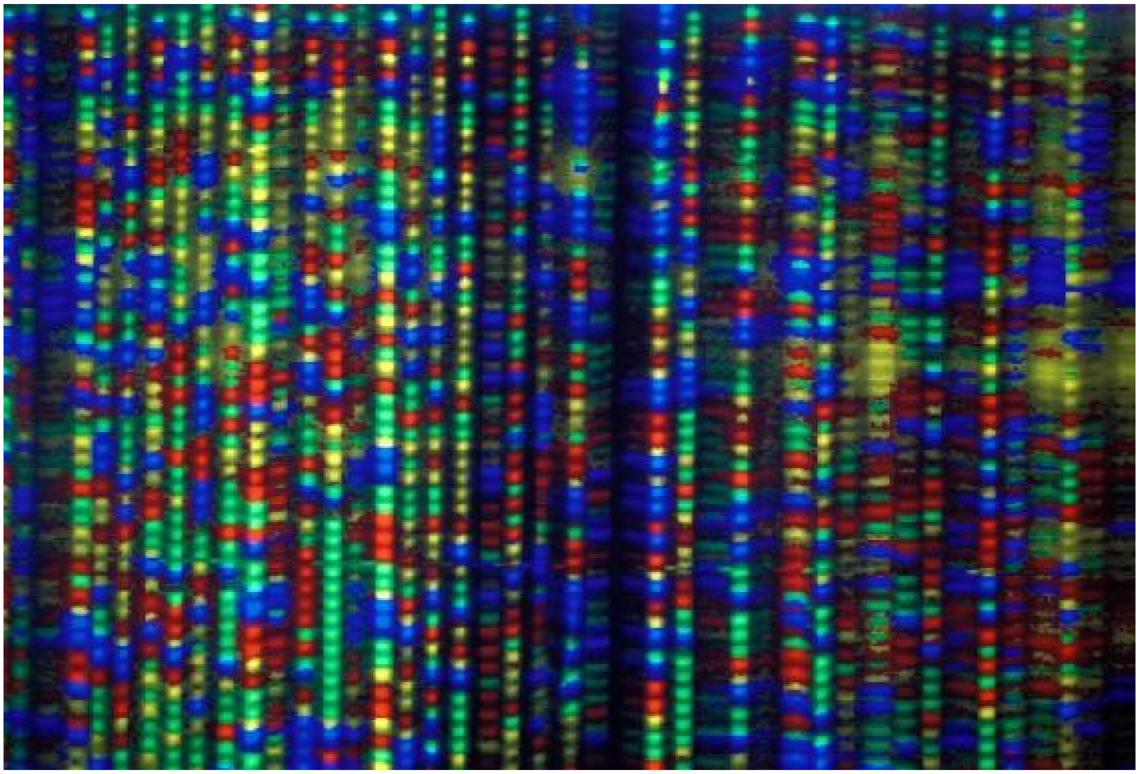
applications.

One domain where we are confident that DNA sequencing will be truly transformative is medicine.

Today's 'breakout' clinical application of DNA sequencing — in terms of the sheer number of tests conducted — is prenatal testing for the presence of an abnormal number of chromosomes, such as trisomy 21, which causes Down's syndrome. This test now relies on detecting the small amount of cell-free fetal DNA that circulates in maternal blood. Not even imagined at the end of the Human Genome Project, it has been described as "the fastest growing genetic test in medical history"[4]. In fact, experts in the field estimate that some 4 million to 6 million pregnant women are now receiving this test each year worldwide, and that the number will surpass 15 million within a decade (D. Bianchi, D. Lo and D. Zhou, personal communication). Some of the hallmarks of the test seem likely to characterize many future applications of DNA sequencing in primary care: it is non-invasive, easy to perform and has low requirements for nucleotide-level accuracy (chromosomes can be counted without assessing sequence variation).

In high-income countries, genome sequencing is already used routinely to evaluate children with ill-defined congenital conditions. Analyses of the resulting sequences can reveal the disease-causing mutations in around 30% of such cases[5, 6] — a figure that will only rise as the ability to interpret the data matures. In some instances, the resulting diagnoses have led to dramatic improvements in clinical management7,8. More typically, they benefit both families and physicians by ending a diagnostic odyssey and providing clinical clarity.

In oncology, considerable investments are being poured into the development of liquid biopsies[9]. It is easy to imagine such a sequence-based cancer test becoming a routine screening tool, used much like Pap smears and colonoscopies. With the advent of cancer treatments that target specific mutations, rather than tumour types[10], liquid biopsies could ultimately guide therapeutic interventions even when tumours are known to exist only from DNA-sequence signatures present in blood samples.



Karen Kasmauski/NGC

Coloured DNA bands.

Various applications can be envisioned outside the clinic, too, particularly for hand-held DNA sequencers. Epidemiologists and even caregivers working in rural areas could use such devices to test air, water, food, and animal and insect vectors, not to mention human throat swabs and body fluids. In fact, easy access to DNA-sequencing technologies in low- and middle-income countries is already facilitating projects such as the Global Virome Project. This aims to sequence numerous samples of wildlife DNA to identify a significant fraction of the viruses that can be transmitted into humans and cause disease.

Meanwhile, public-health specialists are starting to discuss how they might sequence the DNA of all the microorganisms in the waste-water outlets of entire cities to speed up the recognition of disease outbreaks. And marine biologists are exploring ways to monitor the health of the oceans through systematic metagenomic studies.

On the street, portable instruments could bring DNA analysis out of the crime lab and make it a front-line policing tool. Police might be able to 'read' people's DNA, much as they currently check car number plates or identification documents. In fact, the degree to which cheap and easy DNA sequencing opens up possibilities for mass surveillance has recently sparked concern among human-rights groups.

In the home, DNA-sequencing appliances could become the next 'smart' or 'connected' devices, after smoke alarms and thermostats. One commentator even identified the toilet as the ideal place to monitor family health through real-time DNA sequencing[11].

Hitting limits

What are the stumbling blocks?

In a mere 40 years, the central goal of putting molecular data about cells to practical use has changed from an informational challenge to a meta-informational one.

Take clinical applications of genome-sequence data. It may soon be possible to use DNA sequencing routinely to analyse body fluids obtained for any clinical purpose. But only a vast amount of well-organized data about the multi-year medical histories of millions of people will provide the meta-information needed to establish when to ignore such data and when to act on them.

With respect to medicine, we echo the recommendations of advisory groups such as the US National Research Council's Precision Medicine Committee[12] on the need to create a vast “information commons”. This would overlay molecular and clinical data onto the germ-line genome sequences of millions of individuals. Several such population-scale efforts are under way, including the UK Biobank resource and the US All of Us Research Program.

Here we have laid out our best guesses. Surprises are a certainty. In fact, it is possible that decades from now, much of the world's data (now residing on

hard drives or in the cloud) will be stored in DNA, and that the main driver of DNA sequencing will be not our quest to tackle disease, but our insatiable appetite for data storage.

Journal name:
Nature
Volume:
550,
Pages:
179–181
Date published:
(12 October 2017)
DOI:
doi:10.1038/550179a

Comments

Comments

There are currently no comments.

Publishers threaten to remove millions of papers from ResearchGate

Take-down notices “imminent” as lawsuit is filed alleging widespread copyright infringement.

10 October 2017 Updated:

1. 10 October 2017

Millions of articles might soon disappear from ResearchGate, the world’s largest scholarly social network. Last week, five publishers said they had formed a coalition that would start ordering ResearchGate to remove research articles from its site because they breach publishers' copyright. A spokesperson for the group said that up to 7 million papers could be affected,

and that a first batch of take-down notices, for around 100,000 articles, would be sent out “imminently”.

Meanwhile, coalition members Elsevier and the American Chemical Society have filed a lawsuit to try to prevent copyrighted material appearing on ResearchGate in future. The complaint, which has not been made public, was filed on 6 October in a regional court in Germany. (ResearchGate is based in Berlin). It makes a “symbolic request for damages” but its goal is to change the site’s behaviour, a spokesperson says.

ResearchGate may already have begun taking articles down, according to a 10 October statement by the coalition. The group said it had noticed that the site had removed "a significant number of copyrighted articles", although ResearchGate hadn't shared information about this with publishers. "At this point, not all violations have been addressed and ResearchGate will need to take additional steps to cease unauthorized distribution of research articles," the statement says.

The clash has been a long time coming. Researchers are increasingly posting paywalled research papers online, many of them on ResearchGate, a network often likened to Facebook for scientists. The site boasts more than 13 million members and has raised more than US$80 million in start-up funding from investors including Microsoft founder Bill Gates and the Wellcome Trust, the London-based biomedical-research funder.

Not only do academics upload articles to the site, but ResearchGate also scrapes material online and invites researchers to claim and upload these papers, says James Milne, a spokesperson for the five-publisher group, which calls itself the Coalition for Responsible Sharing. In February this year, information scientist Hamid Jamali at Charles Sturt University in Wagga Wagga, Australia, reported that he had examined 500 articles at random from ResearchGate, and found that 40% of them breached copyright[1].

Access issues

In September, the International Association of Scientific, Technical, and

Medical Publishers, a trade group based in Oxford, UK, sent a letter to ResearchGate suggesting that the network introduce an automated filtering system, through which uploaded articles would be shared publicly or privately depending on their copyright status. Publishers generally say that paywalled articles for which they own copyright can be shared only privately; scientists are allowed to upload preprints, and peer-reviewed but unedited manuscripts, online for general access.

“ResearchGate refused to engage with us on that,” says Milne. The Coalition for Responsible Sharing, which also includes publishers Wiley, Wolters Kluwer and Brill, says it is “now left with no other choice” but to issue take-down notices.

Litigation has been tried before: in 2013, Elsevier sent 3,000 notices under the US Digital Millennium Copyright Act to scholarly networks including Academia.edu, demanding that they take down papers that breached Elsevier’s copyright. Those notices were passed on to the networks’ academic users. But the new actions would be on a larger scale.

Terms and conditions

ResearchGate declined to comment on the coalition’s statement, but its terms of service ask users not to store information that infringes copyright. They also state that because the site neither previews nor automatically reviews information that users have stored on it, ResearchGate can’t know about — and isn’t liable for — any possible infringements. The site says it will quickly disable access to infringing material after being notified of a problem.

But repeatedly sending lots of take-down notices is not a long-term solution, Milne says — hence the lawsuit, which aims to clarify what responsibility ResearchGate has to prevent copyright breaches. Milne says Elsevier and the American Chemical Society are hoping that the German court will tell the social network that it has a duty to identify copyrighted material on its website, and remove it; that the site must check whether material it scrapes from the Internet is copyrighted before users are invited to ‘claim’ it and upload it; and that ResearchGate will also be told it cannot modify

copyrighted material.

“The expectation is that ResearchGate will be told by the courts to cease certain behaviours. This could take months or years,” says Milne.

Not all publishers have stopped discussions with ResearchGate. On 9 October, the company posted a joint statement with *Nature*’s publisher Springer Nature, saying that the two firms had been in “serious discussions for some time” about sharing journal articles online while protecting intellectual-property rights, and that they were “cautiously optimistic” that a solution could be found. (*Nature*’s news and comment team is editorially independent from its publisher.)

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22793

Updates

Updated:

Updated to include details of a 10 October statement by the coalition of five publishers, which said that ResearchGate had begun removing from public view some copyrighted articles.

Comments

Commenting is currently unavailable.

Trump EPA begins push to overturn Obama-era climate regulation

The agency's plan to reverse limits on greenhouse-gas emissions is likely to draw legal challenges.

10 October 2017

Jabin Botsford/The Washington Post/Getty

EPA administrator Scott Pruitt has questioned his agency's legal authority to regulate greenhouse-gas emissions.

The US Environmental Protection Agency (EPA) is moving to repeal former

president Barack Obama's landmark regulations to reduce greenhouse-gas emissions from power plants.

The plan, introduced on 10 October, is a step towards fulfilling President Donald Trump's promises to reverse Obama-era climate regulations and end the “war on coal”. But any attempt to repeal the power-plant rule is certain to face lawsuits from environmental groups and many states that support Obama's climate policies.

“The Trump Administration’s persistent and indefensible denial of climate change — and their continued assault on actions essential to stemming its increasing devastation — is reprehensible,” said Eric Schneiderman, attorney general for the state of New York, in a prepared statement. “I will use every available legal tool to fight their dangerous agenda.”

US emissions from electricity generation have been falling in recent years as energy utilities have shifted away from coal, and towards cheap natural gas and renewables. The Obama administration established the power-plant regulations to hasten that progress, and to help the United States to meet its commitments under the 2015 Paris climate accord.

The power-plant rule would reduce greenhouse-gas emissions to 32% below 2005 levels by 2030 — but it is mired in legal challenges. In 2016, the US Supreme Court blocked the regulations from taking effect. Legal challenges from 27 state governments are still pending, although a federal appeals court has put the case on hold while the Trump administration reviews the rule.

Trump has shown no fear of challenging environmentalists on climate issues: he has already announced plans to pull the United States out of 2015 Paris climate pact. But his administration's attempts to roll back various environmental regulations have faced legal setbacks. One of the latest rebukes came on 4 October, when a federal court rejected an effort by the Department of the Interior to delay implementing curbs on methane emissions from oil and gas operations on public lands.

A long fight

The power-plant rule that Trump's administration plans to challenge was made possible by the Supreme Court's decision in 2007 that carbon dioxide and other greenhouse gases are pollutants under the terms of the Clean Air Act. Two years later, the EPA ruled that these gases are a threat to human health and the environment — a decision known as an 'endangerment finding'. That allowed the agency to draft regulations to limit greenhouse-gas output from various sources.

EPA administrator Scott Pruitt sued to overturn the endangerment finding in his former role as Oklahoma's attorney general, before Trump took office. More recently, as EPA's chief, he has questioned his own agency's authority to regulate CO_2. Environmentalists fear that he will attempt to repeal the endangerment finding, which would inevitably prompt a flurry of lawsuits.

The legal fight over the EPA's new plan to repeal the Obama power-plant regulations will almost certainly focus on whether the Clean Air Act allows the agency to require that utilities alter their energy portfolios to reduce emissions. The Obama administration set limits on emissions and then allowed states and utilities to decide how to meet those limits, with options that included expanding efforts to reduce energy consumption and developing new sources of renewable energy.

The Trump administration's proposal says that the EPA overstepped its legal authority when it finalized the Obama-era rules. The administration argues that the Clean Air Act limits the EPA to crafting regulations that can be implemented at power plants themselves. The proposal also says that the EPA is still considering whether and how to craft alternative regulations for power-plant emissions.

Jonathan Adler, who heads the Center for Business Law and Regulation at Case Western Reserve University School of Law in Cleveland, Ohio, says the Trump administration can reasonably argue — as many states have — that the Clean Air Act was not designed to regulate greenhouse gases. Courts often give a certain amount of deference to federal agencies on regulatory matters, he says, but only if the agencies show that they have followed all legal and procedural requirements for finalizing new rules.

“Some of the same legal doctrines that helped the Obama administration

defend its regulatory decisions will now help the Trump administration defend its decisions going in the opposite direction,” Adler says. “This will certainly be a test for whether this administration is capable of engaging in this sort of heavy lift.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22813

Comments

Comments

There are currently no comments.

Climate meetings pose serious test in the Trump era

Annual jamborees fail to ignite public passion but are crucial to progress on global-warming.

10 October 2017

Adrien Morlent/AFP Photo/Getty

In the aftermath of the successful 2015 Paris climate conference, the public remained unengaged.

Climate change is a popular topic in Germany right now. Leading researchers are converging in Potsdam this week to take stock of the economic and societal impacts of global warming across sectors from health to agriculture.

In Berlin, experts are meeting to discuss the potential and risks of various geoengineering technologies intended to counteract the effects of climate change. And next month, at the climax of the climate-meeting season, thousands of delegates will flock to the United Nation's annual climate summit, this year in Bonn.

At the UN meeting, governments will discuss the next steps in implementing the global climate agreement that they reached in Paris almost two years ago. The landmark deal, which came into force last November, aims to limit global warming to 1.5 °C above pre-industrial temperatures. To achieve this ambitious (many say unrealistic) goal, the world's major economies might need to phase out emissions of heat-trapping greenhouse gases entirely within a few decades.

The Paris accord, although based on merely voluntary national contributions, was undoubtedly a rare triumph for international climate diplomacy. It was the most that was possible and the least that was needed. Alas, the excitement did not last long. The subsequent U-turn of the United States — President Donald Trump has resolved to leave the deal, deeming it half-baked, essentially unnecessary and intolerably unfair to the US economy — has dampened spirits. Even so, the rest of the world has pledged to stand firm. The first conference of the parties to the agreement in the Trump era must now work out how to proceed without the world's largest economy. In theory, the annual climate roller coaster is idling through one of the low-key phases in which success is measured by nothing going wrong. In practice, the Bonn meeting will serve as a litmus test of how the rest of the world plans to stand united and to keep the spirit of Paris alive.

Keynote speakers in Bonn (and presenters in Berlin and Potsdam) will no doubt reiterate the severity of the global-warming threat and the urgent need to act. Major meetings often galvanize debate among researchers, pundits and policy watchers. But beyond this predictable fuss in the expert world, do high-level climate meetings and policy events, and the media coverage they bring, help push the wider public to engage with the climate problem?

Not quite, it seems. Results of a survey of the German public, published this week in *Nature Climate Change,* suggest that extensive media coverage of the Paris climate summit had a soothing rather than a mobilizing effect (M.

[Brüggemann *et al. Nature Clim. Change* http://dx.doi.org/10.1038/nclimate3409; 2017](http://dx.doi.org/10.1038/nclimate3409)). Respondents who had taken notice of media reports (and many said they had not) had slightly more trust in the efficacy of global climate policy after the unusually successful meeting. However, fewer were in favour of their own country taking a leading role, and most said that they did not intend to change their behaviour. In essence, respondents were relieved that a political deal had finally materialized, but were disinclined to engage further with the issue.

The researchers who conducted the survey say that this is a missed opportunity. The annual UN meetings bring guaranteed media attention to a topic that many news editors are bored with, and so they are an opportunity to mobilize action. As such, the study authors go so far as to suggest that the lack of public engagement is a failure of journalism.

It might indeed seem worrying that despite the avalanche of information, climate change remains marginal to most people's personal and political choices — Germany's strong green movement notwithstanding. It might even seem like a bad case of civil indifference. Does it matter? There is an argument that climate action does not have to depend on media-stirred engagement from agitated citizens. People often choose to leave responsible decision-makers to deal with complex global problems that only concerted international effort can hope to solve, and this has brought progress on issues such as nuclear non-proliferation and the phase-out of ozone-depleting chemicals.

But climate change is a more complex issue, and one that cuts across many overlapping and sometimes contradictory concerns, from cultural and political issues to ethical and psychological ones. As such, organizations, businesses, scientists, policymakers and others who advocate action on global warming must continue to strive to take the public with them. As many experts have pointed out, that will take creativity and more than repeated references to the serious nature of the problem — in Bonn and elsewhere.

Journal name:
Nature
Volume:
550,

Pages:
158
Date published:
(12 October 2017)
DOI:
doi:10.1038/550158a

Comments

Comments

There are currently no comments.

A. Awad

Developing nations need more than just money

Grants from big science funders can be hard to use without better administration and mutual understanding, says Rana Dajani[1].

10 October 2017

As a molecular biologist based in Jordan, I’m used to colleagues from outside the Middle East and North Africa assuming that brain drain and a lack of funds are the chief obstacles to science in my region. That is not my experience. Like me, many scientists return home after studying in the United States or Europe, and successfully apply for grants, often from international philanthropies or funders.

The real problem is using the money. There is a disconnect between the funding systems that we can tap into and the institutions where we work. Granting agencies often fail to appreciate the constraints we’re operating under. Current practices by both funders and universities practically guarantee that our funds — already limited — are spent inefficiently. We need more investment in administrative systems and more flexibility, because science is unpredictable and creative.

I hear the same sorts of struggles again and again. For example, a researcher in the Middle East received a grant from a US institution to study vectors of disease. It included a line item to cover capturing insects in the desert. But the local university overseeing the funds would not disburse them to cover transport, because the team could not supply officially stamped receipts from a petrol station; services at remote locations in developing nations are rarely equipped to provide such documentation. The scientist has not applied for an international grant since.

Another colleague in the region received a grant budgeting for some human genetic analysis to be performed by a third party in the United States, because the necessary capacity doesn't exist in the Middle East. It took more than a year to get the funder, local university and third party to sign the agreements. But after the samples were shipped, university administrators said they could not process invoices because a bid to supply DNA-analysis services had not first been advertised in local newspapers. It took another year, many committees and much heartache to resolve the issue.

The situation is improving as more grants are awarded. For example, a newly appointed dean of scientific research at my university, Majd Mrayyan — herself a practicing scientist — has reduced the paperwork and minimized the levels of approval needed to begin projects. And the American University in Beirut has set up a department to handle funding logistics, staffed by people who understand the process. It has greatly increased the amount of funding that the university can receive.

Still, few university administrators in developing countries know much about science or how grants are typically handled. Postdoc and technician positions are rare across the Middle East and North Africa. When I hired a lab manager to handle administrative tasks such as ordering equipment, several people told me I was indulging in a luxury.

Institutions such as Harvard University in Cambridge, Massachussetts, where I am currently a visiting fellow, receive as much as 69% of awarded funds as indirect costs, which they put towards infrastructure and overhead — the costs of maintaining a system. By contrast, international grants to researchers in developing countries rarely cover infrastructure or capacity building; in some cases, philanthropists' charters explicitly prohibit them from putting

money into anything not directly related to a funded project.

Even when overhead funds are available, local universities are often wary of spending them on intangibles such as salaries or training. They prefer to use grants to buy instruments and equipment. In one typical occurrence, an award covered the purchase of a DNA sequencer, but not maintenance. The instrument was effectively rendered useless in three years.

How can we solve this? Through capacity and systems building. Funders need to find ways to ensure that recipients have the administrative staff and skills to use their money well, and to help build these foundations where they are lacking. Agencies should encourage the appointment of administrators who have research experience. They might even consider sponsoring training and exchange programmes for administrators.

People involved also need to sit around a table and talk about these issues in real time. When discussions happen — if they happen at all — it is through e-mail, and most communication occurs within groups rather than across them. People at institutions talk among themselves and then formally approach funders; those at funding agencies take the same approach. Each group misses out on nuance and connection with the other.

For every grant awarded, funders, university administrators and scientists should talk about the project together to identify needs and potential conflicts. They could then take the initiative to make changes, which builds ownership and creates useful precedents.

These discussions might reduce many roadblocks that keep scientists in the developing world from being able to use grants more efficiently. Core facilities that allow expensive equipment to be shared would cut down on redundancies and free up available funds. Provisions for maintaining equipment and paying and training technicians should be built into the budgets of both grants and institutions.

People from developed countries might feel noble when they give money to those in developing countries. What is really needed is more complicated — but it’s doable. For funders to have the most impact, they need to sit down with administrators and scientists in developing countries, listen to their

challenges and decide together what to do. That is the way to genuinely make a difference.

Journal name:
Nature
Volume:
550,
Pages:
159
Date published:
(12 October 2017)
DOI:
doi:10.1038/550159a

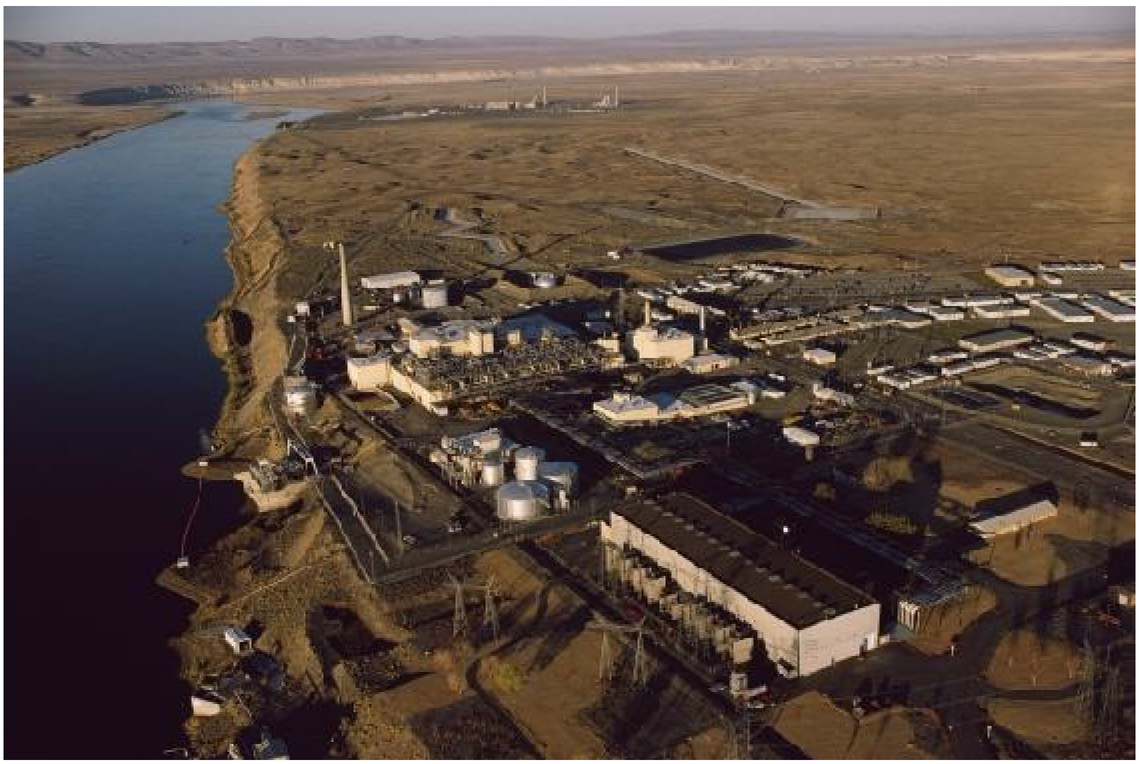
Comments

Commenting is currently unavailable.

How the United States plans to trap its biggest stash of nuclear-weapons waste in glass

After decades of delays, a challenging clean-up project is gaining ground.

10 October 2017



Karen Kasmauski/NGC

Waste from decades of nuclear-weapons production is buried at the Hanford Site in Washington state.

There's a building boom at the Hanford Site, a once-secret complex on the windswept plains of southeastern Washington state. Construction crews are

working to finish a 27-metre-tall concrete structure there by June. If all goes well, the facility will finally enable the US Department of Energy (DOE) to begin treating the toxic, radioactive waste that accumulated at the site for more than 40 years, starting during the Second World War.

Decades after the site stopped producing plutonium for nuclear weapons, the legacy of Hanford's activities is still causing trouble. Just this year, a tunnel holding railway carriages [full of radioactive material collapsed](). Separately, at least a dozen employees who were tearing down a contaminated building [reportedly tested positive for plutonium inhalation](). But the site's biggest challenge lies underground, in 177 carbon-steel tanks. Together, these buried containers hold more than 200 million litres of highly hazardous liquids and peanut-buttery sludge — enough to fill 80 Olympic-size swimming pools. More than one-third of the tanks have leaked, contaminating groundwater with radioactive and chemical waste.

In a 1989 legal agreement with the state of Washington and the US Environmental Protection Agency, the DOE committed to immobilizing the most dangerous waste in sturdy glass logs through a process called vitrification. Several years later, the agency agreed to vitrify other tank waste as well. All told, the process is expected to generate tens of thousands of logs, each weighing multiple tonnes. Those containing high-level waste would be shipped to a permanent storage facility; the rest could be stored on site. But the effort has been plagued by cost overruns, delays and safety concerns. Although the DOE has spent roughly US$20 billion on the tank problem since 1997, no waste has been vitrified.

Four years ago, the agency hit reset. Rather than making a single vitrification plant, it split the project in two. One plant — the building now under construction — would begin vitrifying the less-hazardous, 'low-activity' liquid in the tanks. A bigger, more-complex plant to process the high-level sludge would follow once researchers resolved some thorny safety questions.

On both fronts, there have been signs of progress. This year, the DOE reported that it had resolved crucial questions related to treating the high-level waste. And a laboratory needed for real-time analysis of the low-level waste is nearing completion. If work continues as planned, the site could crank out its first glass logs as early as 2022.

Hanford's critics, accustomed to missed deadlines and management scandals, remain sceptical. But even officials with the state of Washington, which has battled the DOE in court for nearly three decades over clean-up goals and deadlines, are hopeful that efforts are now on track. “There's reason for optimism,” says Suzanne Dahl, who oversees tank activities for the Washington Department of Ecology.

Scientists have been studying vitrification since the 1950s, and a number of countries have used the process to stabilize nuclear waste, including France, India, Russia and the United Kingdom. The United States vitrifies waste at the DOE's Savannah River Site in South Carolina. But the size and complexity of the problem is on a different scale at Hanford.

Established as part of the Manhattan Project during the Second World War, the Hanford Site delivered the plutonium that went into the first nuclear-weapon test and the bomb that was dropped on Nagasaki, Japan, in 1945. It went on to produce the bulk of the plutonium for the US nuclear arsenal. “Hanford is the whole history of nuclear development,” says Ian Pegg, a physicist at the Catholic University of America in Washington DC, who works with the DOE on vitrification experiments.

Toxic brews

The ever-shifting suite of technologies used at the site produced uniquely toxic brews that include radioactive caesium, strontium, americium and residual plutonium; salts; heavy metals; and myriad industrial chemicals. The containers also hold other surprises. People “threw everything imaginable into those tanks”, says Albert Kruger, a glass scientist with the DOE in Richland, Washington. His list includes contaminated gloves, planks of wood, rocks and tape measures.

Once such detritus is removed, vitrification calls for the waste to be combined with ingredients that include silica and boron, then heated to nearly 1,150 °C. The molten mixture is next cooled in stainless-steel canisters to create large cylinders of borosilicate glass — the same material used in oven-safe glassware.

The process is complicated by that fact that each tank contains a cocktail of chemicals and radionuclides that cannot be fully characterized until the waste is extracted. Some of those substances can weaken glass. Others, such as iodine, can't be readily trapped and must be removed. Hanford scientists will have to tailor glass recipes for each batch of waste — a bit like blending different vintages to produce a fine cognac. “Nobody will test the nose, and nobody will take a taste test, but it's an equivalent mechanism,” Kruger says.

Multiple contractors have worked on the Hanford project since 1989, including British Nuclear Fuels Limited, a UK-government-owned company that exported the technology it was using at the Sellafield nuclear-decommissioning complex. After price estimates rose, in 2000 the DOE hired construction and engineering giant Bechtel of San Francisco, California, as the primary contractor.

At that time, the Hanford plant was expected to cost $4.3 billion and to begin making logs in 2007. But as engineers began working through the safety and technical details, the project ballooned in price and complexity. By 2012, senior officials — including a former DOE employee and two contractors who later filed whistle-blower complaints after being fired — were raising concerns. One was that hydrogen, which is generated when heat and radiation split water molecules, would build up in tanks and pipes, creating a risk of explosion. Another was that mixing vessels meant to keep heavy particles moving would not be powerful enough. Over time, enough residual plutonium could settle out to create a dangerous chain reaction.

Then-DOE secretary Steven Chu assembled an expert panel to investigate. Ultimately, Bechtel was ordered to first construct a plant that would vitrify only liquid waste. The liquid represents 90% of the waste volume but just 10% of its radioactivity, and requires less processing than the high-level waste: it can be skimmed off, stripped of highly radioactive caesium and then sent directly to vitrification. “It makes sense,” says David Kosson, a chemical engineer at Vanderbilt University in Nashville, Tennessee, who was on Chu's expert panel. If you have got to pick one place to start, he says, “the low-activity waste is not a bad choice”.

Lingering questions

The high-level-waste facilities remain on hold, but the DOE and its contractors have spent years investigating the technical issues using computer models and prototypes. In February, the agency announced it had resolved issues related to hydrogen build-up and uncontrolled reactions. Scientists familiar with the effort says tests of a newly designed mixing vessel are nearing completion, apparently without any major hitches. The vessel is equipped with six 'pulse jet mixers' that pull waste in and out like turkey basters, to keep solids from settling.

Researchers are also making progress on the glass recipes. Kruger and external scientists have shown that certain compositions can accommodate more waste than previously estimated, and so potentially save on costs. The number of glass logs produced in the high-level waste facility could drop from 18,000 to as few as 7,000, Kruger says. The low-level plant may need to make just 70,000 logs or so, instead of 145,000.

But questions remain. A 2015 DOE report documented more than 500 vulnerabilities that could affect low-level plant operations — including some in the electrical and mechanical systems that would be used to handle radioactive materials. Tom Carpenter, executive director of the watchdog group Hanford Challenge, hopes the plant will work as advertised. But he is concerned that the DOE, its contractors and even the state of Washington are too eager to bring the facility online. “Everyone is desperate to show progress,” he says. “I get that, but you can't paper over the safety issues.” Senior DOE officials at Hanford declined to be interviewed for this story; a Bechtel spokesperson said the company has addressed the vast majority of concerns raised in the report and has submitted its responses to the DOE for verification.

Not everyone is convinced that vitrification is the way to go. The DOE is bound by legal agreements and nuclear-waste regulations to pursue the process, but from a technical standpoint there are better options, says Jim Conca, a consultant and former director of an independent research centre that supports the Waste Isolation Pilot Plant (WIPP) outside Carlsbad, New Mexico, the nation's only operating deep geological repository.

Hanford's high-level wastes are currently slated for disposal at Yucca Mountain, a long-stalled geological repository in Nevada. Water infiltration

is a concern there, so the waste must be encased in glass to help ensure that it remains stable over thousands of years. But Conca says that the tank sludge is safe enough to simply be dried out and sent to WIPP — if regulations could be changed to allow it. Similarly, low-activity waste could be mixed with grout to create concrete-like material, which would be cheaper and, many believe, just as safe. “Does all of that waste technically need to be vitrified for environmental safety? Probably not,” says Kosson. But in the end, Kosson believes that the DOE will press forward with the plan.

Chu remains confident that vitrification can work, but says the DOE should be receptive to new science and shift course as needed. More generally, he says, the country has a long way to go in resolving questions about how — and where — it will dispose of all its nuclear waste. “This is a significant problem, and there has to be a lot of good science in figuring out a better path forward,” he says. “Always keep your mind open.”

The price tag on Hanford's vitrification facilities now stands at $16.8 billion. Assuming that the latest timetable holds, the plant for high-level waste will open for business in the early 2030s, and operations will continue for decades. In the meantime, dangerous waste will remain underground, out of sight but not out of mind.

Journal name:
Nature
Volume:
550,
Pages:
172–173
Date published:
(12 October 2017)
DOI:
doi:10.1038/550172a

Nature News

周三, 25 10月 2017

Nature News

[周三, 25 10月 2017]

- **Nature News**

Nature News

Nature is a weekly international journal publishing the finest peer-reviewed research in all fields of science and technology on the basis of its originality, importance, interdisciplinary interest, timeliness, accessibility, elegance and surprising conclusions. Nature also provides rapid, authoritative, insightful and arresting news and interpretation of topical and coming trends affecting science, scientists and the wider public.

- **India gears up for second Moon mission** [周二, 24 10月 08:00]
  The Chandrayaan-2 orbiter, lander and rover will track how lunar dust might scupper settlement.
- **Reclassify waste to shift the nuclear landscape** [周二, 24 10月 08:00]
  The US Department of Energy should classify and dispose of nuclear rubbish according to risk.
- **Cancer biology still needs physicists** [周二, 24 10月 08:00]
  Considering game theory and the role of physical forces could lead to better treatments for cancer, says Robert Austin.
- **To stay young, kill zombie cells** [周二, 24 10月 08:00]
  Killing off cells that refuse to die on their own has proved a powerful anti-ageing strategy in mice. Now it's about to be tested in humans.
- **Shrew skulls shrink for winter survival** [周一, 23 10月 08:00]
  Getting smaller by absorbing bone tissue may help animals to save energy when food is scarce.
- **Iranian scholar sentenced to death** [周一, 23 10月 08:00]
  Ahmadreza Djalali, a researcher in disaster medicine, has 20 days to appeal against his death sentence.
- **Photons pair up like superconducting electrons** [周五, 20 10月 08:00]
  Discovery raises questions about how a light 'supercurrent' might behave.
- **Quantum machine goes in search of the Higgs boson** [周四, 19 10月 08:00]
  D-Wave system shows quantum computers can learn to detect particle signatures in mountains of data, but doesn’t outpace conventional methods — yet.
- **Sabre-toothed cats prowled Europe 200,000 years after supposedly going extinct** [周四, 19 10月 08:00]
  Ancient-DNA analysis also suggests a surprising connection with sabretooths in North America.
- **Jupiter's stormy winds churn deep into the planet** [周四, 19 10月 08:00]
  Juno probe discovers surprising activity in the giant planet’s interior.
- **The science of puppy dog eyes** [周四, 19 10月 08:00]
  Dogs' facial expressions depend on human attention.

- **The Human Cell Atlas: from vision to reality** [周三, 18 10月 08:00]
  As an ambitious project to map all the cells in the human body gets officially under way, Aviv Regev, Sarah Teichmann and colleagues outline some key challenges.
- **Top Chinese university to consider social-media posts in researcher evaluations** [周三, 18 10月 08:00]
  Controversial policy means mainstream media are starting to rival rigorous academic publications in some universities in China.
- **Mysterious particles spotted in Saturn’s atmosphere** [周三, 18 10月 08:00]
  Source may be dust shed by planet’s iconic rings, according to data from NASA's doomed Cassini probe.
- **Efforts to save leading Hungarian university hit hurdle** [周三, 18 10月 08:00]
  US-registered Central European University faces another year of uncertainty over whether it can continue to operate in Hungary.
- **Sleeping sickness can now be cured with pills** [周三, 18 10月 08:00]
  Researchers seek approval from regulators for this quicker, easier treatment.
- **Self-taught AI is best yet at strategy game Go** [周三, 18 10月 08:00]
  Artificial-intelligence program AlphaGo Zero trained in just days, without any human input.
- **Science must examine the future of work** [周三, 18 10月 08:00]
  As automation changes employment, researchers should gather the evidence to help map the implications.
- **Blue is in the eye of the bee-holder** [周三, 18 10月 08:00]
  Flowers have evolved an ingenious way to attract pollinators.
- **Epic star collision, asteroid fly-by and journal resignations** [周三, 18 10月 08:00]
  The week in science: 13–19 October 2017.
- **New definitions of scientific units are on the horizon** [周三, 18 10月 08:00]
  Metrologists are poised to change how scientists measure the Universe.
- **The future of work** [周三, 18 10月 08:00]
  Digital technologies are upending the workforce. The right research can tell us how.
- **The shape of work to come** [周三, 18 10月 08:00]
  Three ways that the digital revolution is reshaping workforces around the world.
- **Lessons from history for the future of work** [周三, 18 10月 08:00]
  Global comparisons of previous social and economic upheavals suggest that what is to come depends on where you are now, argues Robert C. Allen.
- **The second Renaissance** [周三, 18 10月 08:00]
  Ian Goldin calls on scientists to help society to weather the disruptive transformations afoot.
- **Archaeology: The wonder of the pyramids** [周三, 18 10月 08:00]

Andrew Robinson enjoys a volume rounding up research on the complex at Giza, Egypt.

- **Books in brief** [周三, 18 10月 08:00]
  Barbara Kiser reviews five of the week's best science picks.
- **History: Five millennia of Indian science** [周三, 18 10月 08:00]
  James Poskett applauds a show celebrating discovery on the subcontinent, from zero to the boson.
- **Federal funding: Stifled by budgets, not irrelevance** [周三, 18 10月 08:00]
- **Ornithology: Danish dairy farmer delivers data coup** [周三, 18 10月 08:00]
- **Open data: Spot data glitches before publication** [周三, 18 10月 08:00]
- **PhD students: living wage key to diversity** [周三, 18 10月 08:00]
- **PhD students: side jobs are no solution** [周三, 18 10月 08:00]
- **Breaking and entering** [周三, 18 10月 08:00]
  Escape is not an option.
- **Brazilian Amazon still plagued by illegal use of natural resources** [周二, 17 10月 08:00]
  Practices such as poaching and illegal logging are concentrated near inhabited areas and along rivers, study finds.
- **Give researchers a lifetime word limit** [周二, 17 10月 08:00]
  Brian C. Martinson imagines how rationing the number of publications a scientist could put out might improve the scientific literature.
- **Japanese research leaders warn about national science decline** [周二, 17 10月 08:00]
  Concern mounts over budget cuts and other changes that undermine basic science.
- **Reboot for the AI revolution** [周二, 17 10月 08:00]
  As artificial intelligence puts many out of work, we must forge new economic, social and educational systems, argues Yuval Noah Harari.

India gears up for second Moon mission

The Chandrayaan-2 orbiter, lander and rover will track how lunar dust might scupper settlement.

24 October 2017

Xinhua/Alamy

India’s Chandrayaan-2 moon mission is scheduled to launch next March from the spaceport of Sriharikota.

In a large shed near the headquarters of the Indian Space Research Organisation (ISRO) in Bangalore, a six-wheeled rover rumbles over dark grey rubble in a landscape designed to mimic the Moon’s rocky surface. This test and others scheduled for the next few weeks are crucial steps in India’s

quest to launch a second mission to the Moon next March.

The country’s much anticipated Chandrayaan-2 comes almost a decade after India began its first journey to the Moon, in 2008. “It is logically an extension of the Chandrayaan-1 mission,” says Mylswamy Annadurai, director of the project at ISRO. The spacecraft comprises an orbiter that will travel around the Moon, a lander that will touch down in a as-yet undecided location near the Moon’s south pole and a rover.

India’s maiden Moon trip was a significant achievement for its space programme, but ended prematurely when ISRO lost contact with the orbiter ten months into the planned two-year mission. However, an instrument on a probe that reached the Moon’s surface did gather enough data for scientists to confirm the presence of traces of water.

Chandrayaan-2 will attempt more ambitious technical manoeuvres that will put Indian space technology to the test. For the first time, ISRO will attempt to give a craft a controlled, or soft, landing. The agency has had to develop advanced systems that can guide the lander to a touch down and successfully deploy the rover.

Lunar conditions

Lunar missions are also being planned by China, Japan and other countries, among others. Like these, India’s explorations are partly driven by the need to improve understanding of the Moon’s environment in the event that governments or private entities decide to establish a human settlement there. One poorly understood phenomenon is floating lunar dust. Without an atmosphere like Earth’s, the surface of the Moon is buffeted by solar wind and ultraviolet radiation, creating a layer of charged ions called a plasma sheath in which dust particles can levitate.

If humans colonize the Moon, this dust will be a significant challenge, says planetary scientist Penny King of the Australian National University (ANU) in Canberra. It gets into everything, from astronauts’ suits to machinery and equipment, where it causes damage, she says. “Understanding how it moves

around is pretty critical.” ISRO says the Chandrayaan-2 orbiter and lander will carry a first of its kind instrument, called the Radio Anatomy of Moon Bound Hypersensitive ionosphere and Atmosphere (RAMBHA), to measure the density of the near-surface plasma and how it changes over time.

Evolving environment

The rest of the spacecraft’s suite of instruments will collect data to help scientists study other aspects of the Moon’s present environment and how it has evolved. Chandrayaan-2’s lander will take the first on-site thermal measurements on the lunar surface near a polar region. The mission “is expected to further consolidate the findings from the first mission and add new ones with *in situ* analysis of the lunar surface and ionosphere,” says Annadurai, who is also director of ISRO’s Satellite Centre in Bangalore.

ISRO plans to execute its mission on shoestring budget of just 6.03 billion rupees (US$93 million), including the cost of the rocket and launch. Chandrayaan-2 will be carried into space on one of the agency’s three-stage rockets, a Geosynchronous Satellite Launch Vehicle Mark II, taking off from a spaceport on the island of Sriharikota in the Bay of Bengal. “A nice part of the Indian space programme is that they manage to do things so cheaply,” says ANU astrobiologist Charles Lineweaver. “If it succeeds, maybe everyone else will see that their mission didn’t really need that extra bell or whistle.”

In three to four weeks**,** ISRO will begin one of the final and most complex testing phases for Chandrayaan-2, integrating all of its components. With one Moon mission under its belt, ISRO is settling into its role as a moon-faring organisation. “Maybe we were extra anxious with the first child, as parents. But we relax a bit as more children come along,” he jokes.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22870

Comments

Commenting is currently unavailable.

| 章节菜单 | 主菜单 |

Reclassify waste to shift the nuclear landscape

The US Department of Energy should classify and dispose of nuclear rubbish according to risk.

24 October 2017

Brian Vander Brug/Los Angeles Times/Getty

Reclassification of nuclear waste could make disposal simpler and cheaper.

The United States has a single deep geological repository for nuclear waste. Since 1999, the Waste Isolation Pilot Plant (WIPP), 655 metres down in a massive salt formation near Carlsbad, New Mexico, has received 12,000-odd shipments of what it calls transuranic waste. This is clothing, tools and other

detritus from the nuclear-weapons programme that are contaminated by elements heavier than uranium. It’s more hazardous than low-level waste, which can be buried closer to the surface, but not as dangerous as high-level waste, for which a disposal site has yet to be found.

WIPP was closed for three years after radiation escaped from a ruptured drum in 2014. It was given the all-clear to reopen only in January; an enquiry determined that the drum had been packed improperly before shipment from the Los Alamos National Laboratory in northern New Mexico. Concerns remain about safety, as well as the long-term risk of human intrusion into a facility that will remain dangerous for thousands of years after its eventual closure. But by and large, WIPP has functioned as designed, and it could do even more to help the US Department of Energy (DOE) address the fallout from the country’s nuclear-weapons programme.

Much high-level waste — produced during the reprocessing of spent nuclear fuel into plutonium — is highly radioactive and dangerous. But the evidence suggests that some of the waste that is labelled ‘high level’ technically qualifies as transuranic. This material is still barred from direct disposal at WIPP, purely because of how it was produced. But labels can be changed. If wastes that meet the transuranic criteria could be shipped to WIPP, it would save considerable time and effort as the DOE continues to struggle with the country’s radioactive legacy.

At present, the high-level waste is scheduled to be encased in glass logs for disposal in a separate repository at Yucca Mountain in Nevada. Despite decades of delays and controversies, there are signs of progress at the DOE’s flagship vitrification facility at the Hanford Site in Washington. But even if current plans hold, that facility will not begin processing high-level waste until 2032. Nor is it clear where the logs will actually go. Yucca Mountain was shut down by former president Barack Obama, only to be revived by President Donald Trump. Its long-term prospects are far from certain.

Reclassifying some high-level waste at Hanford, as well as at two facilities in Idaho and South Carolina, offers an alternative path for some of that waste, and one that would reduce an ongoing threat to workers and the environment. More than one-third of the 177 underground storage tanks at Hanford have leaked and contaminated groundwater.

The problem is inertia, compounded by fear, distrust and politics. The DOE is operating under a complex web of rules, regulations and legal agreements, and shifting course isn’t easy. Although the agency has the authority to look through its nuclear-waste inventory and reclassify wastes that meet the WIPP transuranic criteria, it has resisted such a move because it fears that this would spark political uproar — and quite probably legal challenges.

Washington state, which has in place a court-ordered clean-up agreement for Hanford, has been particularly resistant to change. And New Mexico has tied the DOE’s hands at WIPP by banning the disposal of tank wastes and any other materials managed as high-level waste — even if they meet the WIPP criteria. Watchdog groups, meanwhile, are concerned that nuclear-waste reclassification is simply a way of changing the rules and lowering the bar for public and environmental safety.

The proposal briefly bubbled up to the surface several years ago, but political attention shifted after the leak at WIPP. Now a coalition of local governments from communities across the nuclear-weapons industry is reviving the idea. In a white paper published last month, the Energy Communities Alliance urged a two-pronged approach involving the DOE as well as Congress, which could clarify the definition of high-level waste legislatively. The alliance estimated that the DOE could save at least US$40 billion over the lifetime of its clean-up programme — more than 15% of the estimated $257-billion price tag.

After spending some $11 billion on the as-yet-unfinished vitrification plant over the past two decades at Hanford, some may hesitate to change course. But as former DOE secretary Steven Chu said, the worst thing you can do in a multi-decade project such as nuclear-waste clean-up is to close the door to alternatives. In this case, the solution is simple enough: nuclear waste should be managed on the basis of the risk it poses and not the process that produced it.

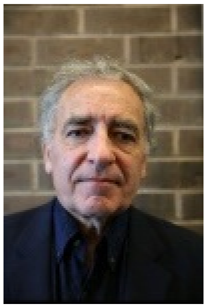
Journal name:
Nature
Volume:
550,
Pages:

429–430
Date published:
(26 October 2017)
DOI:
doi:10.1038/550429b

Comments

Comments

There are currently no comments.



Ted Lewis
III

Cancer biology still needs physicists

Considering game theory and the role of physical forces could lead to better treatments for cancer, says Robert Austin[1].

24 October 2017

Cancer is close to surpassing heart disease as the leading cause of death in the United States. The World Health Organization estimates that worldwide, new cases will rise by 70% in the next two decades. In concert, treatment costs are skyrocketing and could reach US$156 billion by 2020 in the United States alone, according to the US National Cancer Institute (NCI). A modest decline in US cancer mortality rates has been attributed to prevention, such as lower smoking rates, rather than better treatment. Yet, more than 150,000 papers on cancer have been published each year since 2013.

This month, application deadlines closed for several programmes in the US$1.8-billion Cancer Moonshot authorized by the US Congress in 2016. The extra funds to study cancer are badly needed, but we do not have a sufficient fundamental understanding of the disease for these investments to make a near-term difference in treatment.

Comparison of the cancer initiative to former US president John F. Kennedy’s lunar challenge is misleading. When, in 1961, Kennedy declared

the goal of landing on the Moon, we understood gravity well enough to be reasonably confident that if we built rockets powerful enough, we could do it. We could predict distant planetary orbits with startling precision. Getting an astronaut to a nearby satellite was an engineering feat. No new basic principles needed to be discovered.

This is not true for cancer. The deepest puzzle we must solve is how groups of cells behave, which networking theories developed in the physical sciences are well equipped to address. Cancer can move from a localized tumour to remote locations — a process called metastasis. Once that happens, individuals with cancer have a poor prognosis. Metastasis drives the costs of treatment skyward, but these therapies are, tragically, largely futile. Without a better way to explain and treat metastases, new clinical methods will do little to improve the situation.

To be sure, there has been progress. A growing appreciation of how the immune system keeps cancer in check has brought a new class of therapies. Patient-specific chemotherapy and more-precise radiotherapy have also led to advances. But cancer needs more big ideas — and those of scientists from other disciplines should be taken more seriously.

In 2008, I attended a series of workshops organized by the NCI in Bethesda, Maryland, to bring together physicists, engineers, mathematicians and computer scientists to look for new ways of tackling the disease. These led to the creation in 2009 of a dozen designated physical-sciences oncology centres; I led the Princeton Physical Sciences–Oncology Center, based in New Jersey, from 2009 to 2015.

Over that time, large cancer-genome sequencing projects revealed millions of cancer-related mutations. The numbers found in individual tumours and types of cancer range widely. Exactly what causes this variation is unclear. In any case, genetically targeted treatments generally buy affected individuals, at most, a few more months of life.

Since the centres launched, there has been greater recognition of the potential contributions of physical forces to cancer-cell responses, such as the number and location of metastases, or how cells stick together. Networking and game theories — mathematical analyses of social and economic interactions that

represent how humans do or don’t cooperate to minimize costs and maximize gains — have also been adapted to model how cells behave during cancer growth and invasion. Particularly promising, in my view, are theories of the evolution of multicellularity, when cells had to develop mechanisms for living in communities — possibly at the cost of their own selfish, local goals of reproduction. I argue that these approaches have not yet had time to show their potential.

The cancer community has been unenthusiastic about the contributions of physical oncologists. When, several years ago, we proposed a special section on the physics of cancer for a high-profile journal, oncology referees were dismissive. One admitted: “I am not a big fan of the topic.” Another reviewer rejected the proposal because genetics “is the Rosetta Stone with respect to treatment”. Wrote another: “I did not recognize any of the proposed authors.”

Too often, biologists see physicists as human calculators. The big ideas, they think, belong to them, with physicists filling in the details by performing quantitative analyses. To counter this attitude, the Francis Crick Institute in London, for instance, is actively searching for physicists with transformative ideas. We need to do more than hire ‘quants’ to crunch ‘big data’.

To develop new conceptual approaches to cancer, scientists of all stripes must reach out. I have sometimes antagonized biologists by saying that their advice stifles creativity. But I am now working, along with medical physicist Robert Jeraj of the University of Wisconsin–Madison, to form groups within the American Physical Society that focus on oncology. These scientists have strong collaborations with biomedical researchers, but have historically been restricted to advancing imaging technologies — important, but far removed from bringing in ideas about the origins and progression of disease. I also serve on the editorial board of two journals designed as outlets for this sort of work. *Convergent Science Physical Oncology* was launched in 2015, by the Institute of Physics in Bristol, UK, and *Cancer Convergence* (published by Springer Nature, which also publishes *Nature*) will publish its first articles in the next few months.

We need to expand our questions — or risk remaining Earth-bound.

Journal name:

Nature
Volume:
550,
Pages:
431
Date published:
(26 October 2017)
DOI:
doi:10.1038/550431a

Comments

Commenting is currently unavailable.

To stay young, kill zombie cells

Killing off cells that refuse to die on their own has proved a powerful anti-ageing strategy in mice. Now it's about to be tested in humans.

24 October 2017

Illustration by Paweł Jońca

Jan van Deursen was baffled by the decrepit-looking transgenic mice he created in 2000. Instead of developing tumours as expected, the mice experienced a stranger malady. By the time they were three months old, their fur had grown thin and their eyes were glazed with cataracts. It took him years to work out why: the mice were ageing rapidly, their bodies clogged with a strange type of cell that did not divide, but that wouldn't die[1].

That gave van Deursen and his colleagues at Mayo Clinic in Rochester, Minnesota, an idea: could killing off these 'zombie' cells in the mice delay their premature descent into old age? The answer was yes. In a 2011 study[2], the team found that eliminating these 'senescent' cells forestalled many of the ravages of age. The discovery set off a spate of similar findings. In the seven years since, dozens of experiments have confirmed that senescent cells accumulate in ageing organs, and that eliminating them can alleviate, or even prevent, certain illnesses (see 'Becoming undead'). This year alone, clearing the cells in mice has been shown to restore fitness, fur density and kidney function[3]. It has also improved lung disease[4] and even mended damaged cartilage[5]. And in a 2016 study, it seemed to extend the lifespan of normally ageing mice[6].

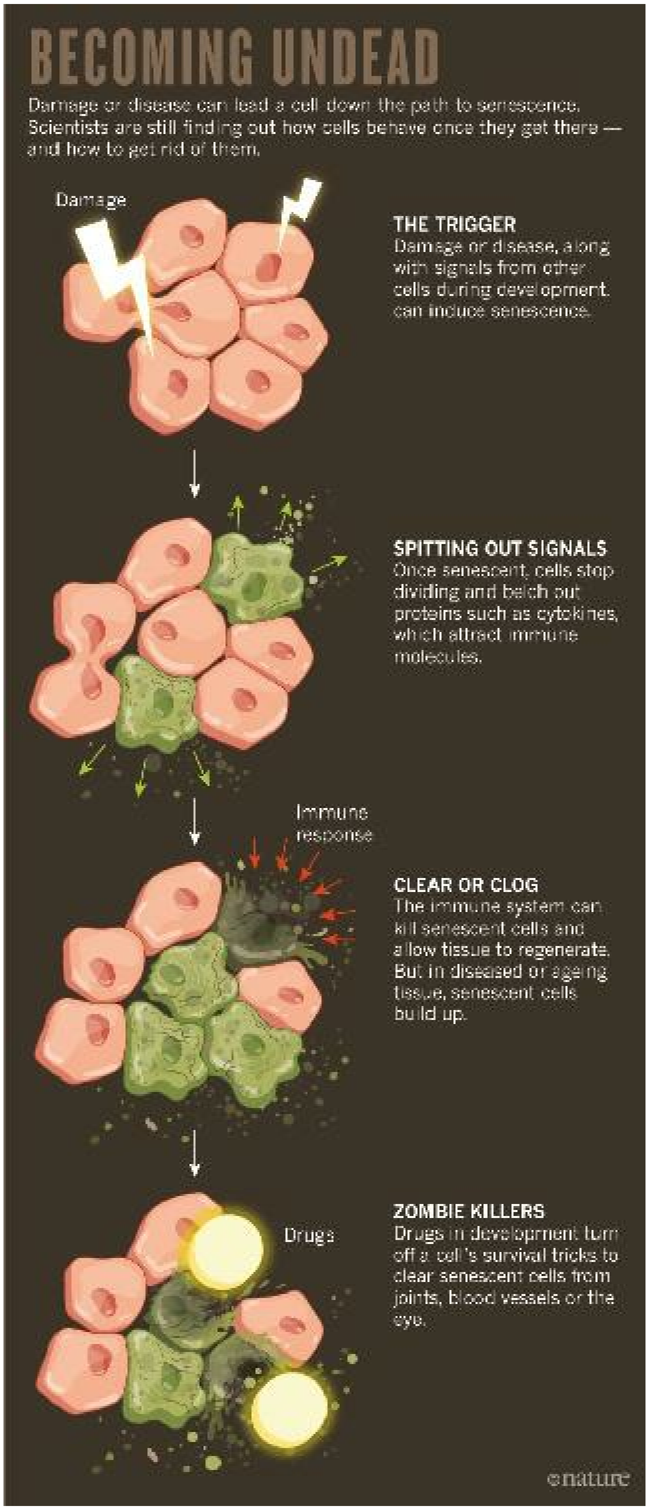
“Just by removing senescent cells, you could stimulate new tissue production,” says Jennifer Elisseeff, senior author of the cartilage paper and a biomedical engineer at Johns Hopkins University in Baltimore, Maryland. It jump-starts some of the tissue's natural repair mechanisms, she says.

This anti-ageing phenomenon has been an unexpected twist in the study of senescent cells, a common, non-dividing cell type first described more than five decades ago. When a cell enters senescence — and almost all cells have the potential to do so — it stops producing copies of itself, begins to belch out hundreds of proteins, and cranks up anti-death pathways full blast. A senescent cell is in its twilight: not quite dead, but not dividing as it did at its peak.

Now biotechnology and pharmaceutical companies are keen to test drugs — known as senolytics — that kill senescent cells in the hope of rolling back, or at least forestalling, the ravages of age. Unity Biotechnology in San Francisco, California, co-founded by van Deursen, plans to conduct multiple clinical trials over the next two-and-a-half years, treating people with osteoarthritis, eye diseases and pulmonary diseases. At Mayo, gerontologist James Kirkland, who took part in the 2011 study, is cautiously beginning a handful of small, proof-of-concept trials that pit senolytic drugs against a range of age-related ailments. “I lose sleep at night because these things always look good in mice or rats, but when you get to people you hit a brick wall,” says Kirkland.

No other anti-ageing elixir has yet cleared that wall, and for a few good reasons. It's next to impossible to get funding for clinical trials that measure an increase in healthy lifespan. And even as a concept, ageing is slippery. The US Food and Drug Administration has not labelled it a condition in need of treatment.

Still, if any of the trials offer “a whiff of human efficacy”, says Unity's president, Ned David, there will be a massive push to develop treatments and to better understand the fundamental process of ageing. Other researchers who study the process are watching closely. Senolytics are “absolutely ready” for clinical trials, says Nir Barzilai, director of the Institute for Aging Research at the Albert Einstein College of Medicine in New York City. “I think senolytics are drugs that could come soon and be effective in the elderly now, even in the next few years.”



The dark side

When microbiologists Leonard Hayflick and Paul Moorhead coined the term senescence in 1961, they suggested that it represented ageing on a cellular level. But very little research was done on ageing at the time, and Hayflick recalls people calling him an idiot for making the observation. The idea was ignored for decades.

Although many cells do die on their own, all somatic cells (those other than reproductive ones) that divide have the ability to undergo senescence. But, for a long time, these twilight cells were simply a curiosity, says Manuel Serrano of the Institute for Research in Biomedicine in Barcelona, Spain, who has studied senescence for more than 25 years. “We were not sure if they were doing something important.” Despite self-disabling the ability to replicate, senescent cells stay metabolically active, often continuing to perform basic cellular functions.

By the mid-2000s, senescence was chiefly understood as a way of arresting the growth of damaged cells to suppress tumours. Today, researchers continue to study how senescence arises in development and disease. They know that when a cell becomes mutated or injured, it often stops dividing — to avoid passing that damage to daughter cells. Senescent cells have also been identified in the placenta and embryo, where they seem to guide the formation of temporary structures before being cleared out by other cells.

LISTEN

Hear Judy Campisi and Jan van Deursen discuss why they're excited to be researching senescence.

You may need a more recent browser or to install the latest version of the Adobe Flash Plugin.

But it wasn't long before researchers discovered what molecular biologist Judith Campisi calls the “dark side” of senescence. In 2008, three research groups, including Campisi's at the Buck Institute for Research on Aging in Novato, California, revealed that senescent cells excrete a glut of molecules — including cytokines, growth factors and proteases — that affect the function of nearby cells and incite local inflammation[7, 8, 9]. Campisi's group described this activity as the cell's senescence-associated secretory phenotype, or SASP[7]. In recent unpublished work, her team identified hundreds of proteins involved in SASPs.

In young, healthy tissue, says Serrano, these secretions are probably part of a restorative process, by which damaged cells stimulate repair in nearby tissues and emit a distress signal prompting the immune system to eliminate them. Yet at some point, senescent cells begin to accumulate — a process linked to problems such as osteoarthritis, a chronic inflammation of the joints, and atherosclerosis, a hardening of the arteries. No one is quite sure when or why that happens. It has been suggested that, over time, the immune system stops responding to the cells.

Surprisingly, senescent cells turn out to be slightly different in each tissue. They secrete different cytokines, express different extracellular proteins and use different tactics to avoid death. That incredible variety has made it a challenge for labs to detect and visualize senescent cells. "There is nothing definitive about a senescent cell. Nothing. Period," says Campisi.

In fact, even the defining feature of a senescent cell — that it does not divide — is not written in stone. After chemotherapy, for example, cells take up to two weeks to become senescent, before reverting at some later point to a proliferating, cancerous state, says Hayley McDaid, a pharmacologist at Albert Einstein College of Medicine. In support of that idea, a large collaboration of researchers found this year that removing senescent cells right after chemotherapy, in mouse models for skin and breast cancer, makes the cancer less likely to spread[10].

The lack of universal features makes it hard to take inventory of senescent cells. Researchers have to use a large panel of markers to search for them in tissue, making the work laborious and expensive, says van Deursen. A universal marker for senescence would make the job much easier — but researchers know of no specific protein to label, or process to identify. "My money would be on us never finding a senescent-specific marker," Campisi adds. "I would bet a good bottle of wine on that."

Earlier this year, however, one group did develop a way to count these cells in tissue. Valery Krizhanovsky and his colleagues at the Weizmann Institute of Science in Rehovot, Israel, stained tissues for molecular markers of senescence and imaged them to analyse the number of senescent cells in tumours and aged tissues from mice[11]. “There were quite a few more cells than I actually thought that we would find,” says Krizhanovsky. In young mice, no more than 1% of cells in any given organ were senescent. In two-year-old mice, however, up to 20% of cells were senescent in some organs.

But there's a silver lining to these elusive twilight cells: they might be hard to find, but they're easy to kill.

Out with the old

In November 2011, while on a three-hour flight, David read van Deursen and Kirkland's just-published paper about eliminating zombie cells. Then he read it again, and then a third time. The idea “was so simple and beautiful”, recalls David. “It was almost poetic.” When the flight landed, David, a serial biotech entrepreneur, immediately rang van Deursen, and within 72 hours had convinced him to meet to discuss forming an anti-ageing company.

Kirkland, together with collaborators at the Sanford Burnham Medical Research Institute in La Jolla, California, initially attempted a high-throughput screen to quickly identify a compound that would kill senescent cells. But they found it to be “a monumental task” to tell whether a drug was affecting dividing or non-dividing cells, Kirkland recalls. After several failed attempts, he took another tack.

Senescent cells depend on protective mechanisms to survive in their 'undead' state, so Kirkland, in collaboration with Laura Niedernhofer and others from the Scripps Research Institute in Jupiter, Florida, began seeking out those mechanisms. They identified six signalling pathways that prevent cell death, which senescent cells activate to survive[12, 13].

Then it was just a matter of finding compounds that would disrupt those pathways. In early 2015, the team identified the first senolytics: an FDA-

approved chemotherapy drug, dasatinib, which eliminates human fat-cell progenitors that have turned senescent; and a plant-derived health-food supplement, quercetin, which targets senescent human endothelial cells, among other cell types. The combination of the two — which work better together than apart — alleviates a range of age-related disorders in mice[14].

Ten months later, Daohong Zhou at the University of Arkansas for Medical Sciences in Little Rock and his colleagues identified a senolytic compound now known as navitoclax, which inhibits two proteins in the BCL-2 family that usually help the cells to survive[15]. Similar findings were reported within weeks by Kirkland's lab[16] and Krizhanovsky's lab[17].

By now, 14 senolytics have been described in the literature, including small molecules, antibodies and, in March this year, a peptide that activates a cell-death pathway and can restore lustrous hair and physical fitness to ageing mice[3].

So far, each senolytic kills a particular flavour of senescent cell. Targeting the different diseases of ageing, therefore, will require multiple types of senolytics. “That's what's going to make this difficult: each senescent cell might have a different way to protect itself, so we'll have to find combinations of drugs to wipe them all out,” says Niedernhofer. Unity maintains a large atlas documenting which senescent cells are associated with which disease; any weaknesses unique to given kinds of cell, and how to exploit those flaws; and the chemistry required to build the right drug for a particular tissue. There is no doubt that for different indications, different types of drug will need to be developed, says David. “In a perfect world, you wouldn't have to. But sadly, biology did not get that memo.”

For all the challenges, senolytic drugs have several attractive qualities. Senescent cells will probably need to be cleared only periodically — say, once a year — to prevent or delay disease. So the drug is around for only a short time. This type of 'hit and run' delivery could reduce the chance of side effects, and people could take the drugs during periods of good health. Unity plans to inject the compounds directly into diseased tissue, such as a knee joint in the case of osteoarthritis, or the back of the eye for someone with age-related macular degeneration.

And unlike cancer, in which a single remaining cell can spark a new tumour, there's no need to kill every senescent cell in a tissue: mouse studies suggest that dispatching most of them is enough to make a difference. Finally, senolytic drugs will clear only senescent cells that are already present — they won't prevent the formation of such cells in the future, which means that senescence can continue to perform its original tumour-suppressing role in the body.

Those perks haven't convinced everybody of the power of senolytics. Almost 60 years after his initial discovery, Hayflick now believes that ageing is an inexorable biophysical process that cannot be altered by eliminating senescent cells. “Efforts to interfere with the ageing process have been going on since recorded human history,” says Hayflick. “And we know of nothing — nothing — that has demonstrated to interfere with the ageing process.”

Fans of senolytics are much more optimistic, emboldened by recent results. Last year, van Deursen's lab went beyond its tests on super-aged mice and showed that killing off senescent cells in normally ageing mice delayed the deterioration of organs associated with ageing[6], including the kidney and heart. And — to the joy of anti-ageing enthusiasts everywhere — it extended the animals' median lifespan by about 25%.

Successful results from mouse studies have already lured seven or eight companies into the field, Kirkland estimates. At Mayo, one clinical trial has opened, pitting dasatinib and quercetin in combination against chronic kidney disease. Kirkland plans to try other senolytics against different age-related diseases. “We want to use more than one set of agents across the trials and look at more than one condition,” he says.

If eliminating senescent cells in humans does improve age-related illnesses, researchers will aim to create broader anti-ageing therapies, says David. In the meantime, researchers in the field insist that no one should take these drugs until proper safety tests in humans are complete. In rodents, senolytic compounds have been shown to delay wound healing, and there could be additional side effects. “It's just too dangerous,” says Kirkland.

Van Deursen says that continuing to answer basic biological questions is the field's best shot at success. “Only then will we be able to understand what

ageing really is, and how we can, in an intelligent way, interfere with it.”

Journal name:
Nature
Volume:
550,
Pages:
448–450
Date published:
(26 October 2017)
DOI:
doi:10.1038/550448a

Comments

Comments

There are currently no comments.

Shrew skulls shrink for winter survival

Getting smaller by absorbing bone tissue may help animals to save energy when food is scarce.

23 October 2017

Karol Zub

Skulls of the common shrew (*Sorex araneus*) shrink by about 15% in winter and regrow the next summer.

Common shrews shrink their heads — including their skulls — in winter, researchers have found. They believe that this dramatic example of downsizing may help the animals to survive when food is scarce.

Individual wild common shrews (*Sorex araneus*) captured and tagged in Germany showed large reductions in skull size and body mass over the winter. Their spines also got shorter, and major organs, including the heart, lungs and spleen, shrank. Even their brain mass dropped by 20–30%, according to Javier Lázaro, a biologist at the Max Planck Institute for Ornithology in Radolfzell, Germany. In spring, the animals started to regrow.

“We hypothesize that these seasonal changes could have adaptive value,” says Lázaro, who led the work. Shrews have an extremely fast metabolism, he points out, and reducing their body mass during winter might increase their chances of survival, because they wouldn’t need so much food. In particular, he adds, “reducing brain size might save energy, as the brain is energetically so expensive”.

Up and down

The researchers trapped live shrews, then anaesthetized, X-rayed and weighed them. They also fitted each animal with a microchip, so they could monitor changes in shrews that were recaptured over their roughly 14-month lifespan. Twelve animals were captured during each key life stage: the first summer of their lives, the next winter and the following spring and summer.

The results are published in *Current Biology*[1] on 23 October. The shrews’ skulls shrank by about 15% from summer to winter, an effect that the X-ray images suggest was caused by resorption of tissue at the joints between skull bones. This bone then regenerated in spring, although the skulls didn’t quite return to their original summer size.

“Tracking of individual animals is crucial here — this is really great work,” says zoologist Leszek Rychlik of Adam Mickiewicz University in Poznań, Poland. Rychlik has previously found[2] that common shrews in northeastern Poland show seasonal changes in body mass on a population level. But Lázaro’s team is the first to show that the skulls of individual shrews shrink.

Cold comfort

Lázaro and his colleagues are now investigating which brain structures change most from season to season, and whether the animals experience any cognitive impairments in winter. If they do, it might not matter too much, says Rychlik. “Their winter life is more boring,” he says. “They are less active, less involved in interactions, not busy with reproduction and searching for partners. They are just focused on foraging and saving energy.”

Just how many species might shrink their brains for winter is not known. Even at the population level, seasonal comparisons are often not possible, because biologists tend to collect specimens in summer rather than winter. In work being prepared for publication, Rychlik has found seasonal differences in skull size and body mass in two other members of the red-toothed-shrew sub-family: the pygmy shrew (*Sorex minutus*) and the Eurasian water shrew (*Neomys fodiens*). Some of Lázaro’s co-authors have also found[3] similar differences in two species of weasel.

These differences were observed in dead animals, but “we think they are caused by the same individual shrink–regrow process”, says Lázaro. He adds that a similar ability might exist in other small, high-metabolism animals that live in seasonal environments and don’t hibernate or use other strategies to save energy. Although still exceptional, he says, “the phenomenon might be more common than we think”.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22874

Comments

Comments

There are currently no comments.

| 章节菜单 | 主菜单 |

Iranian scholar sentenced to death

Ahmadreza Djalali, a researcher in disaster medicine, has 20 days to appeal against his death sentence.

23 October 2017

Courtesy of Vida Mehrannia

Researcher Ahmadreza Djalali was convicted of espionage and sentenced in Iran on 21 October.

A judge in Tehran has ordered the death penalty for Iranian researcher Ahmadreza Djalali, according to his wife and diplomatic sources in Italy.

Djalali is affiliated with the Karolinska Institute in Stockholm, Sweden, and the University of Eastern Piedmont in Novara, Italy. A resident of Sweden

with his family, Djalali was arrested in April 2016 on an academic visit to Tehran and accused of “collaboration with a hostile government”. He works on improving hospitals’ emergency responses to armed terrorism and radiological, chemical and biological threats.

Djalali was convicted of espionage following a trial led by Abolqasem Salavati, a judge in Iran's revolutionary court, and sentenced to death on 21 October, according to Djalali's wife Vida Mehrannia and to Italian diplomatic sources. They say he has 20 days to appeal against the sentence.

Mehrannia says that her husband was accused of obtaining money, academic positions and research projects in exchange for spying on Iran for Israel.

Djalali document

Shortly before the sentence was announced, a close contact of Djalali's (who would prefer to remain anonymous) circulated a document that claims to be a literal transcription of a handwritten text produced by Djalali inside Evin prison, where he is being held. The document states that Djalali believes he was arrested for refusing to spy for the Iranian intelligence service.

According to the document, in 2014 two representatives of the Iranian military and intelligence service asked Djalali to spy on European countries for Iran — in particular, on “critical infrastructures, counter-terrorism and CBRNE [chemical, biological, radiological, nuclear and explosives] capabilities, sensitive operational plans, and also research projects, relevant to terrorism and crisis.” It says he refused.

The document claims that Djalali was forced to make false confessions following “multiple psychological and physical tortures”. “I have never acted against my country, I have never spied for Israel or any other country. My only fault is that I did not accept to use the trust of my colleagues and universities in EU to spy for Iran's intelligence services,” the text states.

Djalali’s colleagues have reacted with dismay. “None of our shared research projects had partners in Israel and I am not aware of any money transfer from Israel to Djalali. We relied on European Commission funds,” says Luca

Ragazzoni, a health researcher at the University of Eastern Piedmont, who worked with Djalali from 2012 to 2015. “We did not have access to secret data,” he says.

Mehrannia says that Djalali is considering a hunger strike in protest at the sentence. Since his imprisonment, Djalali has carried out multiple hunger and thirst strikes. He was also forced to change his lawyer against his will, according to the Committee of Concerned Scientists, a lobby group. Several scholars and human-rights organizations have repeatedly called for a fair trial or release for Djalali.

Djalali’s story echoes those of other Iranian scientists. Omid Kokabee, a physicist released from a Tehran jail in August 2016 after five years' imprisonment, says he believes he was punished for refusing to help a covert nuclear-weapons programme. Hamid Babaei, who was undertaking a PhD in finance in Belgium but is now serving a six-year prison sentence in Iran, has said he was arrested for refusing to spy on his colleagues.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22875

Comments

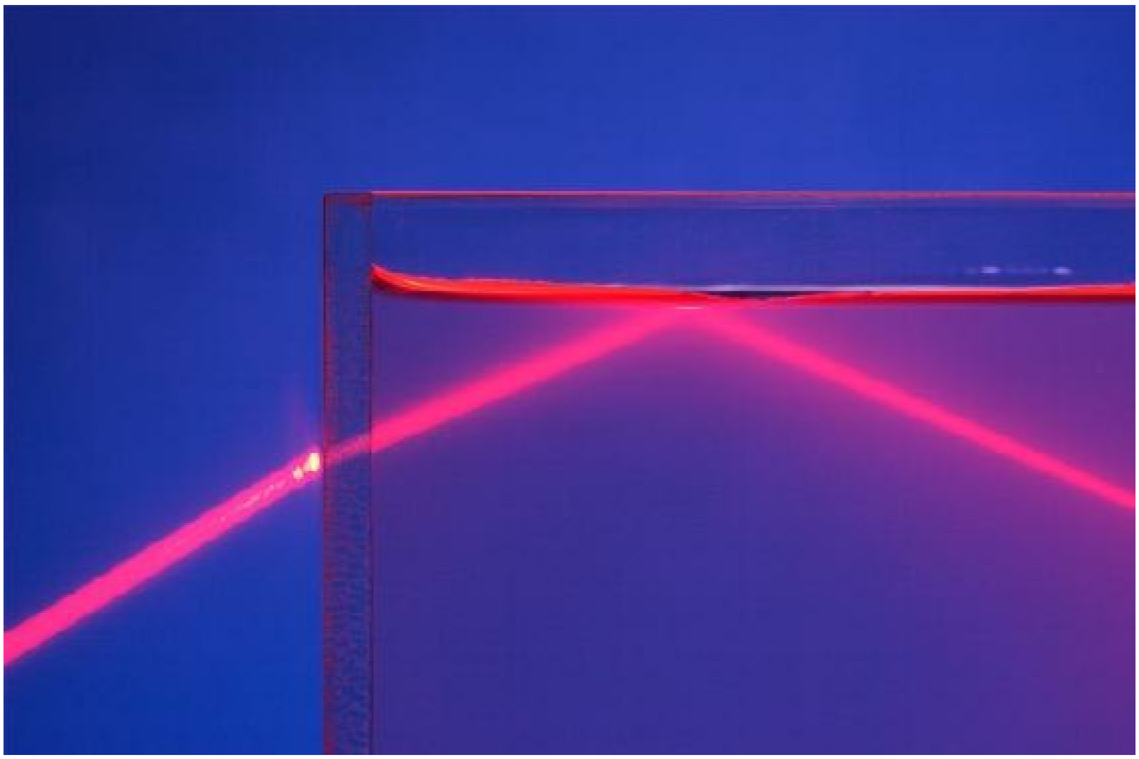
Comments

There are currently no comments.

Photons pair up like superconducting electrons

Discovery raises questions about how a light 'supercurrent' might behave.

20 October 2017



GIPhotoStock/SPL

Photons of light pair up as they travel through water, just like electrons in a superconductor.

Superconductivity — a phenomenon in which electrons can travel through certain materials with zero resistance — has revolutionized parts of medicine, travel and science. Now, an intriguing experiment has seen the same behaviour that underlies superconductivity — but in particles of light. The

finding has left physicists wondering how far the comparison might reach.

“This is really exciting work,” says Nick Vamivakas, a quantum physicist at the University of Rochester, New York, who was not involved with the research. “It’s a beautiful connection between light scattering, condensed-matter physics and quantum optics.”

Conventional superconductivity relies on the formation of ‘Cooper pairs’ of electrons, which stabilize each other’s path and allow electricity to flow without resistance. Its discovery led to the development of powerful superconducting magnets, which are now used in medical scanners, particle accelerators, wind turbines and magnetically levitated trains.

Physicists in Brazil have now seen evidence of photons of light forming similar pairs. The process occurs at room temperature when light passes through a range of transparent liquids, including water, although it is very difficult to observe. “Not only is this formation of pairs possible, but it is everywhere,” says André Saraiva, a theoretical physicist at the Federal University of Rio de Janeiro (UFRJ) and co-author of a paper that has been accepted for publication in *Physical Review Letters.*

The team has yet to explore how far the parallel with superconductivity goes. As photons already interact less with their environment than electrons do, similar pairs in light are unlikely to lead to such dramatic effects as in electric currents. But the work is already triggering speculation about how light ‘supercurrents’ might behave, and how they might be used.

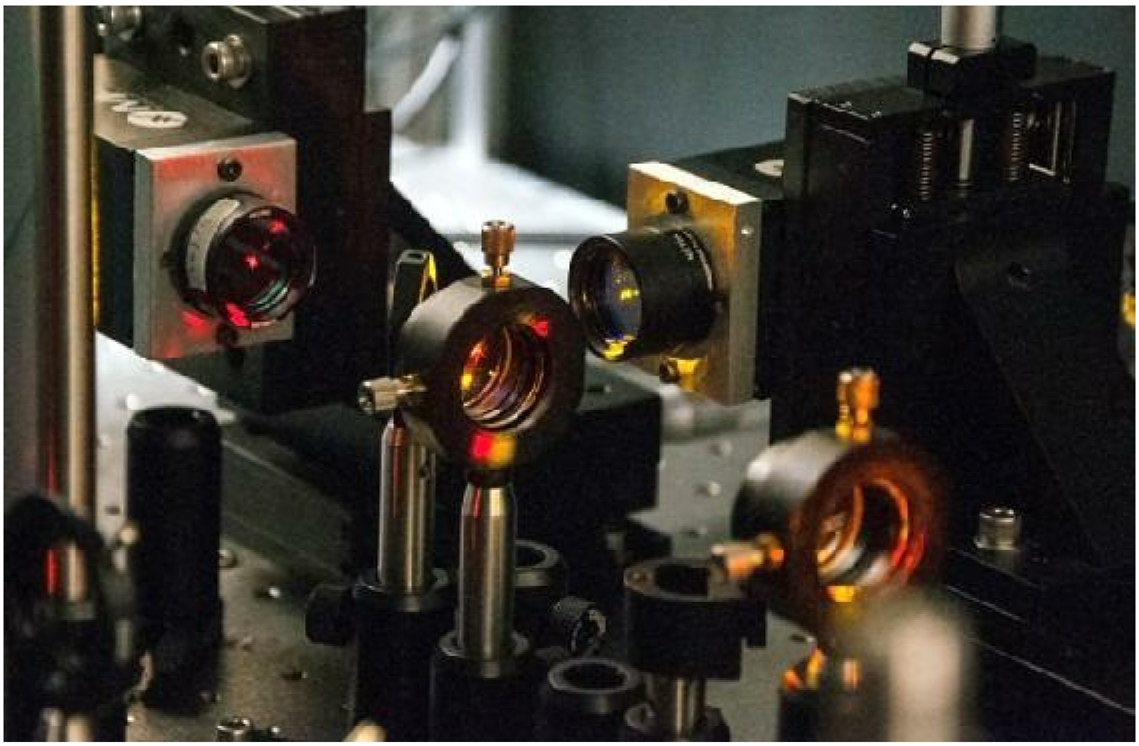
Pairing up

The discovery stems from work led by Ado Jorio at the Federal University of Minas Gerais in Belo Horizonte, Brazil, which investigated how light scatters within materials. When this happens, photons can lose energy to the atoms in the material, which vibrate. If a second photon immediately absorbs this packet of vibrational energy, the two photons become indirectly linked, with one gaining the energy the other lost.

When Jorio described his research to the condensed-matter department at

UFRJ, it sparked an idea in physicist Belita Koiller. She noticed the similarity between this process (in which vibrations caused by one photon affect another) and the formation of Cooper pairs in superconductivity, when distortions in an atomic lattice, caused by a speeding electron, allow the particle to attract a partner in its wake.

In both cases, pairs form as a result of movement in the atoms around them. In superconductors, however, the vibrations are of a fleeting kind allowed by quantum mechanics, known as virtual phonons. Koiller and her team wondered: was this true for light as well?



Cassiano Rabelo

Physicists in Brazil used a filter to capture only photon pairs created by quantum vibrations known as virtual phonons.

First, the UFRJ team showed mathematically that if photons also interact via virtual phonons, their behaviour would be an exact match for Cooper pairs in superconductors. Then the researchers looked for evidence of such pairs by shining pulses of laser light at room temperature through water and seven other transparent liquids. They used detectors to examine the emerging photons, searching for pairs that arrived simultaneously, in which one photon had shifted towards red (losing energy) and the other towards blue (gaining energy).

If the arriving pairs were created by virtual phonons, rather than the standard scattering process, the energy shifts of the photons should be too small to come from classically allowed vibrations, so the team applied a filter to let through only this range of energy shifts. They compared the results with the number they saw when both types of energy shifts were allowed.

In both cases, they saw the same rate of photon pairs, suggesting that the pairs had to be created by the virtual process. The signal was tiny: of around 10 quadrillion photons pumped through the material per second, they saw 10 pairs, compared with the 1 pair every 10 seconds that they would have expected to see by chance.

It's an interesting discovery, says Andrea Ferrari, a physicist at the University of Cambridge, UK, although he cautions that the explanation will need to be validated by other groups. “I would say this is not the end, but certainly the beginning.”

Intriguing possibilities

The possibility of Cooper-like pairs in light has both quantum optics and condensed matter physicists taking notice, says Saraiva, largely because they want to see how far the analogy with superconductivity can be stretched. In matter, Cooper pairs are behind a wide range of intriguing effects — but so far the team has no data to hint whether the same would apply with light. “These are very important questions we’re keen to answer,” says Saraiva.

If the team can boost the number of photon pairs, there could also be applications. Harnessing the way the paired photons interact with matter might reveal currently invisible properties of a material. And if the particles can be shown to correlate in ways beyond their timing — to have their quantum properties intrinsically linked — room-temperature water could

prove a remarkably cheap source of 'entangled' photons, which are essential for quantum cryptography and computing.

Physicists are also wondering whether the pairs might form supercurrents, behaving similarly to their electron counterparts: perhaps light would disperse less as it travels through a material, for example, leading to more efficient quantum communication. Might paired photons even make materials more transparent? At this stage, says Saraiva, we just don't know.

For now, all this is pure speculation. But mapping concepts from condensed-matter physics onto light research has a pedigree of generating useful technologies, says Vamivakas. Photonic crystals, for example, which are used to tailor how photons flow through materials, grew out of insights about how a crystal lattice influences electrons in mattter, he points out. Vamivakas says that when he first heard of the latest work, he asked his students: "Hey, why didn’t we think of this?"

The discovery might not have happened at all if it hadn't involved such a simple experimental set-up. Funding for science in Brazil has been cut by 60% since 2013, leaving many laboratories unable to sustain their equipment. “We were fortunate to come across such a profoundly important phenomenon that does not require special equipment to see,” says Saraiva. “We can’t count on this kind of luck every time."

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22868

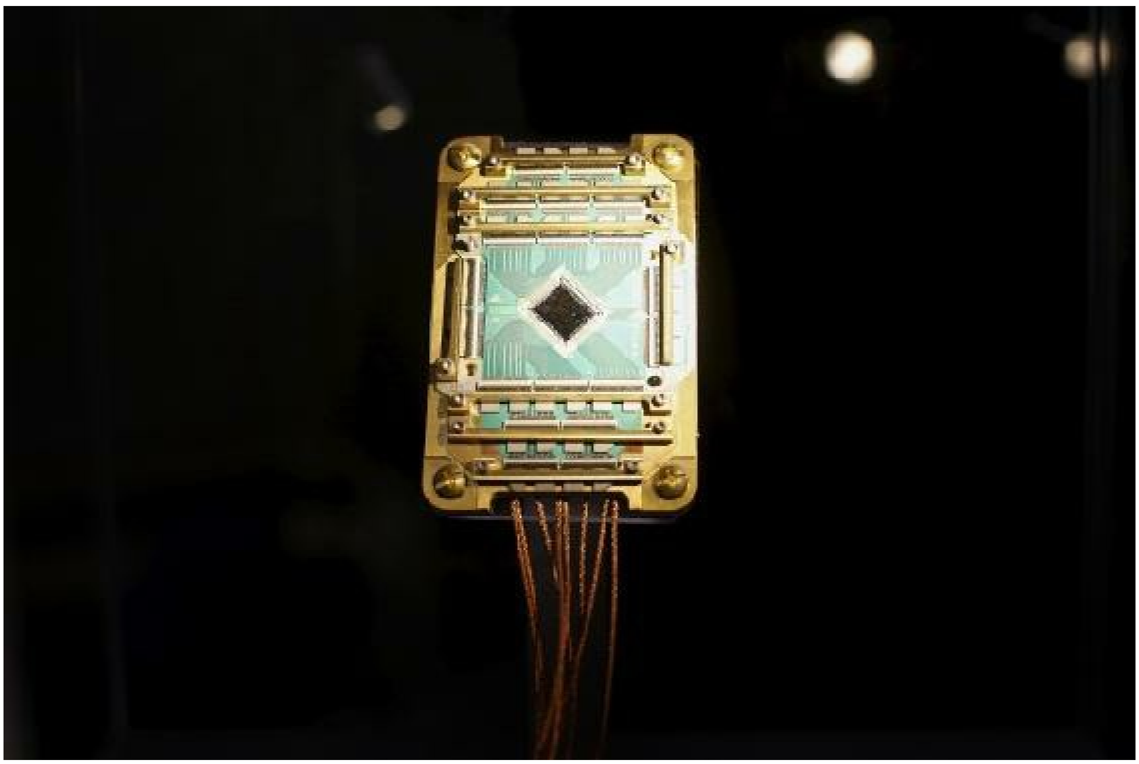
Comments

Commenting is currently unavailable.

Quantum machine goes in search of the Higgs boson

D-Wave system shows quantum computers can learn to detect particle signatures in mountains of data, but doesn’t outpace conventional methods — yet.

19 October 2017



Stephen Lam/Reuters

A quantum processing unit such as this might soon offer a more efficient way to detect rare particles.

A rudimentary quantum computer has rediscovered the Higgs boson. Sort of.

Physicists have been working hard to develop machines that can use quantum mechanical tricks to speed up computation. But they also hope that such quantum computers can return the favour and help them to discover new laws of nature.

Now, a team has shown that a quantum circuit can learn to sift through reams of data from atom-smashing experiments in search of a new particle. Their proof-of-principle study — performed using a machine built by quantum-computing company D-Wave working on the now-familiar case of the Higgs boson — does not yet provide a clear advantage over conventional techniques. But the authors say that quantum machine learning could make a difference in future experiments, when the amounts data will grow even larger. Their research was published on 18 October in *Nature*[1].

Kyle Cranmer, a physicist at New York University who wasn't involved in the work, says that it's refreshing to see a quantum machine applied to a practical physics problem — instead of the usual mathematical questions such as factoring whole numbers into primes. "Before this point, people were aware that this maybe some day will be relevant," he says. "This makes it looks like maybe it is."

Optimal solutions

In 2012, two experiments at the Large Hadron Collider (LHC) at CERN, Europe's high-energy physics lab near Geneva, Switzerland, announced that they had proof of the existence of the Higgs boson, the last missing piece in the standard model of particle physics. The two experiments, called CMS and ATLAS, found evidence of the boson created in proton collisions from the way in which the Higgs decayed into more-common ones, such as pairs of high-energy photons. But each time the LHC collides two protons, hundreds of other particles are created, some of which can be misinterpreted as photons when they hit the detectors.

To help speed up their search for the Higgs, ATLAS and CMS physicists used simulated data to train machine-learning algorithms to tell wheat from chaff — photons from impostors.

More recently, particle physicist Maria Spiropulu, who helped lead the Higgs search at CMS, wanted to know whether a quantum computer could help to make the training process more efficient, in particular by reducing the amount of simulated data required to train the system. “I wanted to see if it can solve the Higgs problem, because I know the Higgs problem,” says Spiropulu, who is at the California Institute of Technology in Pasadena.

Her collaborator Alex Mott, a physicist who is now at DeepMind in London, translated the learning process into something that could be calculated by a ‘quantum annealing’ computer built by D-Wave, which is based in Burnaby, Canada. This type of machine finds the optimal solutions to certain problems by allowing superconducting loops, which encode quantum information, to fall into their lowest-energy state.

The idea was to have the quantum machine find the optimal criteria that an ordinary computer could then use to look for the photon signatures of the Higgs in real data. To test their theory, the team gained access to a D-Wave machine at the University of Southern California in Los Angeles. The experiment was successful, Spiropulu says: “We can train with small data sets and find the optimal solution.”

The researchers didn’t use those criteria to rediscover the Higgs — because they didn't need to. Showing that it is possible was “the coolest part” of their work, says Cranmer, who is a data-analysis specialist and helped lead the Higgs search in the ATLAS collaboration.

Beyond physics

Don’t expect physicists to switch to quantum computers just yet: so far, the machine hasn’t performed better than a virtual version of itself that Spiropolu and her team ran on a conventional computer. And there is a long way to go to demonstrate that these techniques are more efficient than some existing machine-learning algorithms that are able to train on relatively small data sets, Cranmer says. Spiropulu agrees, adding that it will be necessary to test the various approaches against one another to see which is best.

But the results could have an impact in fields beyond physics. Davide Venturelli, a physicist working for the non-profit Universities Space Research Association and at the NASA Ames Research Center in Mountain View, California, manages a programme that makes a D-Wave machine at Ames (jointly run by Google and NASA) available to experimenters around the world. Researchers in fields ranging from Earth science to bioinformatics are interested in using quantum annealers, in particular for machine-learning applications, he says.

“The interesting thing is that this whole thing works,” Mott says.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22860

Comments

Comments

There are currently no comments.

Sabre-toothed cats prowled Europe 200,000 years after supposedly going extinct

Ancient-DNA analysis also suggests a surprising connection with sabretooths in North America.

19 October 2017

Roman Uchytel/SPL

The sabre-toothed cat *Homotherium latidens* might have travelled between Eurasia and North America.

Sabre-toothed cats existed in Europe for hundreds of thousands of years longer than previously thought, according to a study[1] that settles a long-running debate among palaeontologists. The authors also found evidence that *Homotherium latidens*, a Eurasian sabretooth, and *Homotherium* serum from North America are genetically almost indistinguishable.

The findings are part of a project that used partial genome reconstructions to examine the evolutionary history of *Homotherium* sabre-toothed cats, which had smaller, more serrated fangs than *Smilodon* — the sabretooth most people think of, with its long fangs. The latest results, published on 19 October in *Current Biology*[1], upend ideas of how *Homotherium* moved between continents and when it went extinct.

When a trawler dredged up an ancient *H. latidens* jawbone while fishing in the North Sea off the Netherlands in 2000, it sparked controversy. Radiocarbon dating showed that the specimen was just 28,000 years old[2], shocking palaeontologists: the youngest *Homotherium* fossil found in Eurasia up to that point was about 300,000 years old. The analysis of ancient DNA in the latest study confirms the age of the North Sea specimen.

The team also constructed partial genomes of two *H. serum* fossils from the Yukon Territory in Canada and the North Sea *H. latidens* specimen. The two species were so similar genetically that they should probably be combined under the *H. latidens* name, says Johanna Paijmans, a palaeogeneticist at the University of Potsdam in Germany and lead author of the study.

But combining the species might be a bit premature until researchers find more sabretooth specimens in Europe, says Julie Meachen, a palaeontologist at Des Moines University in Iowa.

Mind the gap

Until then, researchers can only speculate as to why there’s such a huge gap in the Eurasian sabretooth fossil record and how animals on two different continents could be so genetically similar. Migration between *Homotherium* populations in Eurasia and North America could explain the species’ similarities, Meachen says.

It could also explain why sabretooths seem to pop back into existence in the fossil record hundreds of thousands of years after researchers thought they died out in Europe. The North Sea specimen could be evidence that the cats migrated back into Western Europe from Asia or over the Bering land bridge from North America. Or it could be that the Eurasian *H. latidens* population dwindled to such low numbers that the animals just don’t show up in the fossil record, says Paijmans.

“There’s no reason it can’t be both,” says Margaret Lewis, a palaeontologist at Stockton University in Galloway, New Jersey. She adds that the species was probably very mobile, and that carnivores in general are always rarer in the fossil record than prey animals because there aren't as many predators. Some answers certainly lie in the DNA of the older European fossils, says Lewis.

But the technology to obtain those answers simply doesn’t exist yet, says Paijmans. As DNA ages, it degrades and becomes harder to extract. Right now, researchers can obtain DNA from the mitochondria — a cell’s battery pack — of younger specimens such as the North Sea *Homotherium*, but not from older fossils. However, Paijmans remains hopeful that the technology will eventually catch up.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22861

Comments

Comments

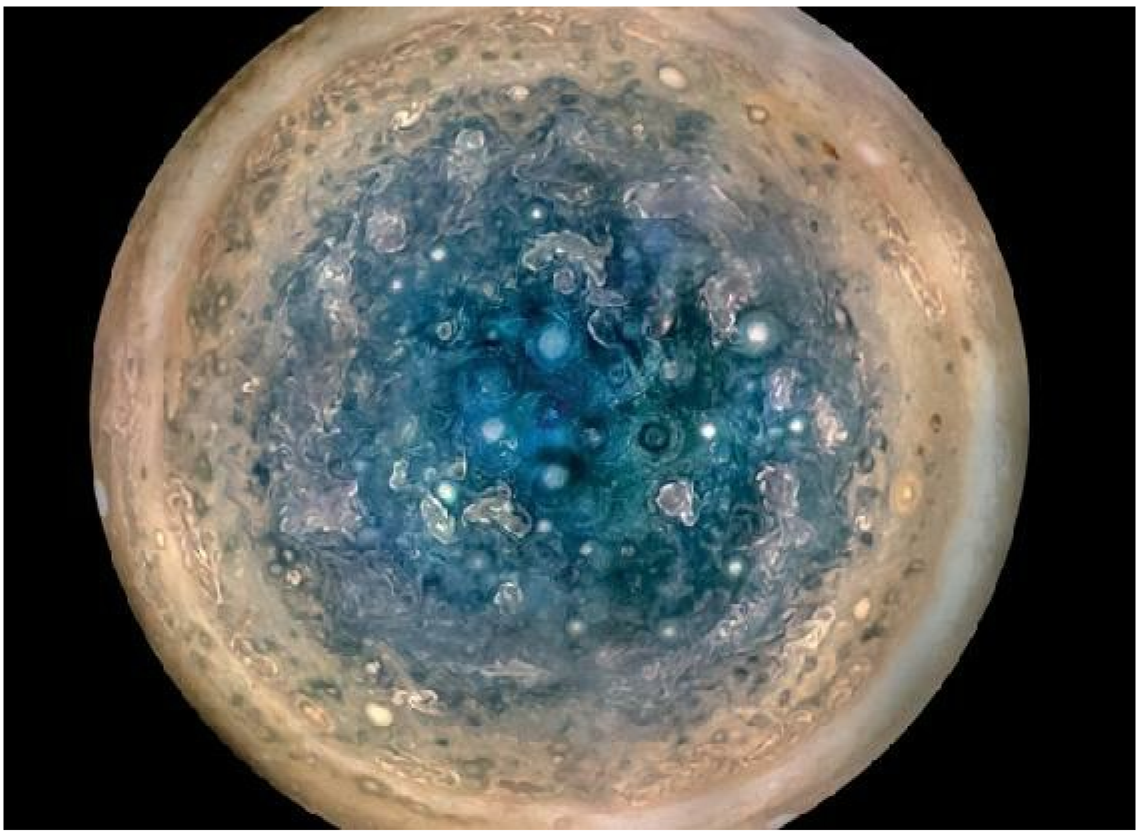
There are currently no comments.

Jupiter's stormy winds churn deep into the planet

Juno probe discovers surprising activity in the giant planet’s interior.

19 October 2017

Provo, Utah



NASA/JPL-Caltech/SwRI/MSSS/Betsy Asher Hall/Gervasio Robles

A ring of cyclones swirls around Jupiter's south pole.

NASA's Juno spacecraft has plumbed the depths of Jupiter, revealing that the planet's famous bands of swirling winds extend thousands of kilometres down. The work is the sharpest glimpse yet into Jupiter's interior.

Jupiter's colourful stripes are atmospheric patterns composed of winds that flow alternately east and west. Until now, researchers haven't been able to say whether those bands are confined to a shallow layer or reach deeper into the planet. "Determining this is one of the main goals of the Juno mission," said team member Yohai Kaspi, a geophysicist at the Weizmann Institute of Science in Rehovot, Israel, on 18 October at the American Astronomical Society's Division for Planetary Sciences meeting in Provo, Utah.

Juno arrived at Jupiter in July 2016 and has been looping around it once every 53 days. The mission has already revealed several mysterious phenomena, such as Jupiter's patchy magnetic field and sets of cyclones that whirl around the planet's north and south poles like dancers around a maypole.

By studying Jupiter's gravitational field, researchers can probe thousands of kilometres into the planet. On each close fly-by, Juno measures the planet's complex gravitational tug. These observations have already revealed that Jupiter has a small, 'fuzzy', poorly defined core[1].

Inner whirl

The latest results show that Jupiter's gravitational field is askew, with different patterns in its northern and southern hemispheres, said Tristan Guillot, a planetary scientist at the Observatory of the Côte d'Azur in Nice, France. That suggests that its hydrogen-rich gas is flowing asymmetrically deep in the planet. "This is something that was not expected," Guillot said at the meeting. "We were not sure at all whether we would be able to see that."

Another clue to the structure of Jupiter's interior came from how the gravity field varies with depth. Theoretical studies predict that the bigger the gravity signal, the stronger the flow of gas deep down[2, 3]. That information is important for teasing out whether all of Jupiter's interior is rotating as a single solid body, or whether different layers spin separately from one another, like a set of nesting Russian dolls moving within each other.

Juno detected a gravity signal powerful enough to indicate that material is flowing as far down as 3,000 kilometres. “We’re just taking the clouds and the winds and extending them into the interior,” Kaspi said. Future work could help to pinpoint how strong the flow is at various depths, which could resolve whether Jupiter’s interior really resembles Russian dolls.

Juno scientists are now looking to see what else the gravity data will tell them, such as how far the famous storm called the Great Red Spot extends into the atmosphere. Another instrument aboard Juno has already hinted that the Great Red Spot’s roots may go hundreds of kilometres down, and it could go even deeper. “It’s not yet clear that it is so deep it will show up in gravity data,” said David Stevenson, a planetary scientist at the California Institute of Technology in Pasadena. “But we’re trying.”

Polar circles

Juno has also been peering into Jupiter’s depths in other ways. One big surprise from the mission was the clusters of cyclones at each pole, seen by Juno’s cameras in visible and infrared wavelengths. Scientists had not spotted the storms before because Juno is the first spacecraft to fly over Jupiter’s polar regions. There are eight cyclones around the north pole and five around the south pole — all are mysterious, because computer modelling suggests that such small storms would not be stable in swirling polar winds.

The answer may lie in a quirky physics concept known as a vortex crystal, said Fachreddin Tabataba-Vakili, a planetary scientist at NASA’s Jet Propulsion Laboratory in Pasadena. Such crystals have been seen in a few Earth-based phenomena such as rotating superfluids; they are born when small vortices form and persist as the material in which they are embedded continues to flow.

Something about the flow around Jupiter’s poles may set up the same dynamics, Tabataba-Vakili said. Next up is to work out why there are eight cyclones at one pole and five at the other, he added.

Between Jupiter's polar cyclones and its deep interior flows, Juno continues to tease out new surprises from the Solar System's biggest planet. "It's clear that giant planets have a lot of secrets," Guillot said.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22866

Comments

Comments

There are currently no comments.

The science of puppy dog eyes

Dogs' facial expressions depend on human attention.

19 October 2017

Everett Coll./Mary Evans Picture Library

Making eyes: dogs' facial expressions really are aimed at us, research suggests.

Every dog owner is familiar with the ‘puppy dog eyes’ expression. As the inner brow lifts, the eyes get bigger and bigger … It’s tempting to interpret this as a plea from a sad dog for a scrap of the family dinner. Now, a small study provides support for the idea that dogs do indeed produce facial expressions to communicate with people — although perhaps just to engage us, rather than to manipulate us.

The dogs in the study produced more than twice as many facial expressions ('puppy dog eyes' was one of the most common) when a researcher was facing them than when she was turned away. But it didn't seem to matter whether she also held food. Earlier studies have shown that seeing food is more exciting to a dog than is social contact with a silent person, so something other than the dogs' emotional state must have been responsible for the effect.

"Dogs make their eyes more attractive to us while we are watching, not just when we are in the vicinity or in response to food," says Brian Hare, a cognitive neuroscientist and co-director of the Duke Canine Cognition Center at Duke University in Durham, North Carolina. "This is fantastic work."

The study, published on 19 October in *Scientific Reports*[1], adds to a growing body of work that shows how sensitive dogs are to human attention. It also provides the first evidence in a non-primate species that facial expressions can be used actively to communicate, says psychologist Juliane Kaminski at the Dog Cognition Centre at the University of Portsmouth, UK, who led the research. Researchers had previously assumed that such expressions are an involuntary reflection of an animal's emotional state.

Brow-raising results

Kaminksi and her colleagues studied 24 pet dogs of various breeds (including 10 mongrels) and ages (from 1 to 12 years). Each dog was tied with a lead in a quiet room, with a video camera trained on its face. An experimenter, to whom the dog had been introduced, stood a metre away.

The person adopted four different positions, in turn: facing the dog and displaying food in her hands; facing it and not displaying food; facing away from the dog and displaying food; and facing away and not displaying food. Throughout, she tried to keep her gaze focused on a spot on the wall, and did not respond to the dog's behaviours. All the dogs completed two such trials, on separate days.

Their facial expressions were analysed by the Dog Cognition Centre's

Bridget Waller, using a system she helped to create, called DogFACS. It is based on the Facial Action Coding System for people, which identifies observable facial changes associated with underlying muscle movements. Although the ‘inner brow raiser’ expression signifies sadness in people, there’s no evidence that it indicates sadness in dogs, she notes. But humans tend to find it appealing.

Kaminski cautions against concluding that dogs use the expression to communicate any specific message, however. “Seeing the food plus seeing the human being attentive does not make the dogs want to look super cute.”

It would be interesting to determine whether dogs modulate these expressions based on the identity of the person, says Gregory Berns, a neuroscientist at Emory University in Atlanta, Georgia, who has used brain scans to explore dog behaviour. “My impression is that dogs frequently attempt to communicate with us humans, but we are not very good at recognizing the signs.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22867

Comments

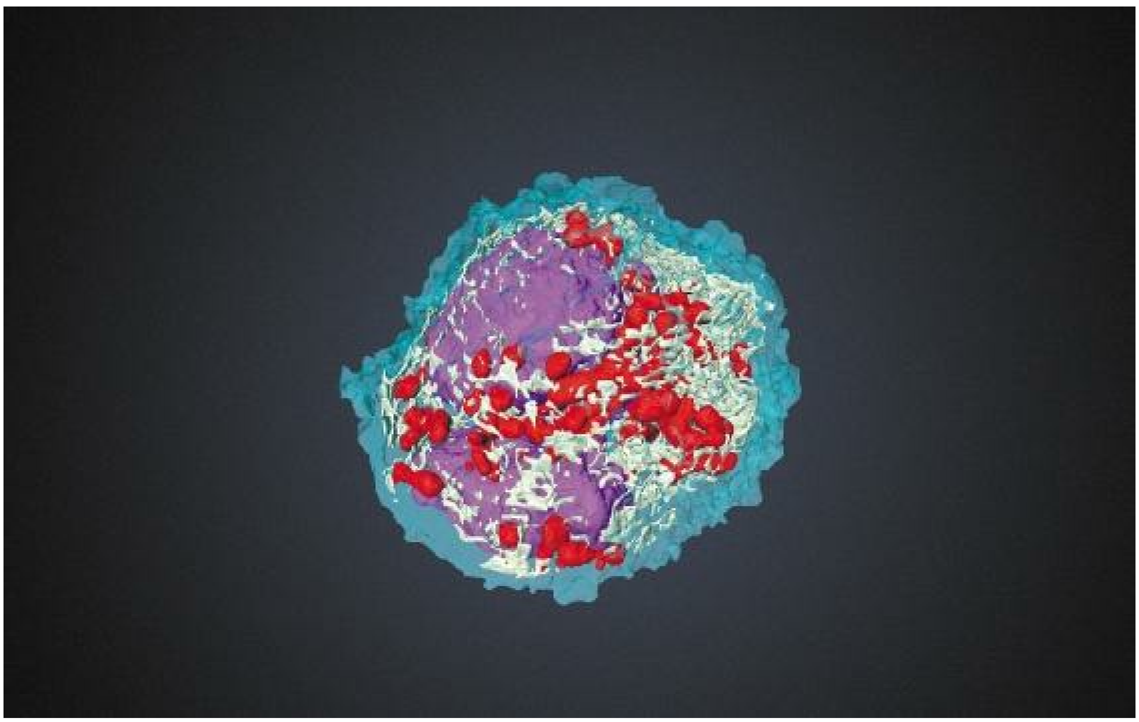
Comments

There are currently no comments.

The Human Cell Atlas: from vision to reality

18 October 2017

As an ambitious project to map all the cells in the human body gets officially under way, Aviv Regev, Sarah Teichmann and colleagues outline some key challenges.



Villani, A.-C. ET AL. SCIENCE 356, EAAH453 (2017); image Kathryn White; reconstruction James Fletcher

A new type of human dendritic cell recently discovered using single-cell RNA sequencing.

Our knowledge of the cells that make up the human body, and how they vary

from person to person, or throughout development and in health or disease, is still very limited. This week, a year after project planning began, more than 130 biologists, computational scientists, technologists and clinicians are reconvening in Rehovot, Israel, to kick the Human Cell Atlas initiative[1] into full gear. This international collaboration between hundreds of scientists from dozens of universities and institutes — including the UK Wellcome Trust Sanger Institute, RIKEN in Japan, the Karolinska Institute in Stockholm and the Broad Institute of MIT and Harvard in Cambridge, Massachusetts — aims to create comprehensive reference maps of all human cells as a basis for research, diagnosis, monitoring and treatment.

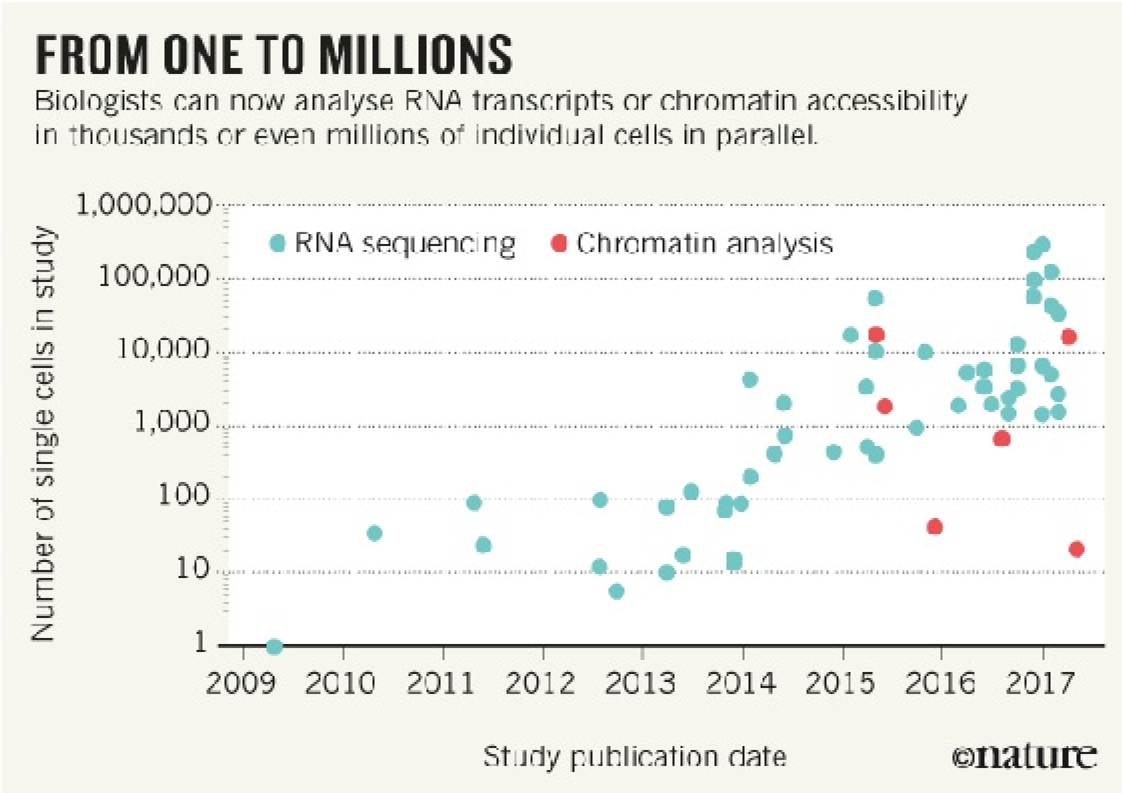
On behalf of the Human Cell Atlas organizing committee, we outline here some of the key challenges faced in building such an atlas — and our proposed strategies. For more details on how the atlas will be built as an open global resource, see the white paper[2] posted on the Human Cell Atlas website.

Cells have been characterized and classified with increasing precision since Robert Hooke first identified them under the microscope in the seventeenth century. But biologists have not yet determined all the molecular constituents of cells, nor have they established how all these constituents are associated with each other in tissues, systems and organs. As a result, there are many cell types we don't know about. We also don't know how all the cells in the body change from one state to another, which other cells they interact with or how they are altered during development.

Technology revolution

New technologies offer an opportunity to build a systematic atlas at unprecedented resolution. These tools range from single-cell RNA sequencing to techniques for assessing a cell's protein molecules and profiling the accessibility of the chromatin. For example, we can now determine the RNA profiles for millions of individual cells in parallel (see '<u>From one to millions</u>'). Protein composition and chromatin features can be studied in hundreds or thousands of individual cells, and mutations or other markers tracked to reconstruct cell lineages. We can also profile multiple

variants of RNA and proteins *in situ* to map cells and their molecules to their locations in tissues.



Source: Svensson, V., Vento-Tormo, R. & Teichmann, S. A. Preprint at https://arxiv.org/abs/1704.01379 (2017)

We anticipate that the atlas will help researchers to answer key questions in diverse biological fields. In cellular taxonomy, it might enable the discovery and identification of cell types and molecular markers or signatures (a collection of genes, say, that characterize a specific cell type). In histology, it should enable researchers to relate tissue structure to the position of cells and molecules. Developmental biologists will be able to use it to track cell fate and lineage. Physiologists could characterize dynamic states, such as the cell cycle, and transient responses such as a T cell’s reaction to a pathogen.

The atlas could also facilitate research on the molecular mechanisms of communication within and between cells. And it should allow biologists to compare cell types across species to better understand human evolution, and

to determine to what extent animal model systems and organoids reflect human biology.

Crucially, the atlas should help researchers to compare healthy reference cells to diseased ones in the relevant tissues — and so facilitate the development of better drugs and more accurate predictions of unintended toxicity. The atlas could also aid regenerative medicine — the process of replacing, engineering or regenerating human cells, tissues or organs to establish normal function. Key diagnostic tests, such as the complete blood count — a routine blood screen that provides crude counts of white blood cells, red blood cells and so on — would become vastly more informative if cell types and states could be identified with much finer granularity. Such information could, for example, help to diagnose blood cancer, autoimmunity or infection before clinical symptoms appear.

Early studies are already showing tremendous potential in all these areas. New cell types have been found in the brain[3–7], gut[8], retina[9] and immune system[10], and these discoveries have yielded new insight — into how the immune system[11] functions, for example, and into the dynamics of tumour ecosystems[12]. Yet, to take the next step — to build a human cell atlas that is truly useful — requires taking the long view and addressing various systemic and organizational challenges, as well as technical and scientific ones.

The challenges

Agree on scope. In light of the enormous complexity of the human body, and the rapid evolution of technologies for probing cells and tissues, and for analysing the data, we plan to build this resource in phases and generate reference maps at increasing resolution as the project progresses.

The first draft of the atlas will profile cells' molecular and spatial characteristics, capturing only those cell types that occur above a pre-specified rarity — ones that make up more than 1% of a sample, say. These cells will be obtained from major tissues from healthy donors, taking into account the genetic diversity, geographical location and person's age. Although disease will not be a focus of the first draft of the atlas, we plan to

look at some disease samples to compare them with healthy cell types.

The first draft will focus on tissues, not whole organs. Extremely rare cells may be missed, and sample sizes may be too small to fully reveal the links between cellular characteristics and human diversity. In later phases, the atlas could take on entire organs, include small cohorts of people (say, 50–60) with diseases of interest, gather bigger sample sizes and provide greater power to associate molecular variation with the underlying genetic diversity. A similar step-wise strategy was deployed in the Human Genome Project; even a partially assembled genome proved immediately useful to researchers, and human genetic variation in health and disease was tackled over several years after the full genome was sequenced.

The atlas will provide an important starting point for functional studies — for instance, those aimed at establishing the mechanistic links between cell states and disease. But such studies are themselves beyond its scope. Again, this parallels what happened with the Human Genome Project: studies of functional elements in the genome, which are ongoing, have relied on the reference sequence obtained through the project.

The atlas will aim to provide a detailed representation of molecules, cells, tissues, organs and systems, allowing researchers to zoom in and out to identify patterns and interactions at various levels of resolution. To this end, those compiling the atlas must establish how many cells to sample, which types of molecular features to analyse, how to assign cells to different categories and how to subdivide those categories. At the spatial level, they must decide how to sample complex anatomies and histologies. Lastly, they need to establish ways of connecting the various layers of cellular and spatial information from different samples to a single anatomical reference by developing what is termed a common coordinate framework.

To ensure the best use of resources, those involved in the initiative must agree on the desired resolution for each phase of the atlas. Researchers could, of course, try to pursue ever-rarer cell types, but potentially at ever-greater expense. In this respect, the Human Cell Atlas will pursue similar approaches to those used in human genetic studies that focus on variants present at a certain frequency. Here, geneticists have begun to tackle increasingly rare variants as technologies have advanced.

Be open and fair. To have maximum impact, the Human Cell Atlas must be an open resource, on many levels.

The project is already open to all interested participants who are committed to its values. Discussions about particular organs, tissues, technologies or computational approaches are running on more than a dozen Slack channels that anyone can join.

Wherever consent agreements allow, atlas data will be made publicly available in an open-source data-coordination platform as soon as possible, after they have been collected and have passed quality-control checks. All standards established to ensure the production of high-quality data, and any updates to those standards, will also be shared. The same goes for new technologies and computational methods resulting from the project.

Atlas data and analysis products will exist in multiple public clouds (currently, those hosted by Google, Amazon and Microsoft) to ensure that people with different preferred cloud environments can access them. Because computation will happen in the cloud, individual researchers will not need to download and store all the data or have access to their own high-performance computing power. Finally, in addition to the continual release of data and periodic formal data releases, publications interpreting the data will help to establish standardized approaches and disseminate the insights and value that can be gained from them.

As much as possible, the atlas must reflect the diversity of humans and human experience. The broad distribution of participating researchers, institutions and countries involved in the initiative will, in itself, help to ensure tissue diversity. The initiative currently includes members from 5 continents and more than 18 countries, including Japan, Israel, South Africa, China, India, Singapore, Canada and Australia.

Getting appropriate consent agreements and fostering public trust from the outset will also help efforts to obtain sufficient geographical, gender, age and genetic diversity in sampling. As part of the global initiative, an ethics working group will establish how best to obtain informed consent from sample donors, how the terms of that consent can be adhered to and how to protect the privacy of participants and donors appropriately. Various existing

projects involving human samples, such as the public-research project ENCODE (the Encyclopedia of DNA Elements), which aims to identify all the functional elements of the human genome, can provide guidance on this.

Procure samples appropriately. Obtaining tissue samples using standardized procedures, with appropriate consent and in a way that enables other researchers to know exactly where the sample came from is a complex endeavour. To access the diversity of human tissues needed, researchers will work with both fresh tissue from live donors and specimens obtained postmortem or from transplant organ donors.

We plan to learn from, and build on, pre-existing reliable procurement processes. Examples include those used in the Genotype-Tissue Expression Project (GTEx, a database and tissue bank designed to help researchers to gain insight into the mechanisms of gene regulation in humans) and the Cambridge Biorepository for Translational Medicine, a resource for multidisciplinary research projects for which fresh tissue is required.

Organize effectively. The Human Cell Atlas consortium is built on four distinct and interconnected pillars. Collaborative biological networks involve experts in biological systems or organs as well as in genomics, computation and engineering, working together to build maps of each tissue, system or organ. Several biological-network pilot projects have been formulated through grass-roots efforts in the Human Cell Atlas community. As well as revealing new biology and helping to build a collaborative international network, these activities are informing the community about how to structure sampling and conduct analyses for a full-scale cell atlas.

A technical forum involving genomics experts, imaging specialists and biotechnologists, is developing new technologies, and testing, comparing and disseminating existing ones. A data-coordination platform is being designed to bring researchers to the data by developing the software to upload, store, process and serve data. The platform also provides an open environment in which computational methods and algorithms developed by any interested group can be shared. Finally, an analysis garden involves computational biologists working together to develop sophisticated techniques for data mining and interpretation.

Activities across all areas are currently governed by a scientific steering group, the Human Cell Atlas organizing committee. Co-chaired by two of us (A. R. and S. A. T.), this includes 27 scientists from 10 countries and diverse areas of expertise. The committee establishes working groups (about 5 so far, consisting of about 5 to 15 members each) that tackle specific key areas. For instance, an analysis working group is crafting best practices for computational analysis through a community-wide process, including workshops and jamborees. The committee governs the data-coordination platform, including making all policy decisions and approving its overall plan.

Join the effort

Having a catalogue of genes at our fingertips has transformed research in human biology and disease. Similarly, we believe that the Human Cell Atlas will catalyse progress in biology and medicine. Descriptors such as 'cell type' and 'cell state' can be difficult to define at the moment. An integrative, systematic effort by many teams of scientists working together and bringing different expertise to the problem could dramatically sharpen our terminology, and revolutionize the way we see our cells, tissues and organs. We invite you to join the effort.

Journal name:
Nature
DOI:
doi:10.1038/550451a

Supplementary information

PDF files

1. HCA organizing committee (61K)

Comments

Comments

There are currently no comments.

Top Chinese university to consider social-media posts in researcher evaluations

Controversial policy means mainstream media are starting to rival rigorous academic publications in some universities in China.

18 October 2017

Wang Zhao/AFP/Getty

News articles written by researchers at some Chinese universities will now be considered in evaluations.

One of China’s most prestigious universities plans to give some articles in

newspapers and posts on major social-media outlets the same weight as peer-reviewed publications when it evaluates researchers.

The policy has sparked a vigorous debate among Chinese academics. Proponents say it will encourage researchers to engage with the public, but many are concerned that it will promote those who toe the party line established by China’s strictly censored media and social media, at the expense of more highly qualified researchers. Critics also say the system could be manipulated to inflate a researcher’s impact, for example by artificially boosting page views.

Zhejiang University in Hangzhou announced the policy on its WeChat page on 15 September, saying that it would mainly apply to the humanities and social sciences. But Chinese researchers say the move could influence science as well, by giving a hiring and promotion advantage to politically minded scientists.

“You do not need to be good scientist, you do not need to publish good science papers,” says one biologist at a prominent Beijing-based university who requested anonymity. He is concerned that the policy could alter evaluations at China’s main grant agency, the National Natural Science Foundation of China (NSFC). “If they open the Pandora’s box, the NSFC might change its policy as well,” he says. The agency's head, Yang Wei, says it will do no such thing. NSFC grants are given solely “according to the judgement of peer reviewers”, he says.

Viewing figures

The Zhejiang policy sets specific criteria: articles have to be original, written by the researcher and at least 1,000 words long; they need to be picked up by major news outlets and widely disseminated through social media; and they need to have been seen by a large number of people. The policy requires an article to be viewed more than 100,000 times on WeChat, China’s most popular instant-messaging service, or 400,000 times on news aggregators such as Toutiao. Articles that meet the criteria will be considered publications, alongside papers in peer-reviewed journals.

The university has also established a publication hierarchy, with official media outlets such as the *People's Daily* considered most important, regional newspapers and magazines occupying a second tier, and online news sites such as Sina, NetEase or Sohu ranking third.

Ping Fu, who researches library science at Central Washington University in Ellensburg, is concerned that the policy will blur the distinction between peer-reviewed academic publications and popular writing. This could affect the top levels of scholarship in China, he says. Liu Jin-ping, a biologist at Hainan University in Haikou, also worries that the policy will give prominence to stories that "flatter the government". Some academics will aim to "become Internet stars" so they can be promoted, he wrote on his blog.

Full credit

Lin Boqiang, an energy-policy and climate-change researcher at Xiamen University who has published some 800 media commentaries, thinks researchers should get credit for this work. He "criticizes government policy all the time" and would never write something incorrect to please political powers, he says: "Our reputation is on the line."

But both Liu and Lin are concerned the system could be gamed, either for self-interest or with political motivation. Lin says these articles should not be considered equal to academic publications. "Other universities will do this," he says. "I hope they do it in a more sophisticated way."

Zhejiang University refused to answer *Nature*'s questions about the policy, but it posted a statement on its homepage in response to the controversy, saying that the commentaries in the mainstream media will supplement and not replace peer-reviewed journals: "This policy is to explore more forms of exposure of research, especially for humanities and social sciences, and the assessment will be made by a strict panel review, which will not lower the academic standard."

Grant committees in other countries encourage researchers to do public outreach, but the Zhejiang policy is rare in how it ranks such efforts for

researcher evaluation. Jilin University in Changchun announced a similar policy in August.

Balancing act

Glen Peters, a climate-policy researcher at the Center for International Climate Research in Oslo, agrees that researchers should be acknowledged for important contributions to public understanding, but he says the challenge in giving scientists credit for public outreach is how to measure its quality and impact against those of conventional journal publications. “If you don’t get the weighting right, then incentives could be perverted and lead to bad outcomes, such as poor quality and political bias,” he says. “The potential is high, but so are the risks.”

One journalist at China’s *Legal Daily* has questioned whether such a policy is legal. It was drafted by the university’s propaganda department, part of the Communist Party of China. According to the laws that govern universities, evaluation decisions are supposed to be made by university administrative departments or faculty committees, writes the journalist.

Some scientists contacted by *Nature* are confident that this initiative will not affect science. But others see it as part of the government’s attempts to control information. There is already concern about Chinese President Xi Jinping’s efforts to align education with communist values and to control what is written by journalists or on social media. Scientists say that bans on Google, Google Scholar and other Internet-based technologies hamper their ability to stay in touch with international peers. “There are certainly many layers of concern,” says one environmental scientist who did not want to be named for fear of damaging relationships with Chinese colleagues.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22822

Comments

Commenting is currently unavailable.

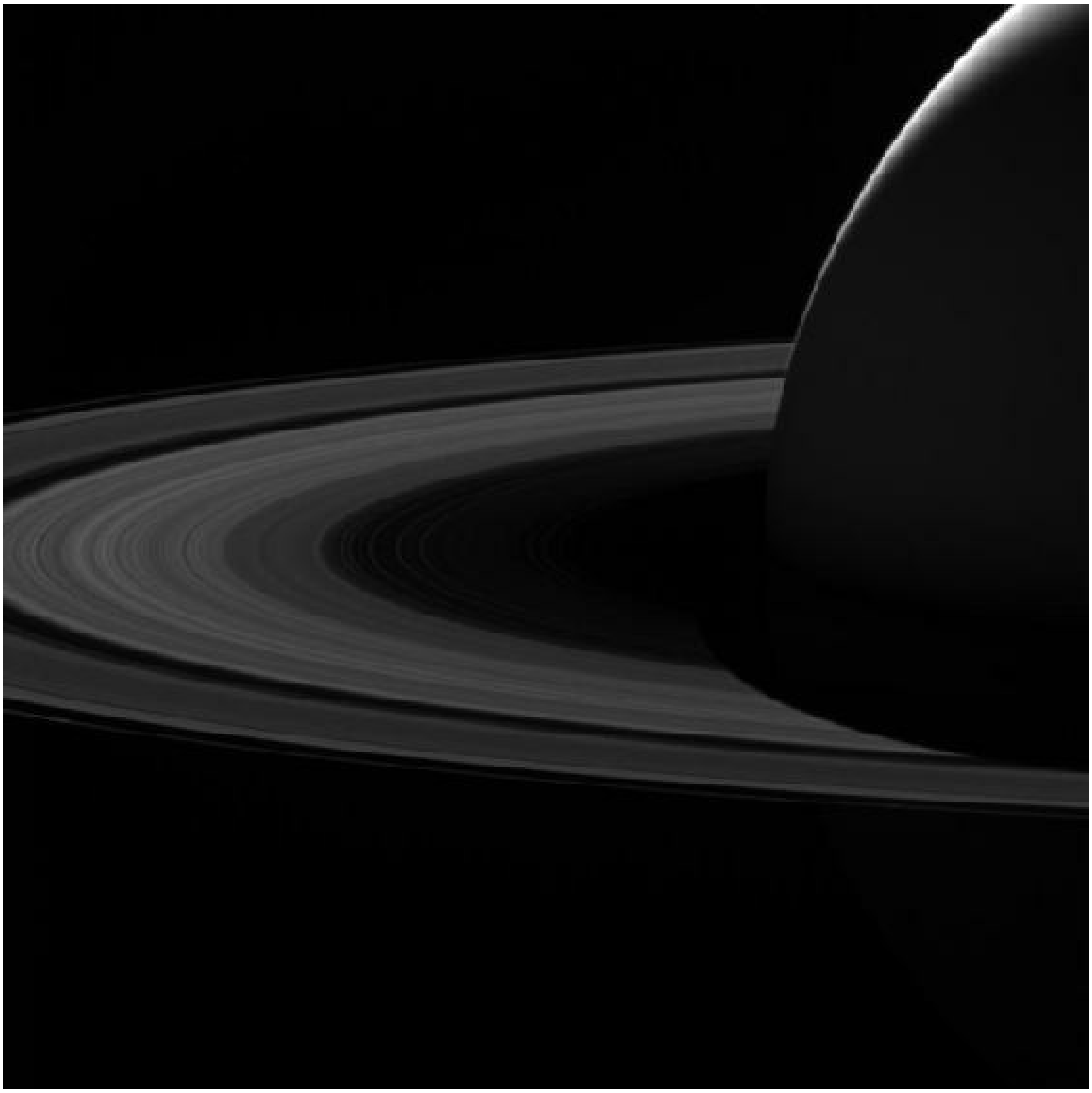
| 章节菜单 | 主菜单 |

Mysterious particles spotted in Saturn’s atmosphere

Source may be dust shed by planet’s iconic rings, according to data from NASA's doomed Cassini probe.

18 October 2017

Provo, Utah



NASA/JPL-Caltech/SSI

Saturn's rings are made of whirling bands of ice and dust.

NASA's Cassini spacecraft continues to yield surprising discoveries, more than a month after it burned up on its mission-ending dive into Saturn. New data from the probe suggest that Saturn's majestic rings are showering tiny dust particles into the planet's upper atmosphere, where they form a complicated and unexpected chemical mix.

A mass spectrometer aboard Cassini detected the strange chemistry as the

probe spent its final five months looping between Saturn and its rings.

“We really hit the jackpot,” said Mark Perry, a planetary scientist at the Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland. He reported the findings on 17 October at a meeting of the American Astronomical Society’s Division for Planetary Sciences in Provo, Utah.

Mission scientists had expected Cassini's mass spectrometer to spot the signature of water molecules as the spacecraft slipped between the planet and its rings. In the 1970s and 1980s, NASA's Pioneer and Voyager missions found fewer charged particles than expected in Saturn’s uppermost atmosphere. On the basis of those data, researchers proposed in 1984 that water molecules coming off the rings — mostly in the form of ice — act as catalysts to strip charged particles from the atmosphere[1]. Cassini's final months gave scientists their first opportunity to test this idea directly.

Chemical surprise

But it wasn't evidence of water that jumped out at Cassini's science team. Data from the mass spectrometer revealed a witch’s brew of chemicals, including methane, a molecule that could be carbon monoxide and more-complex molecules. The concentrations of these chemicals are greatest around Saturn’s equator and at high altitudes, which suggests that the material is shedding off the planet’s rings.

The deeper the probe went into the atmosphere, the stranger the measurements became. Cassini’s closest swings past Saturn's surface revealed a panopoly of heavy molecules, Perry told conference attendees. The scientists have not yet pinpointed each type of molecule, but clearly, there is much more than just water around.

By analysing the types of material that could be coming off the rings, Perry’s team concluded that the debris must be fragments of tiny dust particles, which measure just 1 to 10 nanometres across but are relatively heavy. When these particles spiralled off the rings and slammed into Cassini’s mass spectrometer, they shattered into smaller pieces.

Exactly how those particles make the journey from the rings to the atmosphere remains to be seen. “We have a lot of work to do to understand how they are getting in there,” Perry said. “None of the models predict this.”

On these final plunges, pulled along by Saturn’s gravity, Cassini was zooming along at more than 30 kilometres per second — a speed more than four times greater than the mass spectrometer was designed to withstand. “These are higher speeds than anything it has ever seen,” noted Linda Spilker, a planetary scientist at the Jet Propulsion Laboratory in Pasadena, California, and Cassini’s project scientist.

At such enormous speeds, anything that Cassini rammed into would have splintered into bits.

Journal name:
: Nature

DOI:
: doi:10.1038/nature.2017.22838

Comments

Comments

There are currently no comments.

Efforts to save leading Hungarian university hit hurdle

US-registered Central European University faces another year of uncertainty over whether it can continue to operate in Hungary.

18 October 2017

Ferenc Isza/AFP/Getty Images

A sudden change to Hungarian higher-education law in April led to widespread protests.

The threatened Central European University (CEU) in Budapest has been dealt a blow in its efforts to avert possible closure in Hungary.

The country’s parliament voted on 17 October to postpone for a year a

decision that would allow the university to keep operating there. At a press conference held by the university shortly after the vote, CEU rector Michael Ignatieff called the delay “unacceptable” and “unnecessary”.

In April, the Hungarian government unexpectedly amended its higher-education law to require that all foreign-accredited universities there had to operate as higher-education institutes in their countries of origin by 1 January 2018.

The change drew protests and was widely believed to be politically motivated. Critics saw it as an attack on billionaire philanthropist George Soros, who founded the university in 1991 and has openly criticized Hungary’s strict refugee policies.

The CEU took steps to comply with the new requirements and on 3 October sealed an agreement with Bard College in Annandale-on-Hudson, New York, to provide educational activities there. Accredited courses run jointly by the universities would be launched next year, the CEU said. The agreement still needs to be signed by the Hungarian government and ratified by the country’s parliament.

But on 16 October the government proposed delaying the implementation of the amendment until 1 January 2019, and the parliament approved the delay the next day.

A government spokesperson told *Nature* that the purpose of the delay was to give other foreign higher-education institutions time to comply with the new requirements, adding that three institutions, including the CEU, are still in negotiation.

Zoltan Balogh, Hungary’s minister for human capacity, suggested on 16 October that government sign-off of the CEU’s agreement might have to wait for the new deadline.

“We are being deliberately kept in legal limbo,” said Ignatieff, who fears the uncertainty will make it hard to retain faculty and recruit students. “We are being slowly strangled in this battle for academic freedom.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22855

Comments

Comments

There are currently no comments.

Sleeping sickness can now be cured with pills

Researchers seek approval from regulators for this quicker, easier treatment.

18 October 2017

Neil Brandvold

Health workers screen people in a remote village in the Democratic Repulic o the Congo for sleeping sickness.

For the first time, researchers have cured the deadly neurological disease sleeping sickness using pills instead of a combination of intravenous infusions and pills. The investigators presented the results from final clinical trials on 17 October at the European Congress on Tropical Medicine and

International Health in Antwerp, Belgium, providing hope that the treatment will help to eliminate the malady within a decade.

The oral therapy — called fexinidazole — cured 91% of people with severe sleeping sickness, compared with 98% who were treated with the combination therapy. It also cured 99% of people in an early stage of the disease who would typically undergo a spinal tap to determine whether they needed infusions. The relative ease of the treatment with fexinidazole means that if approved, it might save more lives than the current option, say the investigators leading the phase 3 trial, the final phase of testing before the drug goes to regulators for approval.

Sleeping sickness is endemic to Africa and generally infects extremely poor people who live in remote regions. The sick often suffer from the disease for years before seeking treatment, causing them and those caring for them to miss work and spend their savings on traditional medicines. Trekking to a hospital and remaining there for intravenous infusions is costly as well.

“It’s not just the person with sleeping sickness, it’s the family that takes care of them during years of this neurological, very serious disease,” says Philippe Büscher, a sleeping-sickness specialist at the Institute of Tropical Medicine in Antwerp, Belgium, who was not involved in the study. “Whatever money they have, they’ll spend on this instead of anything else.”

Büscher commends the team for conducting a quality clinical trial under extraordinary circumstances in countries hit hardest by the disease, the Democratic Republic of the Congo and the Central African Republic. Investigators had to carry equipment to remote clinics over rugged terrain; one study site was repeatedly robbed; and early on in the trial, some participants fled armed conflict. “I need to congratulate them for beautiful work,” Büscher says.

Neil Brandvold

The hospital where Pablo Loela was being treated for sleeping sickness canno afford to provide food for their patients: families must provide meals for their loved ones.

A better way

Sleeping sickness — also known as human African trypanosomiasis — is spread through the bite of tsetse flies carrying parasites, most commonly *Trypanosoma brucei gambiense*. The organism infects the central nervous system, and patients can experience confusion, daytime sleepiness, night-time insomnia and various psychiatric symptoms, including manic episodes and aggression. If left untreated, they enter a coma and die. For decades, the only treatment was a toxic arsenic-based drug that killed one in 20 patients.

In 2009, researchers introduced a safer option: nifurtimox–eflornithine combination therapy, or NECT, which consists of pills and 14 intravenous

infusions. For the first time in 50 years, the incidence of sleeping sickness slipped below 10,000 new cases per year; it’s currently around 2,200, according to the World Health Organization. But the need for infusions, along with the spinal tap required to qualify a patient for the treatment, still present obstacles in regions where sterile equipment, electricity and doctors are in short supply.

The group that developed NECT — a non-profit research organization based in Geneva, Switzerland, called the Drugs for Neglected Diseases initiative (DNDi) — continued searching for a better therapy. In 2007, it discovered fexinidazole, a compound that had been shelved by Paris-based pharmaceutical company Sanofi. With the firm's agreement, the DNDi took the drug through clinical trials. It estimates that developing the therapy through to approval will cost a total of around US$50 million — a fraction of what pharmaceutical companies often spend on new drugs.

Just the beginning

Sanofi will soon submit an application for drug approval through the European Medicines Agency, whose sign-off could pave the way for regulators in the Democratic Republic of the Congo. The drug might get a green light by the end of next year, says Nathalie Strub Wourgraft, the DNDi’s medical director. Because it is a simple oral treatment, she suggests that patients might even be treated at home, which would save them and their families the expense of hospital stays.

However, Büscher argues that home treatments could be dangerous because people who don’t respond to fexinidazole could die of the disease if not seen immediately by medical staff. It’s imperative that patients follow up with health workers, he says, and he suggests offering people incentives to return to the clinic, such as money or staples including salt or sorghum. “This is a success,” he says, “but it is not the end.”

DNDi researchers and their colleagues are currently working on what they hope will be an even better oral treatment to cure the disease in a single dose, and more reliably than fexinidazole.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22856

Comments

Commenting is currently unavailable.

Self-taught AI is best yet at strategy game Go

Artificial-intelligence program AlphaGo Zero trained in just days, without any human input.

18 October 2017

Xavierarnau/Getty

AlphaGo Zero came up with Go strategies that human players haven't invented in thousands of years.

An artificial intelligence (AI) program from Google-owned company DeepMind has reached superhuman level at the strategy game Go — without learning from any human moves.

This ability to self-train without human input is a crucial step towards the dream of creating a general AI that can tackle any task. In the nearer-term, though, it could enable programs to take on scientific challenges such as protein folding or materials research, said DeepMind chief executive Demis Hassabis at a press briefing. “We’re quite excited because we think this is now good enough to make some real progress on some real problems.”

Previous Go-playing computers developed by DeepMind, which is based in London, began by training on more than 100,000 human games played by experts. The latest program, known as AlphaGo Zero, instead starts from scratch using random moves, and learns by playing against itself. After 40 days of training and 30 million games, the AI was able to beat the world's previous best 'player' — another DeepMind AI known as AlphaGo Master. The results are published today in *Nature*[1], with an accompanying commentary[2].

Getting this technique, known as reinforcement learning, to work well is difficult and resource-intensive, says Oren Etzioni, chief executive of the Allen Institute for Artificial Intelligence in Seattle, Washington. That the team could build such an algorithm that surpassed previous versions using less training time and computer power “is nothing short of amazing”, he adds.

Strategy supremo

The ancient Chinese game of Go involves placing black and white stones on a board to control territory. Like its predecessors, AlphaGo Zero uses a deep neural network — a type of AI inspired by the structure of the brain — to learn abstract concepts from the boards. Told only the rules of the game, it learns by trial and error, feeding back information on what worked to improve itself after each game.

At first, AlphaGo Zero’s learning mirrored that of human players. It started off trying greedily to capture stones, as beginners often do, but after three days it had mastered complex tactics used by human experts. “You see it rediscovering the thousands of years of human knowledge,” said Hassabis.

After 40 days, the program had found plays unknown to humans (see 'Discovering new knowledge').

Discovering New Knowledge

Deepmind

Approaches using purely reinforcement learning have struggled in AI because ability does not always progress consistently, said David Silver, a scientist at DeepMind who has been leading the development of AlphaGo, at the briefing. Bots often beat their predecessor, but forget how to beat earlier versions of themselves. This is the project's first "really stable, solid version of reinforcement learning, that's able to learn completely from scratch," he said.

AlphaGo Zero's predecessors used two separate neural networks: one to predict the probable best moves, and one to evaluate, out of those moves, which was most likely to win. To do the latter, they used 'roll outs' — playing multiple fast and randomized games to test possible outcomes. AlphaGo Zero, however, uses a single neural network. Instead of exploring possible outcomes from each position, it simply asks the network to predict a winner. This is like asking an expert to make a prediction, rather than relying on the games of 100 weak players, said Silver. "We'd much rather trust the predictions of that one strong expert."

Merging these functions into a single neural network made the algorithm both stronger and much more efficient, said Silver. It still required a huge amount of computing power — four of the specialized chips called tensor processing units, which Hassabis estimated to be US$25 million of hardware. But its predecessors used ten times that number. It also trained itself in days, rather than months. The implication is that "algorithms matter much more than either computing or data available", said Silver.

Think outside the board

Several DeepMind researchers have already moved from working on AlphaGo to applying similar techniques to practical applications, said Hassabis. One promising area, he suggested, is understanding how proteins fold, an essential tool for drug discovery.

Generating examples of protein folding can involve years of painstaking crystallography, so there are few data to learn from, and there are too many possible solutions to predict structures from amino-acid sequences using a brute-force search. The puzzle shares some key features with Go, however. Both involve well-known rules and have a well-described goal. In the longer term, such algorithms might be applied to similar tasks in quantum chemistry, materials design and robotics.

Silver acknowledged that to apply its approach to real-world tasks more generally, the AI will need the ability to learn from smaller amounts of data and experience. Another essential step will be learning the rules of a game for itself, as another DeepMind bot did in 2015 for arcade games. Hassabis reckons this is something AlphaGo Zero could eventually do: “We’re pretty sure it would work, it would just extend the learning time a lot,” he said.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22858

Comments

Comments

There are currently no comments.

Science must examine the future of work

As automation changes employment, researchers should gather the evidence to help map the implications.

18 October 2017

VCG/Getty

Automation will take away jobs, but a bigger question is how many it will generate.

In 2014, the *Los Angeles Times* began beating its rivals to report earthquakes, using an algorithm to convert announcements from the US Geological Survey

(USGS) to breaking news within a few minutes. This June, it announced that a magnitude-6.8 quake had shaken Santa Barbara, California. That was certainly news to the distinctly unshaken residents of Santa Barbara; the earthquake the newspaper was reporting on had actually happened in 1925. The paper's Quakebot had misinterpreted an update to the USGS seismic database and published its story online without anyone checking. The story was deleted and Santa Barbarans (and human journalists everywhere) could breathe a sigh of relief.

The tale encapsulates many of the issues that surround the intensifying debate about the roles of computers and humans in the workplace of the future — both the very near and the very far. Much of that debate places people and algorithms in direct competition. From lorry drivers threatened by self-driving vehicles to doctors who could be replaced by know-it-all diagnostic devices, many jobs as we know them could be done by artificial intelligence (AI) systems.

In an Editorial last year on the likely role and risks of AI in future society, *Nature* noted that even academic debate on the topic is polarized between sceptics and fanciful futurists (see *Nature* **532,** 413; 2016). In a special issue this week, we try to find and explore some middle ground, by bringing together and assessing the evidence on how automation will affect the future of work.

In a sense, this debate is nothing new. Technology and automation have been putting people out of jobs for hundreds of years, as historian Robert Allen discusses in a Comment. So have other factors — chiefly economic trends and globalization. But the spread of technology has also created new roles. In broad terms, as manufacturing jobs in the West have been transferred to low-wage economies elsewhere, politicians and economists have looked to tech to help fill the gap. These new industries, they argue, both need direct labour to develop them and create employment indirectly through the need for service and support. But will this trend continue? The true debate over the future of work is not whether computers will replace people in many jobs — they surely will — but whether they are team players. For how long will Quakebot and its descendants need a human supervisor?

Both sceptics and fanciful futurists will find something to agree and disagree

with in the articles that follow. In a Comment, Yuval Noah Harari, historian and best-selling author of *Sapiens* (Harper, 2014) and *Homo Deus* (Harvill Secker, 2015), argues: “The challenges posed in the twenty-first century by the merger of infotech and biotech are arguably bigger than those thrown up by steam engines, railways, electricity and fossil fuels.” He also offers reassurance about job prospects for some people, from a perhaps unlikely source. Each US military drone flying over Syria keeps 110 people in a job, he writes — 30 operators and 80 analysts to process the information it sends back. This is not an argument for more drones, the use of which is controversial. But, as Harari writes: “A careful study of the military job market might tell us a lot about potential future developments in the civilian economy.”

Careful study, *Nature* naturally argues, is something that (human) scientists and other academics excel at. As the 2016 editorial put it, “it is crucial that progress in technology is matched by solid, well-funded research to anticipate the scenarios it could bring about”, such as impacts on mental health and management, and how humans interact with robots. It’s important, too, to study possible political and economic reforms that will allow those usurped by machinery to contribute to society.

The Oxford Martin Programme on Technology and Employment at the University of Oxford, UK, is doing just this (see go.nature.com/2xxauvm). Oxford economist Ian Goldin offers his own thoughts.

Among the topics worthy of examination is the future fate of science and scientists. So far, the application of technology and automation to research has fuelled, and not felled, the need for human support. Indeed, fields such as bioinformatics exist only because of the work that computers generate for scientists. But as explored in a Careers Feature, science is not immune from the gig economy — short-term employment on specialist tasks such as writing a literature review or managing a database. The trend towards parcelling off and even publishing science as a series of steps rather than full papers could see demand for freelance services rise. (The breakdown of complex tasks into a series of simpler steps is, of course, also a proven path to automation.)

Still, browse ‘help needed’ adverts for scientific gigs and the future looks less

rosy. As little as US$80 to perform a detailed meta-analysis of published studies? It’s hardly worth even plugging in for that.

Journal name:
Nature
Volume:
550,
Pages:
301–302
Date published:
(19 October 2017)
DOI:
doi:10.1038/550301b

Comments

Comments

There are currently no comments.

Blue is in the eye of the bee-holder

Flowers have evolved an ingenious way to attract pollinators.

18 October 2017

Ron Reznick/VW Pics/UIG via Getty Images

Nanostructures on flowers generate a blue halo that attracts bees.

The car maker Lexus announced a new paint job for its LC coupé this month, which it says will appeal to drivers who value the interaction of science and craftsmanship. The car is blue and the science it leans on is the optics of iridescence. Lexus says that it uses several layers of pigment to increase the amount of incoming light that reflects as blue. The finish, it claims, is “more blue” than anything seen before — and more time-consuming to apply. People who buy the model are unlikely to suffer that common psychological

bias experienced by owners of a new car who suddenly notice other vehicles everywhere the same colour as theirs: at present, the company can make just two a day.

Lexus says that its new blue is based on the famous wings of the morpho butterfly. These contain no pigment, but look blue because of how the wing structure physically separates the various components of white light and reflects only certain wavelengths. The company could also have borrowed the idea from the (less PR friendly) tarantula spider, many species of which use the hairs on their legs and body to show off the same blue effect. In fact, such iridescence is fairly common in plants and animals — sometimes deliberate (the shimmer of the peacock tail) and sometimes less so (the same effect from a fresh cut of meat). It's why a blue-cooked steak really does look blue. blue pigments are rare), and this week a paper online in *Nature* explores its role in flowering plants (E. Moyroud *et al. Nature* http://dx.doi.org/10.1038/nature24285; 2017).

Fewer than 10% of the 280,000 species of flowering plant naturally produce blue petals. This presents a problem, because the bees on which many flowers rely for pollination struggle to see any colour other than blue. So how do these flowers attract the insects they need?

The new study shows that they use structural-colour techniques to generate an iridescent blue halo. From the tulip to the golden perennial sweet pea, a dozen different flowering plants of varying colours were found to have surface nanostructures that produced the optical effect. It's visible to the human eye, too, and best seen against dark-coloured petals.

In a series of tests with bumblebees (*Bombus terrestris*), the researchers demonstrate that the insects avoid artificial flowers made to have smooth surfaces that don't produce the blue ring. And they show how the insects see the halo more easily than we do, because bee vision can better distinguish the ultraviolet frequencies into which the structural-colour effect spreads. The findings are discussed in an accompanying News & Views article (D. D. Deheyn *Nature* http://dx.doi.org/10.1038/nature24155; 2017).

Lexus boasts that it took more than a decade to develop its new blue paint. It took the flowers a lot longer: their ability to generate the halo effect has

evolved over millions of years, and perhaps emerged in each species independently. In both cases, the colour is best appreciated at first hand. Photographs do not do it justice. Take a stroll in the garden. And keep one eye on the road.

Journal name:
Nature
Volume:
550,
Pages:
302
Date published:
(19 October 2017)
DOI:
doi:10.1038/550302a

Comments

Comments

There are currently no comments.

Epic star collision, asteroid fly-by and journal resignations

The week in science: 13–19 October 2017.

18 October 2017

Events | People | Research | Facilities | Policy | Awards | Funding | Trend watch

EVENTS

Flames devastate northern California Wildfires have scorched about 890 square kilometres in Northern California, leaving at least 41 people dead as of 17 October, making them the deadliest fires in the state's history. Nearly 100,000 residents of Napa and Sonoma Counties had been evacuated from their homes, although this week officials have started to let people return. At least 88 of the many hundreds of people who were reported missing are still unaccounted for. The exact cause of the flames is unknown, but the area was primed for a conflagration. Vegetation flourished in the region after record rainfall last winter, and heatwaves this summer dried everything out, turning it into kindling. Winds gusting at more than 100 kilometres per hour hindered the efforts of firefighters to bring the blazes under control.

Justin Sullivan/Getty

Journal editors quit Five German scientists said on 12 October that they have resigned their editorial positions at journals published by Elsevier, after negotiations over a national licensing agreement for German institutes ground to a halt. For more than a year, a consortium of German science organizations called Projekt DEAL has been pushing for a new type of nationwide licence with Elsevier that would include open-access options and replace the need for individual institutional subscriptions. About 200 German universities and research institutes have cancelled their individual contracts with the Dutch publisher.

Asteroid buzz A house-sized asteroid whizzed by Earth on 12 October, passing within 44,000 kilometres of the planet — just above the orbits of geostationary satellites — and providing a test of international planetary defences. Telescopes around the globe swivelled to track the body, which is estimated to be 15–30 metres wide and is known as 2012 TC4. NASA, the European Space Agency and other asteroid-hunting groups gathered data to fine-tune orbital calculations and establish its future path. The asteroid's next

close pass will be in 2050, when it will safely fly by Earth. Future Earth impacts after that date have not been ruled out.

PEOPLE

Trump nominations Barry Myers, the chief executive of weather-forecasting firm AccuWeather, is US President Donald Trump's pick to lead the National Oceanic and Atmospheric Administration (NOAA), the White House said on 11 October. Myers, an attorney by training, has led AccuWeather — based in State College, Pennsylvania — since 2007. Some scientists worry that his ties to the company could lead to conflicts of interest, and note that he has no direct experience with NOAA's broader research portfolio, which includes the climate, oceans and fisheries. Two days later, the White House announced that Trump had nominated Kathleen Hartnett White, a former Texas environmental regulator and prominent climate sceptic, for its top environmental post. If confirmed as chair of the Council on Environmental Quality, White would advise the president and coordinate federal policies on energy and the environment. White is a fellow at the Texas Public Policy Foundation, a conservative think tank based in Austin. She has called efforts to shift away from fossil fuels "environmental lunacy".

New Pasteur chief Stewart Cole was appointed on 13 October as the next president of the Pasteur Institute in Paris, replacing Christian Bréchot, who had reached the institute's mandated retirement age. Many of the Pasteur's researchers had wanted Bréchot to stay on, but a campaign to change the age-limit rule was unsuccessful. Cole, a microbial-pathogenesis specialist, has held several posts at the biomedical research institute and will begin his four-year term in January. Last month, Bréchot was appointed president of the Global Virus Network, an international coalition of virologists based in Baltimore, Maryland.

RESEARCH

Epic stellar clash Researchers announced on 16 October that they had for the first time witnessed the collision of two neutron stars — and perhaps the

subsequent formation of a black hole. The event was first spotted on 17 August by gravitational-wave detectors in the United States and Italy and by a NASA γ-ray probe. More than 70 observatories rushed to observe the collision’s aftermath; their discoveries are detailed in dozens of papers and solve several cosmic mysteries.

FACILITIES

FAST’s first pulsars The world’s largest single-dish telescope has observed its first two pulsars. The Five-hundred-meter Aperture Spherical Telescope (FAST) in southern China’s Guizhou province detected the neutron stars in August. Researchers at the National Astronomical Observatories of China reported the results on 10 October after they were confirmed by an Australian telescope. The observations suggest FAST is working well, despite its radical design: the dish consists of thousands of panels that move to track radio signals, requiring elaborate coordination. Signals from the two pulsars were captured a year into an estimated three-year debugging phase. FAST, which is expected to find hundreds, possibly thousands, of pulsars, is looking for clues to how the Universe formed, as well as for signs of extraterrestrial life.

China Daily/Reuters

POLICY

Climate-rule repeal On 10 October, the US Environmental Protection Agency moved to repeal former president Barack Obama's landmark regulations to reduce greenhouse-gas emissions from power plants. Agency administrator Scott Pruitt signed a measure to begin the process of rescinding the Obama policy, a move that is expected to spark lawsuits by environmental groups and some states. The power-plant rule would reduce greenhouse-gas emissions to 32% below 2005 levels by 2030. In 2016, the Supreme Court blocked the policy from taking effect; legal challenges from 27 state governments are still pending, although a federal appeals court has put the case on hold while the administration of President Donald Trump reviews the rule.

Measuring impact UK science minister Jo Johnson has announced plans to

assess universities on their economic impact and engagement with wider society. Higher-education bodies will consult on creating a Knowledge Exchange Framework, an evaluation system designed to incentivize activities such as transferring technology into industry, spinning off companies and conducting contract research, training and consultancy, Johnson said on 12 October. If implemented, the framework would become a third strand of UK university assessment, alongside the Teaching Excellence Framework and Research Excellence Framework.

AWARDS

MacArthur grants The philanthropic MacArthur Foundation in Chicago, Illinois, announced its 2017 award recipients on 11 October. Six of the 24 winners — often referred to as MacArthur geniuses — are scientists. They include anthropologist Jason De León of the University of Michigan in Ann Arbor, who uses methods including archaeology and forensic science to study undocumented migrants on the US–Mexican border; computational linguist Regina Barzilay of the Massachusetts Institute of Technology in Cambridge, who deciphers ancient languages using machine learning; and immunologist Gabriel Victora of the Rockefeller University in New York City, who observes how antibodies evolve in the immune system in real time. Each winner gets US$625,000 over 5 years, with no restrictions on how they can spend the money.

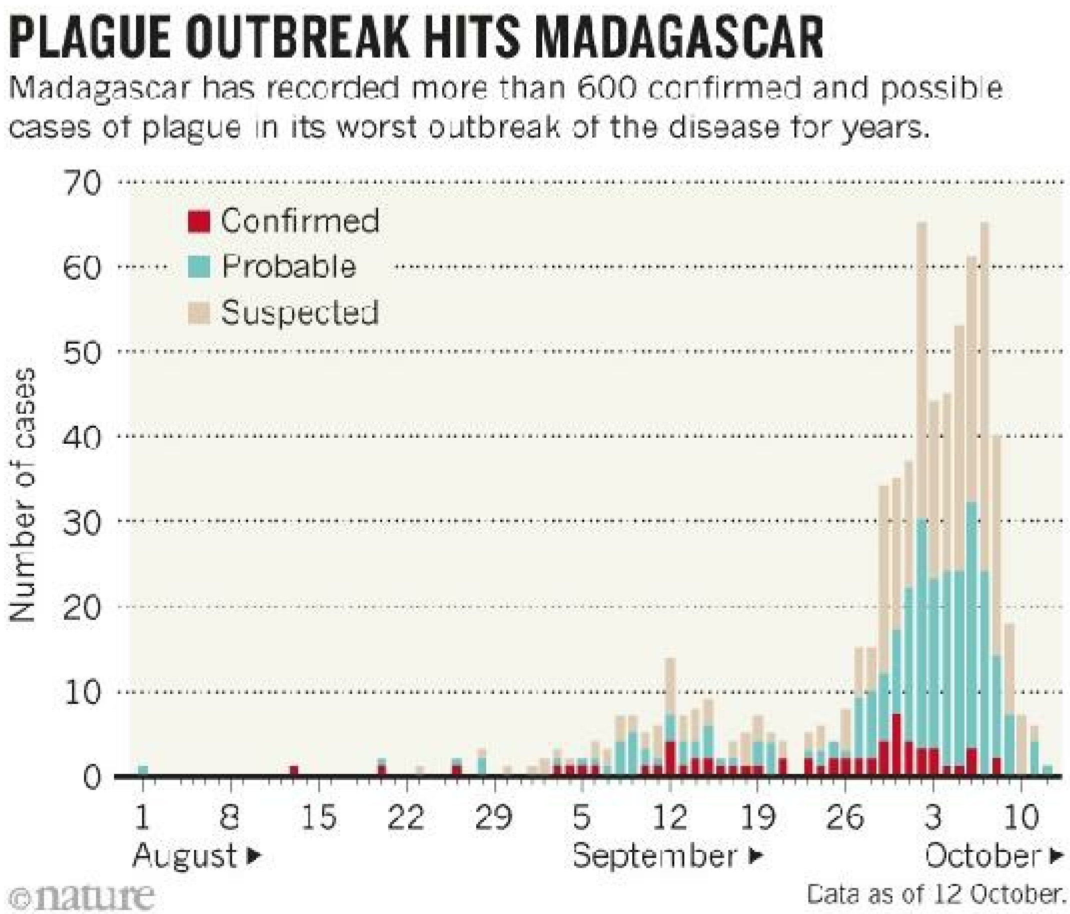
FUNDING

Research boost Online shopping giant Alibaba will set up seven international research laboratories as part of its plan to spend US$15 billion on research and development over the next three years. The company, based in Hangzhou, China, announced the Alibaba DAMO Academy on 11 October. The seven labs will be established in China, the United States, Russia, Israel and Singapore. Research topics will include data intelligence, the ‘Internet of things’, quantum computing and human–machine interfaces. Recruitment of the first 100 researchers is under way. The advisory board of the academy includes prominent scientists from outside China, including

geneticist George Church of Harvard University in Cambridge, Massachusetts.

TREND WATCH

Madagascar is battling an outbreak of plague, with more than 600 cases and at least 57 deaths since 1 August. Plague is endemic to the island and surfaces almost annually. But the current outbreak is unusually large, and cases are mostly of pneumonic plague, which is deadlier and more transmissible than the more usual bubonic form. Untreated, pneumonic plague can kill within 24 hours. On 10 October, the World Health Organization reported a linked case of plague in the Seychelles.



Source: WHO

Journal name:
Nature
Volume:
550,
Pages:
306–307
Date published:
(19 October 2017)
DOI:
doi:10.1038/550306a

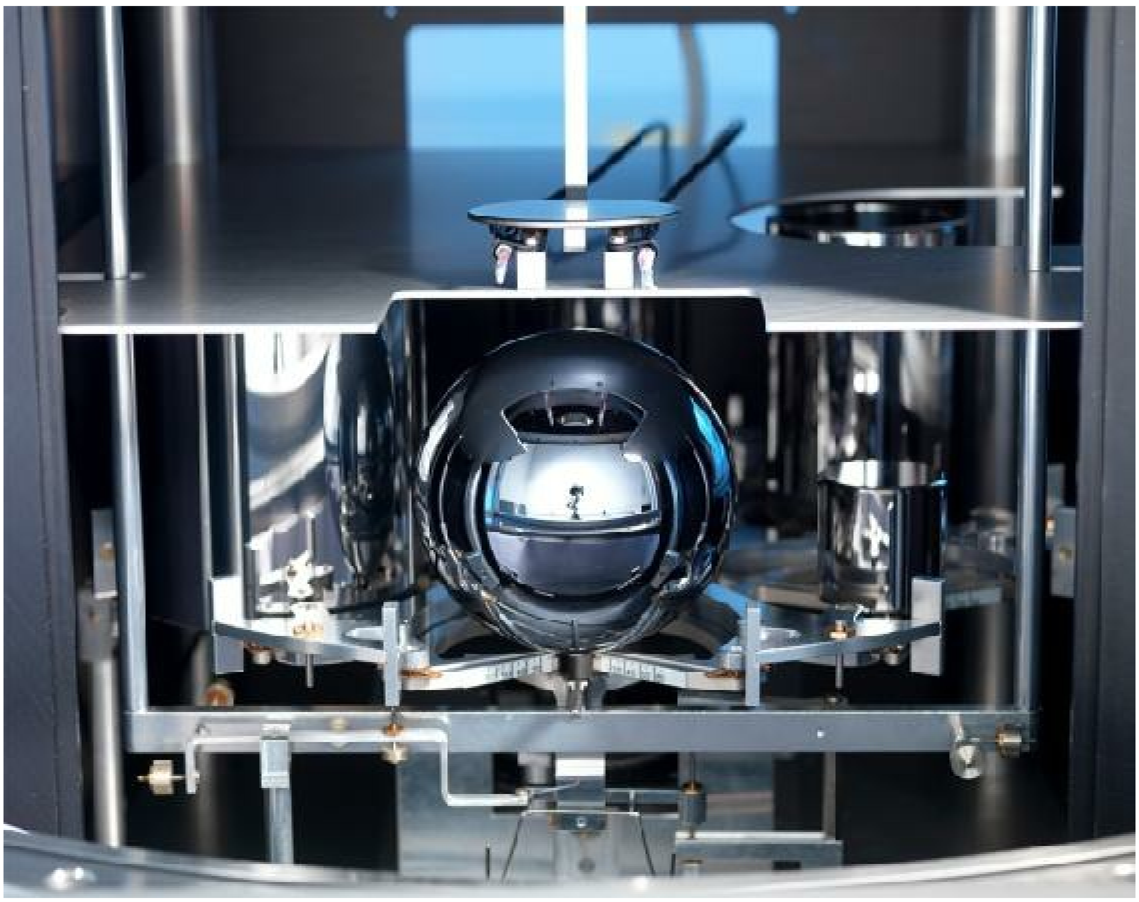
Comments

Commenting is currently unavailable.

New definitions of scientific units are on the horizon

Metrologists are poised to change how scientists measure the Universe.

18 October 2017



Natl. Phys. Lab., UK

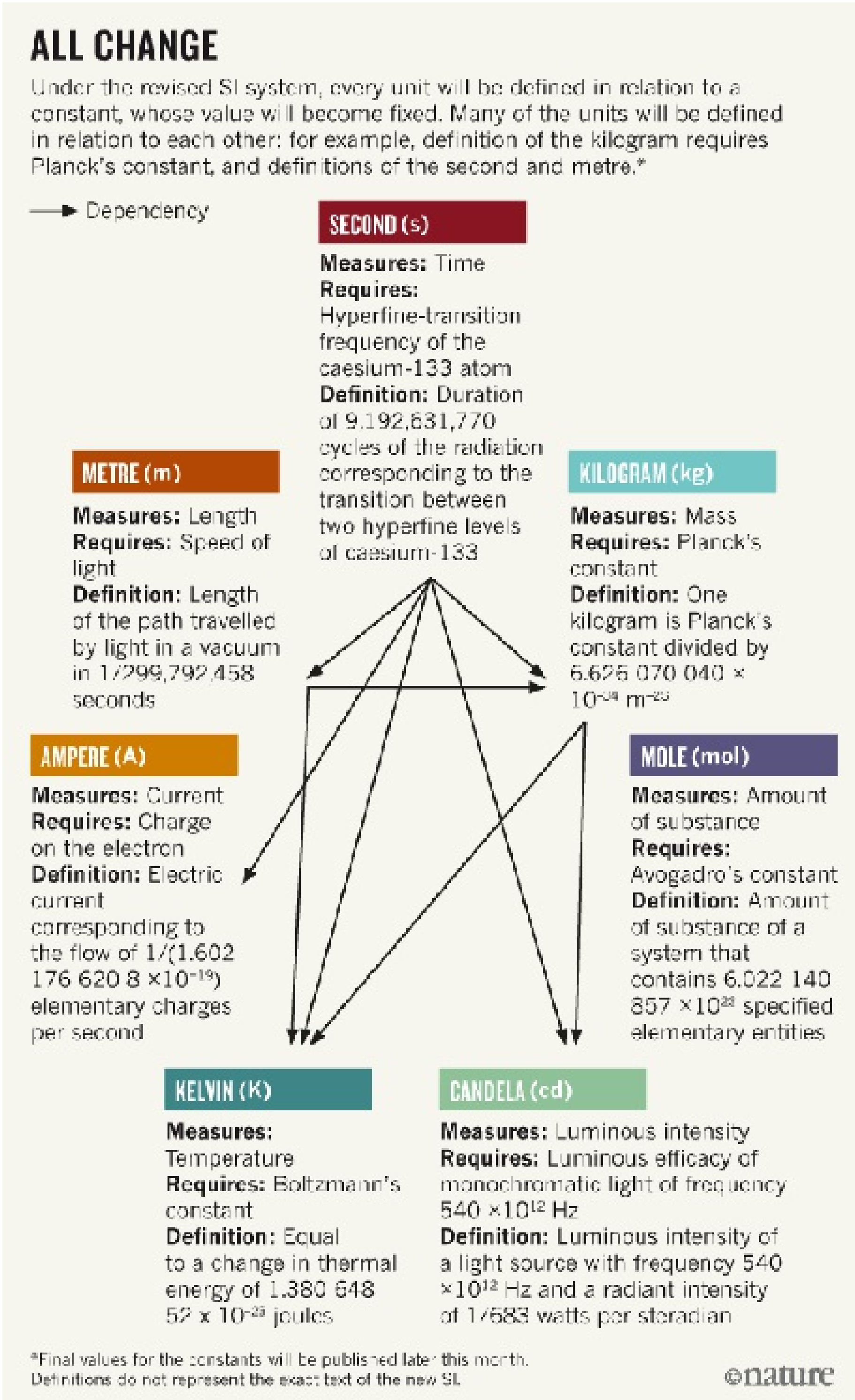
A sphere of pure silicon can be used to define a unit of measurement known as a mole.

Revamped definitions of scientific units are on their way. In the biggest

overhaul of the international system of units (SI) since its inception in 1960, a committee is set to redefine four basic units — the ampere, the kilogram, the kelvin and the mole — using relationships to fundamental constants, rather than abstract or arbitrary definitions. The International Bureau of Weights and Measures is reviewing the plans at a meeting near Paris from 16 to 20 October. Its recommendations will then go before the General Conference on Weights and Measures, which oversees the SI system, in November 2018. The changes would take effect in May 2019.

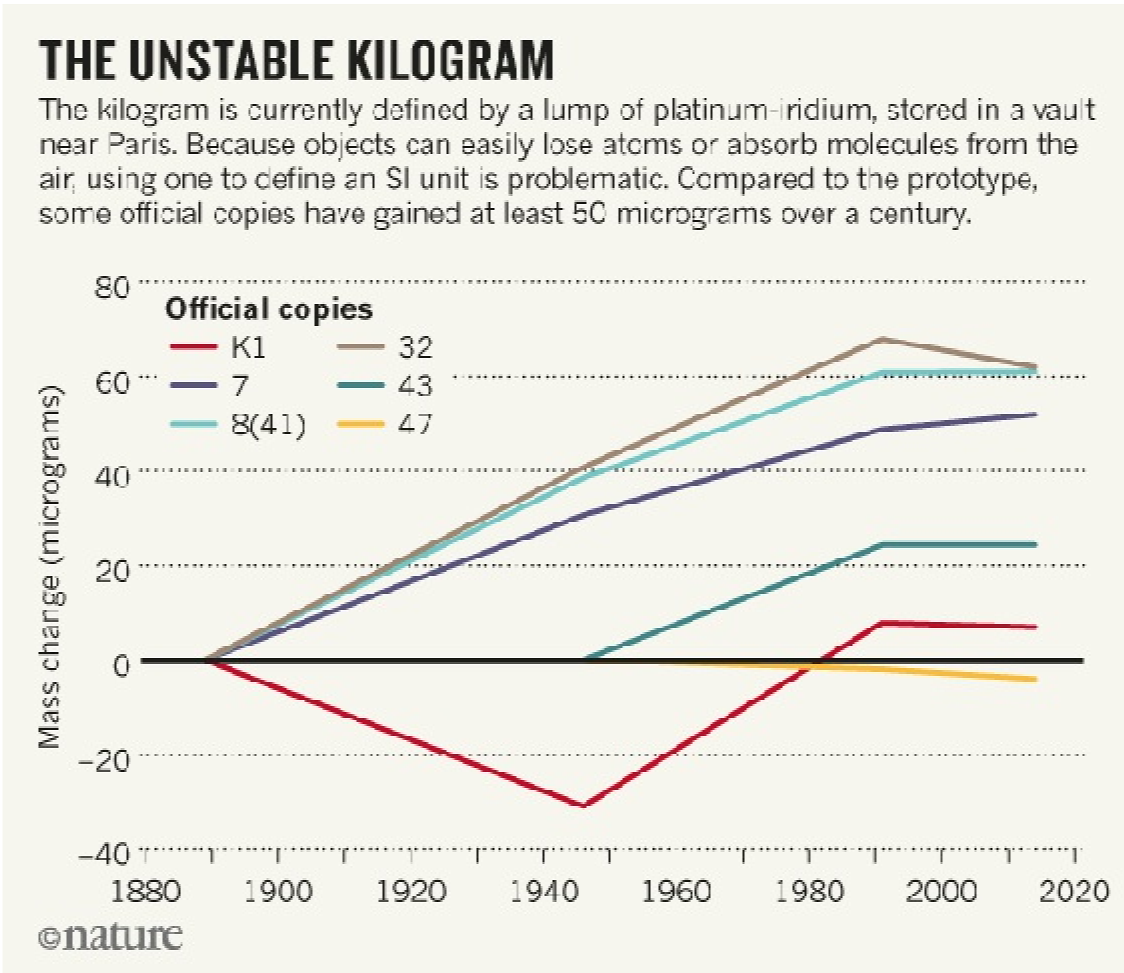
The kilogram is currently defined as the mass of a chunk of metal in a vault in Paris. And an imaginary experiment involving the force between two infinite wires defines the ampere, the unit of electrical current. The mole, meanwhile, is the amount of substance in a system with as many elementary entities as there are atoms in 0.012 kilograms of carbon-12, while the kelvin relates to the temperature and pressure at which water, ice and water vapour co-exist in equilibrium, known as the triple point of water. In the future, these units will be calculated in relation to constants — for example, the ampere will be based on the charge of an electron.

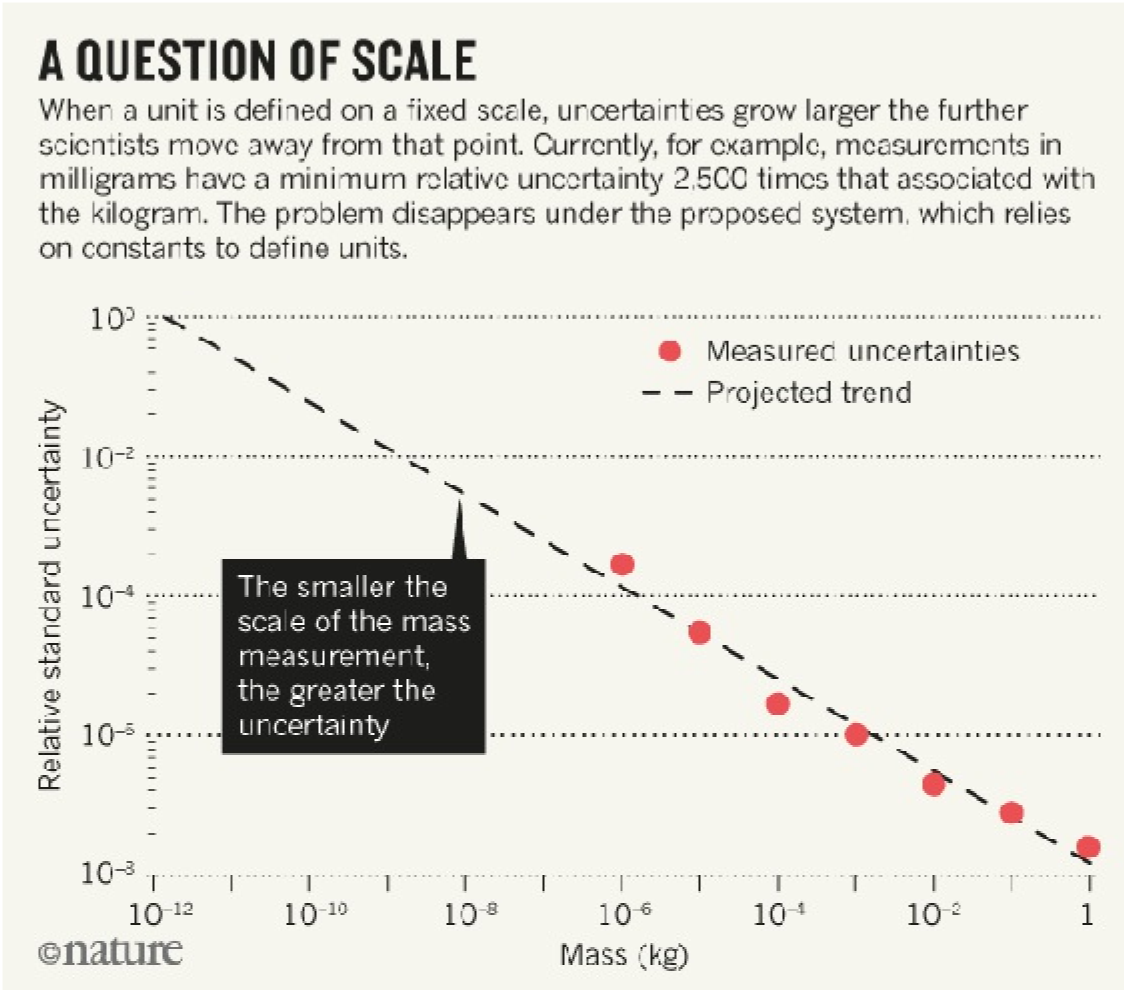
Redefinition might not affect everyday measurements, but it will enable scientists working at the highest level of precision to do so in multiple ways, at any place or time and on any scale, without losing accuracy.


ALL CHANGE
Under the revised SI system, every unit will be defined in relation to a constant, whose value will become fixed. Many of the units will be defined in relation to each other: for example, definition of the kilogram requires Planck's constant, and definitions of the second and metre.*
Dependency
SECOND (s)
Measures: Time
Requires: Hyperfine-transition frequency of the caesium-133 atom
Definition: Duration of 9,192,631,770 cycles of the radiation corresponding to the transition between two hyperfine levels of caesium-133
METRE (m)
Measures: Length
Requires: Speed of light
Definition: Length of the path travelled by light in a vacuum in 1/299,792,458 seconds
KILOGRAM (kg)
Measures: Mass
Requires: Planck's constant
Definition: One kilogram is Planck's constant divided by 6.626 070 040 × 10−34 m−2s
AMPERE (A)
Measures: Current
Requires: Charge on the electron
Definition: Electric current corresponding to the flow of 1/(1.602 176 620 8 ×10−19) elementary charges per second
MOLE (mol)
Measures: Amount of substance
Requires: Avogadro's constant
Definition: Amount of substance of a system that contains 6.022 140 857 ×1023 specified elementary entities
KELVIN (K)
Measures: Temperature
Requires: Boltzmann's constant
Definition: Equal to a change in thermal energy of 1.380 648 52 x 10−23 joules
CANDELA (cd)
Measures: Luminous intensity
Requires: Luminous efficacy of monochromatic light of frequency 540 ×1012 Hz
Definition: Luminous intensity of a light source with frequency 540 ×1012 Hz and a radiant intensity of 1/683 watts per steradian
*Final values for the constants will be published later this month.
Definitions do not represent the exact text of the new SI.
©nature

The problem

For measurements on conventional scales, existing definitions of SI units suffice. But they are poor tools for modern science at the extremes. And basing units on specific points or materials can be troublesome and inelegant, say metrologists.





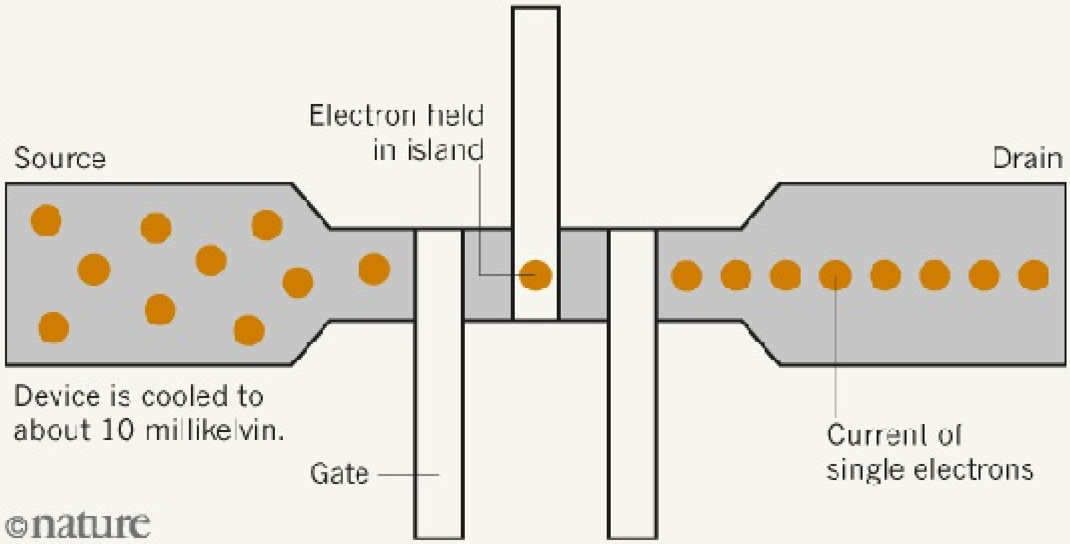
Source: Shaw, G. et al. Metrologia 53, A86–A94 (2016).

The techniques

Under the revamped SI system, researchers will be able to use various experiments to relate constants to each of the units measured.

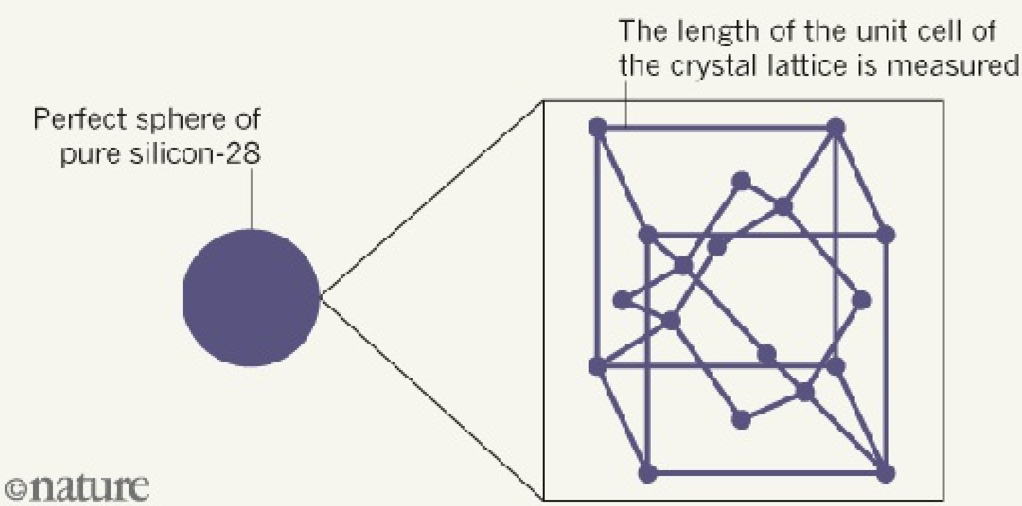
AMPERE: THE SINGLE-ELECTRON PUMP

Used to measure the charge of an electron, an electron pump could become one tool for determining the ampere. By trapping individual electrons as they travel rapidly across a conductor, the pump can generate a measureable current by counting single electrons.



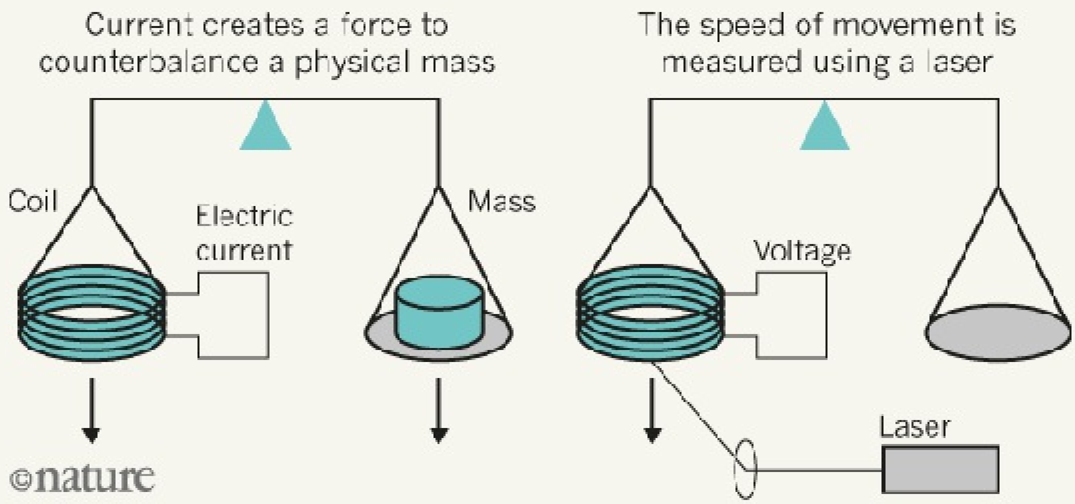
MOLE: THE SILICON SPHERE

As the device that gives scientists Avogadro's constant, this silicon sphere offers a state-of-the-art way to measure a mole. It would determine the precise number of atoms in a perfect sphere of pure silicon-28. Researchers do this by using lasers to measure the length of a unit of the sphere's crystal lattice, and its mean diameter.



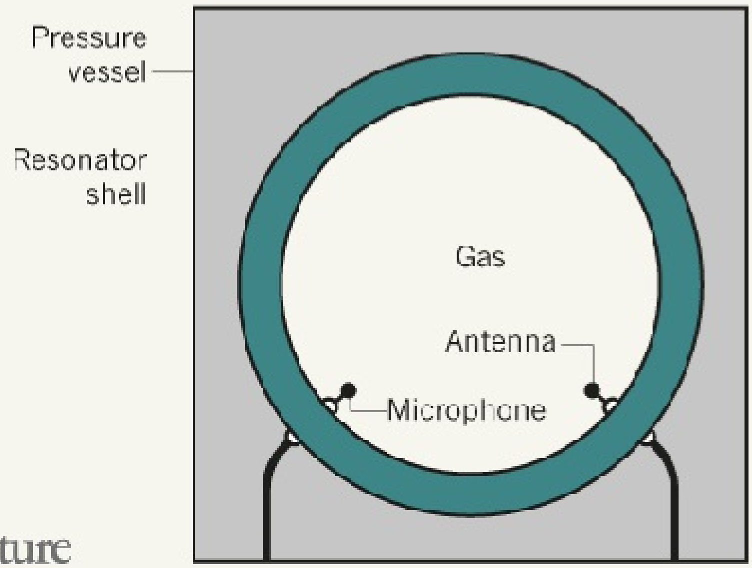
KILOGRAM: THE WATT BALANCE

The Watt balance compares mechanical power with electromagnetic power using two separate experiments. First, a current is run through a coil in a magnetic field to create a force that counterbalances a known physical mass. Then, the coil is moved through the field to create a voltage. By measuring the speed as well as experimental values that relate the voltage and current to Planck's constant, scientists can precisely determine the weight of a mass in kilograms.



KELVIN: ACOUSTIC THERMOMETRY

This technique could be used to derive precise temperature measurements. The speed of sound in a gas-filled sphere (which is proportional to the average speed of the atoms in it) can be determined at a fixed temperature, by analysing the frequency of sound waves that resonate within in it and measuring the sphere's volume.



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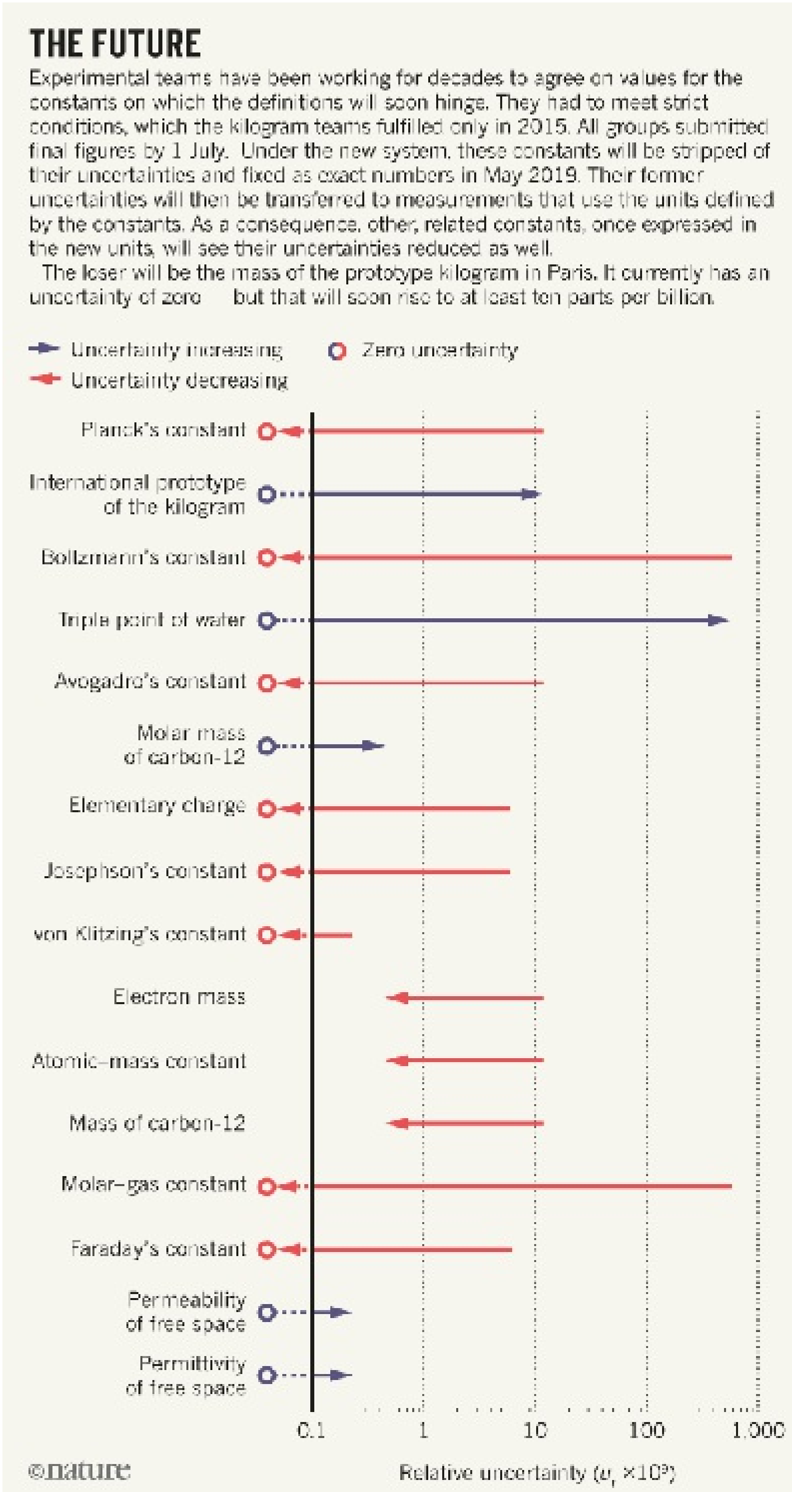


Journal name:

Nature

Volume:

550,
Pages:
312–313
Date published:
(19 October 2017)
DOI:
doi:10.1038/550312a

Comments

Comments

There are currently no comments.

The future of work

Digital technologies are upending the workforce. The right research can tell us how.

18 October 2017

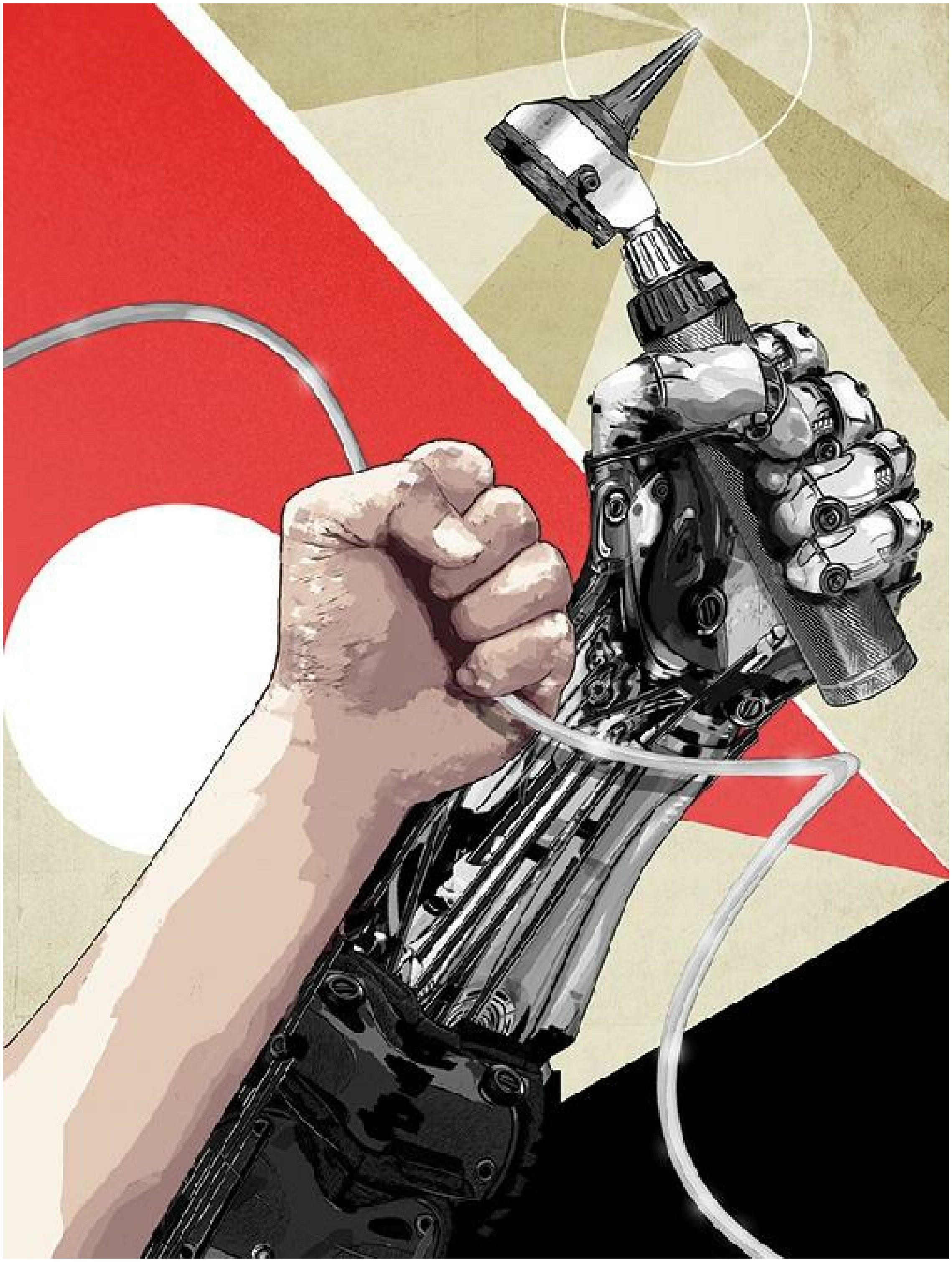


Illustration by Chris Malbon

Robots did not write this sentence, or any other part of *Nature*. But that could

change. Dramatic shifts in labour are reshaping society, the environment and the political landscape. Consider this disorienting estimate from the World Economic Forum: 65% of children entering primary schools now will grow up to work in jobs that do not yet exist. This week, *Nature* asks: what light is research shedding on the future of work, and how will the changes affect scientists' working world?

A News Feature explores which jobs are most at risk of being replaced by artificial intelligence and machine learning; whether a decentralized 'gig economy' will democratize work; and what programmes will best prepare workers. “There's a huge need, a huge opportunity, to study the changes,” says economist Erik Brynjolfsson. And the scientific workforce is feeling these shifts. A Careers Feature reports on people doing research outside the traditional career path. “I love the freedom,” says Cecile Menard, an independent land-surface modeller in Edinburgh, UK, “but for other people, it may be too stressful.”

Important lessons can be drawn from the past. Economic historian Robert Allen synthesizes three centuries of data to see when and where the relationship between wages and productivity was most like today's — and finds that some regions are in uncharted waters. These changes call for new socio-economic models and a revolution in education, concludes historian Yuval Noah Harari. And economist Ian Goldin argues that our era has more parallels with the Renaissance than the Industrial Revolution. This time, he urges, “knowledge and enquiry must find a way to conquer prejudice and ignorance”.

Journal name:
Nature
Volume:
550,
Pages:
315
Date published:
(19 October 2017)
DOI:
doi:10.1038/550315a

Comments

There are currently no comments.

The shape of work to come

Three ways that the digital revolution is reshaping workforces around the world.

18 October 2017 Corrected:

1. 24 October 2017

Illustration by Chris Malbon

Last year, entrepreneur Sebastian Thrun set out to augment his sales force with artificial intelligence. Thrun is the founder and president of Udacity, an education company that provides online courses and employs an armada of salespeople who answer questions from potential students through online chats. Thrun, who also runs a computer-science lab at Stanford University in California, worked with one of his students to collect the transcripts of these chats, noting which resulted in students signing up for a course. The pair fed the chats into a machine-learning system, which was able to glean the most effective responses to a variety of common questions.

Next, they put this digital sales assistant to work alongside human colleagues. When a query came in, the program would suggest an appropriate response, which a salesperson could tailor if necessary. It was an instantaneously reactive sales script with reams of data supporting every part of the pitch. And it worked; the team was able to handle twice as many prospects at once and convert a higher percentage of them into sales. The system, Thrun says, essentially packaged the skills of the company's best salespeople and bequeathed them to the entire team — a process that he views as potentially revolutionary. “Just as much as the steam engine and the car have amplified our muscle power, this could amplify our brainpower and turn us into superhumans intellectually,” he says.

The past decade has seen remarkable advances in digital technologies, including artificial intelligence (AI), robotics, cloud computing, data analytics and mobile communications. Over the coming decades, these technologies will transform nearly every industry — from agriculture, medicine and manufacturing to sales, finance and transportation — and reshape the nature of work. “Millions of jobs will be eliminated, millions of new jobs will be created and needed, and far more jobs will be transformed,” says Erik Brynjolfsson, who directs the Initiative on the Digital Economy at the Massachusetts Institute of Technology in Cambridge.

But making firm predictions is difficult. “The technology is rushing ahead, which in a way is a good thing, but we have a huge gap in understanding its implications,” Brynjolfsson says. “There's a huge need, a huge opportunity, to study the changes.” Researchers are beginning to do just that, and the emerging evidence resists simple storylines. Advances in digital technologies are likely to change work in complex and nuanced ways, creating both opportunities and risks for workers (see 'More research needed').

More research needed

Illustration by Chris Malbon

Scientists are grappling with how technology could alter workplaces.

The changing world of work presents an almost endless number of topics for

scientists to explore. Here are two other workplace trends and the research questions — as yet mostly unanswered — that they raise.

How will workers respond to new forms of tracking and surveillance?

Although employers have long monitored the performance of their staff, workplace surveillance is entering a new era.

Companies can now log workers' keystrokes and remotely take screenshots of their computers, for example, or use motion sensors, biometrics, radio-frequency identification (RFID) chips and the Global Positioning System to track their movements, even after hours.

But it's not yet clear whether workers will show widespread resistance to the increasing use of surveillance technology, or where they might draw the line. And could new forms of surveillance backfire in less obvious ways, undermining trust, morale or innovation?

How will human-enhancement technologies affect worker health and safety?

Technologies for improving human performance — from cognition-boosting drugs to bionic 'exoskeletons' that are designed to make physical labour safer and easier — are beginning to make their way into the workplace.

In some cases, these technologies could help to protect the health and safety of workers. An alertness-enhancing drug, such as modafinil, might help long-haul drivers avoid accidents, and exoskeletons could reduce joint stress and muscle fatigue. But researchers don't know whether the long-term use of these technologies could harm workers, either directly or indirectly, perhaps by encouraging overwork or increased risk-taking.

Here are three pressing questions about the future of work in a digital world and how researchers are beginning to answer them.

Will machine learning displace skilled workers?

In previous waves of automation, technological advances have allowed machines to take over tasks that were simple, repetitive and routine. Machine learning opens up the possibility of automating more complex, non-routine cognitive tasks. “For most of the last 40 or 50 years, it was impossible to automate a task before we understood it extremely well,” Brynjolfsson says. “That's not true anymore. Now machines can learn on their own.”

Machine-learning systems can translate speech, label images, pick stocks, detect fraud and diagnose disease — rivalling human performance in some new and surprising domains. “A machine can actually look at many, many, many more data samples than a human can handle,” says Thrun. Earlier this year, he led a team that demonstrated that some 129,000 images of skin lesions could be used to train a machine to diagnose skin cancer with a level of accuracy that matches that of qualified dermatologists[1].

LISTEN

Reporter Benjamin Thompson finds out how lessons from the past can help explore the future of work.

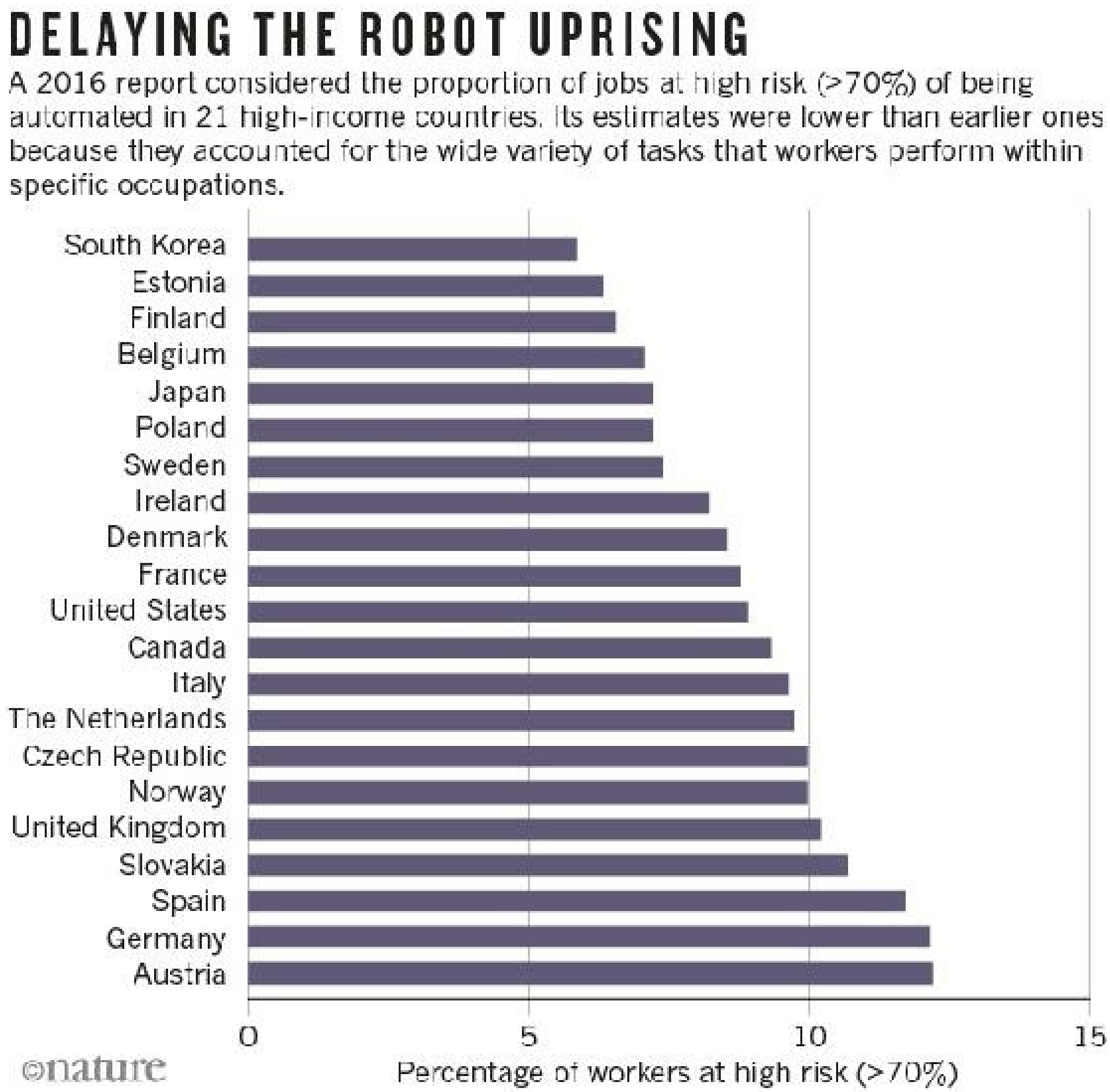
You may need a more recent browser or to install the latest version of the Adobe Flash Plugin.

These advances have raised concerns that such systems could replace human workers in fields that once seemed too complex to be automated. Early estimates seemed dire. In 2013, researchers at the Oxford Martin Programme on Technology and Employment at the University of Oxford, UK, reviewed the advances and lingering challenges in machine learning and mobile robotics to estimate how susceptible 702 different occupations were to automation[2]. Their startling conclusion was that 47% of jobs in the United States were at high risk of computerization, with jobs in transportation, logistics, production and administrative support particularly vulnerable. That spelt trouble for workers such as taxi drivers, legal secretaries and file clerks.

Since then, however, other researchers have argued that the 47% figure is much too high, given the variety of tasks that workers in many occupations

tend to perform. “Once you go deeper, once you look into the task structure of what people really do at work, then you find that the estimates get much lower,” says Ulrich Zierahn, a senior researcher at the Centre for European Economic Research in Mannheim, Germany.

For instance, the Oxford study reported that clerks in bookkeeping, accounting and auditing face an automation risk of 98%. But when Zierahn and his colleagues analysed survey data on what people in those professions actually do, the team found that 76% of them had jobs that required group work or face-to-face interaction. For now at least, such tasks are not easily automated[3]. When the authors extended their approach to other professions, they found less-alarming figures for the number of at-risk jobs in the 21 countries surveyed. In the United States, the share of workers at high risk of automation was just 9%, and the figure ranged from a low of 6% in South Korea and Estonia to a high of 12% in Germany and Austria (see 'Delaying the robot uprising').



Sources: OECD/Ref. [3] (http://go.nature.com/2KK4D4Y)

Brynjolfsson is now working with Tom Mitchell, a computer scientist at Carnegie Mellon University in Pittsburgh, Pennsylvania, to drill deeper into the impact of machine learning. They have developed a rubric outlining the characteristics that make certain tasks especially amenable to this approach. For instance, machine-learning systems are adept at tasks that involve translating one set of inputs — say, images of skin lesions — into another set of outputs, such as cancer diagnoses. They're also most likely to be used for tasks in which the large digital data sets required for training the system are readily available. Brynjolfsson and Mitchell are now going through several

large occupational databases to determine how well a variety of workplace tasks match up with these and other criteria.

Even with these kinds of analysis in hand, determining the consequences for the labour market is complex. Just because a task can be automated doesn't mean that it will be; new technologies often require costly and time-consuming organizational changes. Legal, ethical and societal barriers can also delay or derail their deployment. “AI is not yet an off-the-shelf product,” says Federico Cabitza, who studies health-care informatics at the University of Milano-Bicocca in Italy. Implementing medical machine-learning systems, for instance, requires both technological readiness and willingness to devote the thousands of person-hours necessary to make these systems operational, he says — not to mention buy-in from caregivers and patients.

Research suggests that the workforce is flexible in adapting to new technologies. In the second half of the twentieth century, increasing automation prompted shifts within occupations as employees began performing more complex and non-routine tasks. In some future cases, these shifts could be positive; if automated systems start making routine medical diagnoses, it could free doctors to spend more time interacting with patients and working on complex cases. “The fact that computers are becoming good at medical diagnosis doesn't mean that doctors will disappear as a job category,” Mitchell says. “Maybe it means we'll have better doctors.”

Indeed, many people might find themselves working alongside AI systems, as the Udacity salespeople did, rather than being replaced by them. Self-driving cars, for instance, are not yet able to navigate all situations on their own, so car manufacturer Nissan is developing a human-powered solution. If one of its autonomous cars encounters a situation it doesn't understand, such as roadworks or a traffic accident, it will contact a remote command centre where a human 'mobility manager' can take control until the car has passed the trouble spot. “Machines think in a very different way, fundamentally, than humans do, and each has its strengths,” says Pietro Michelucci, executive director of the Human Computation Institute in Ithaca, New York. “So there's a real natural marriage between machines and humans.”

Will the gig economy increase worker

exploitation?

Flexibility, variety and autonomy: these are the promises of the burgeoning gig economy, in which workers use online platforms to find small, short-term jobs. This sort of on-demand, digitally mediated gig work can take a variety of forms, from driving for the taxi service Uber to completing microtasks — including taking surveys, translating a few sentences of text or labelling an image — on a massive crowd-working platform such as Amazon Mechanical Turk.

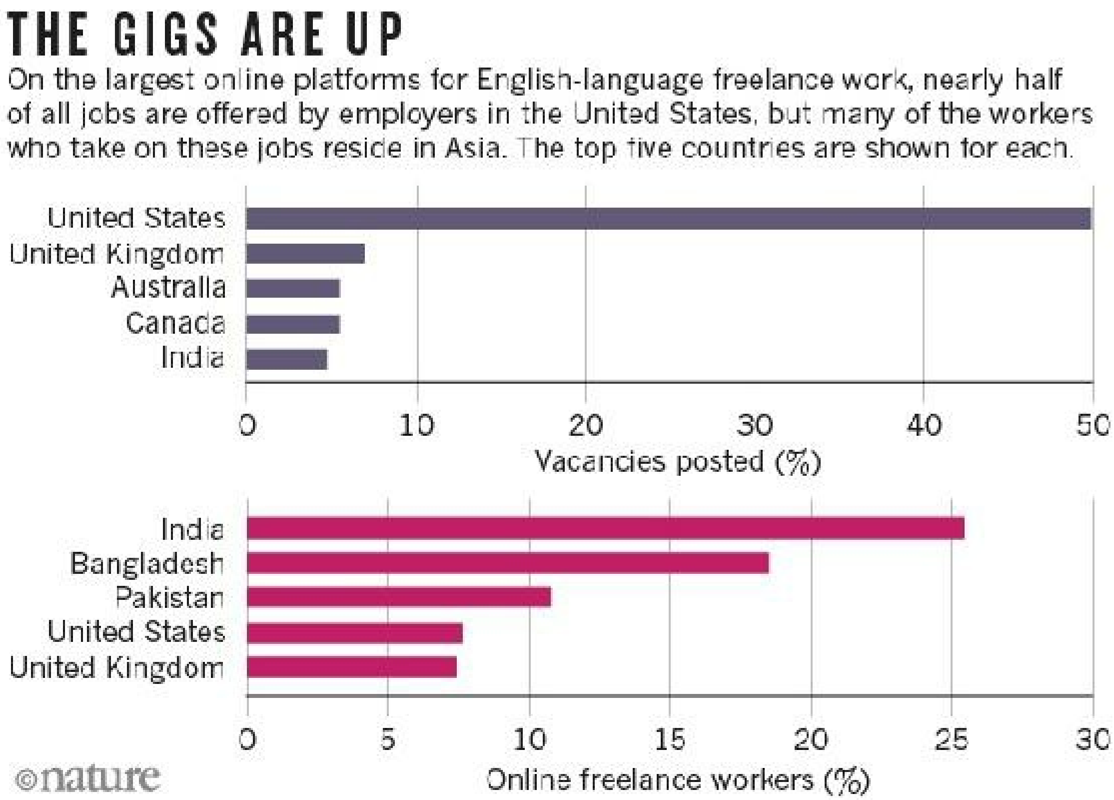
These digital platforms allow workers to complete tasks from anywhere, meaning they could remove some geographical barriers to getting good jobs. “Someone in Nairobi is no longer constrained by the local labour market,” says digital geographer Mark Graham of the University of Oxford.

Graham and his colleagues have spent several years studying the digital, on-demand economy in southeast Asia and sub-Saharan Africa. They have conducted face-to-face interviews with more than 150 gig workers in these regions, surveyed more than 500 people and analysed hundreds of thousands of transactions on online labour platforms.

Their preliminary results show that these jobs do pay off for some gig workers; 68% of the survey respondents said that the work makes up an important part of their household income. And digital platforms provided jobs to a variety of people — including women who were primary caregivers and migrants without work permits — who said that their employment opportunities were otherwise limited. “There are some people who really thrive in this system,” Graham says. “But it's not like that for everyone.”

There is a pronounced oversupply of labour in the gig economy, leading some workers to drop their rates below what they consider fair. Many also work long hours at high speeds and to tight deadlines. “They tend to have a very precarious existence, so they're worried about saying no to jobs that they do get,” Graham says. “We talked to quite a few people who have done things like stay up for 48 hours straight, just working solidly in order to get their contracts done on time.”

Considerable geographical inequities remain. In a 2014 study[4], Graham and several colleagues analysed more than 60,000 transactions on one major platform in March 2013. Most jobs, they found, were listed by employers in high-income countries and completed by workers in low- or middle-income countries (see 'The gigs are up').



Source: Ilabour (http://go.nature.com/2GZE5TZ)

But those who live close to where the jobs are still seem to have an advantage. They win a disproportionate share of jobs and earn significantly more — US$24.13 per hour, on average — than foreign workers, who earned $11.66 per hour for comparable work. And some low- and middle-income nations attracted many more jobs than others; India and the Philippines are the top two recipients in Graham's analysis.

Practical concerns could explain some of these disparities. Language and time-zone differences might make some employers reluctant to hire foreign workers, and the history of outsourcing labour to India and the Philippines

may have helped make workers there more attractive to employers. But discrimination, both conscious and unconscious, could play a part, too; Graham's team found task listings explicitly stating that people from certain countries need not apply. “Even though these technologies have been able to connect different parts of the world, they have not been able to bridge these kinds of differences as much as we hoped,” says Mohammad Amir Anwar, a researcher who works with Graham.

Another large ethnographic study of gig workers is beginning to reveal more about how this work gets done. It also provides some clues about what workers need to succeed. Between 2013 and 2015, two senior researchers at Microsoft Research — anthropologist Mary Gray in Cambridge, Massachusetts, and computational social scientist Siddharth Suri in New York City — surveyed roughly 2,000 gig workers in the United States and India and conducted longer interviews with nearly 200 of them.

One of the first things they discovered was that, although gig workers are often portrayed as independent, autonomous labourers, many of them were in fact communicating and collaborating with each other[5]. Workers helped each other to set up accounts and profiles, shared information about good employers and newly posted jobs, and provided technical and social support. Workers are making a deliberate effort to add human connections back into the system, Suri says, and they're doing it on their own time. “So they clearly must value it.”

In a more quantitative follow-up study[6], in which they mapped the social connections among more than 10,000 Amazon Mechanical Turk workers, Gray, Suri and their colleagues found that this kind of collaboration can have real pay-offs. Workers who had connections to at least one other person on the platform had higher approval rates, were more likely to gain elite 'master' status, and found out about a new task more quickly than unconnected workers. For people to be productive, says Gray, “it turns out that they really need to collaborate. They need each other.”

Can the digital skills gap be closed?

For years, experts have been sounding the alarm about a looming shortage of digital skills. They have warned that there are too few trained workers to fill high-tech jobs, and that a lack of basic digital literacy could prevent workers in certain geographical regions or demographic groups from thriving in the digital economy. In response, various innovative programmes for boosting digital literacy and skills have sprung up worldwide. Research is now starting to provide some clues about what does and doesn't work — and about where skills training might fall short.

There have been some documented successes. More than a decade ago, the US Defense Advanced Research Projects Agency began developing a personalized, interactive and adaptive 'digital tutor' system to train new recruits to the US Navy for jobs as information-systems technology (IT) technicians. Students would work with the tutor one-to-one, completing lessons on different topics and solving related problems. The system prioritized conceptual learning and reflection, regularly prompting students to review what they'd learnt. When the tutoring system judged that a student had mastered the material, it would move on to the next subject.

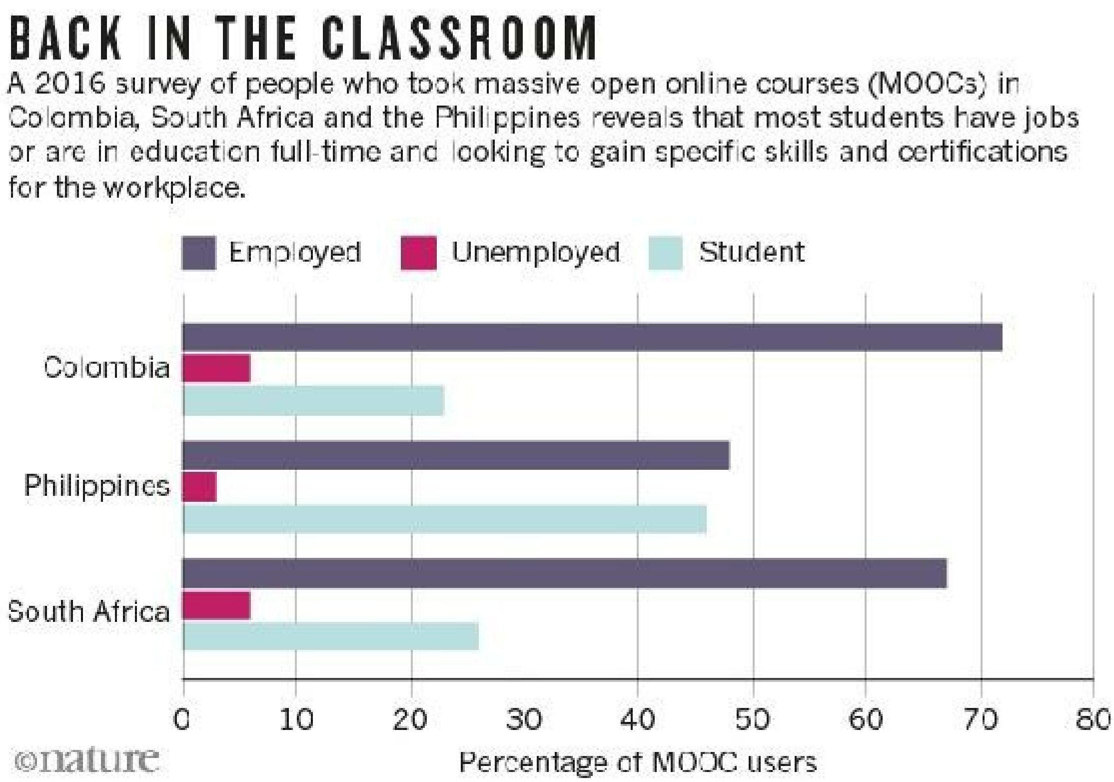
In a 2014 review[7] of the programme, researchers at the Institute for Defense Analyses in Alexandria, Virginia, found that 12 recruits who completed the 16-week course outperformed graduates of conventional, classroom-based US Navy IT training that lasted more than twice as long. The 12 even did better than a group of senior naval IT technicians — who each had an average of nearly ten years' experience — on almost every measure. “If we can do that, why not do more of it?” says Dexter Fletcher, who co-authored the review. “Why not begin to apply this seriously to workforce training?”

In a follow-up study[8], Fletcher found that a slightly modified version of the digital tutor yielded similar results when it was used to train 100 military veterans for civilian jobs in IT. Within six months of completing the programme, 97% of the veterans who wanted IT jobs had landed them, earning an average annual salary roughly equal to that of someone with 3–5 years of experience in the field.

Numerous other strategies have been promoted to improve digital skills and employment, including massive open online courses (MOOCs) — university-

level classes that are delivered over the Internet — and coding bootcamps, which are intensive, short-term training courses that teach the basics of computer programming.

In a 2016 analysis[9] of 1,400 MOOC users in Colombia, the Philippines and South Africa, researchers determined that 80% of students were from low- or middle-income backgrounds and that 41% had only basic computer skills. More than half of the students (56%) were female, and computer science was the most popular MOOC topic. "Women are actually engaging in MOOCs in areas where they are underrepresented," says Maria Garrido, a co-author of the report at the University of Washington's Information School (see 'Back in the classroom').



Source: Ref. [9] (http://go.nature.com/2YFAPWC)

But the quality of these programmes can vary enormously, and few have been rigorously evaluated. Coding bootcamps can be expensive, require a significant time investment and are located primarily in technology corridors

and urban settings. And achievement gaps remain; in a 2015 study[10] of more than 67,000 MOOC students, two Stanford researchers found that female students and students of both genders from Africa, Asia and Latin America were less likely to reach certain course milestones — such as watching more than 50% of the lectures — and earned lower grades than male students and MOOC students from North America, Europe and Oceania.

Even those who complete digital-skills courses can still face a variety of barriers to employment. When researchers interviewed students in a Kenyan IT programme at Strathmore University in Nairobi in 2004, some of the students said that they were worried about graduating into a local economy that didn't appreciate their expertise or have jobs in which they could put it to use[11]. “And this was especially true for the women,” says Lynette Yarger, an information scientist at Pennsylvania State University in University Park, who was involved in the research. As one student put it: “Because I am a woman, employers may not think that they should give me a job working in IT, so I may never fully get to use all that I have learned to do, work that I want to do.”

One thing the research is already making clear is that even well-designed training programmes might not be sufficient to ensure success in the world of digital work. “The fact that you have better skills and know how to use a computer doesn't necessarily mean that you automatically can get a good job,” Garrido says. “Digital skills are an important piece of the puzzle, but they're not enough.”

Journal name:
Nature
Volume:
550,
Pages:
316–319
Date published:
(19 October 2017)
DOI:
doi:10.1038/550316a

Corrections

Corrected:

> An earlier version of this story erroneously located the Human Computation Institute in Fairfax, Virginia.

Comments

Comments

There are currently no comments.

Lessons from history for the future of work

18 October 2017

Global comparisons of previous social and economic upheavals suggest that what is to come depends on where you are now, argues Robert C. Allen.

Lewis Hine/Pictorial Press Ltd/Alamy

Children working in a cotton mill in Macon, Georgia, in January 1909.

Today is not the first time that people have worried that machines will render

human labour obsolete, making a few very rich and the majority very poor.

Since the Industrial Revolution, mechanization has been controversial. Machines pushed up productivity, raising incomes per capita. But they threatened to put people out of work, to lower their wages and to divert all the gains from growth to the owners of businesses. The stocking-frame operators of Nottingham, UK (the Luddites), wrecked improved knitting machines that threatened their jobs. Mobs burnt down the first mills housing spinning and weaving equipment in the 1760s and 1790s.

Now, it is robots that threaten work, wages and equality[1]. Are the gains of technological progress destined to benefit only the top 1% of earners?

Economists' stock answer to this question is 'no'[2]. Technical progress in the past three centuries has led to incomes in the West (that is, the developed nations of today) that are much higher than they were in 1700 in real terms, and the fraction of the adult population employed in these countries is at record levels. Despite mechanization, automation and computerization, people have found jobs. Somehow the economy has always adjusted; somehow in the future it always will.

I think this answer is too simplistic.

Phase shift

There have been long periods of economic history in which things did not work out well, and we must wonder whether we are in another. Also, the 'future of work' depends very much on where you are in the world. Most discussions in the West focus on how technological evolution in the West affects jobs in the West. This frame is too narrow for the twenty-first century: we must investigate the effect of technological change on work everywhere. For the past three centuries, the global economy has been sufficiently integrated that new technology in one place affects work in others.

LISTEN

Reporter Benjamin Thompson finds out how lessons from the past can help explore the future of work.

You may need a more recent browser or to install the latest version of the Adobe Flash Plugin.

Rather than ask (unanswerable) questions about how machines will affect work over the next centuries, we can ask what the invention of the textile mill meant for a girl growing up in Manchester, UK, in 1800 or the wife of a subsistence rice farmer in China's Yangtze Delta at the same time. Technological change affected their futures of work very differently and often detrimentally. Similar things are happening now.

We need to divide the past into periods defined by trends. The periods I suggest here reflect Western history, which is not as limiting as it sounds: globalization means that developments in one region affect others.

The three phases are: the Industrial Revolution (1750–1830); the Western ascent to affluence (1830–1970); and the problem-ridden present (since 1970). Each holds lessons and pressing research questions for today.

The industrial revolution

The Industrial Revolution was Britain's creative response to the globalization of the world economy that occurred after Columbus's voyage to America in 1492 and Vasco da Gama's sail around Africa to India in 1498. Britain's colonies in North America, the Caribbean and India formed a large market for Britain's handicraft industries. Exports boomed, and by the mid-eighteenth century about one-third of Britain's workforce was employed in making metal goods and cloth.

Large data sets of wages and prices over this period[3] have been assembled since the 1980s and show that real wages rose as a consequence of this export boom[4]. Inventors designed machines to save expensive labour. Mechanization paid in Britain rather than elsewhere because labour was more expensive relative to capital; that is why the Industrial Revolution was

primarily a British affair.

Textiles were the world's most important manufactured product in terms of employment before the Industrial Revolution, and the first to be mechanized. Indian cotton cloth was imported to Europe, where it was a smash hit. English manufacturers struggled to compete because English wages were so high. The invention in the 1760s and 1770s of spinning machines to speed up cloth-making, including Hargreave's spinning jenny, Arkwright's water frame and Crompton's spinning mule, solved the problem. The first victims of technological unemployment were the British women spinning cotton by hand and, later, the much-larger number spinning wool, once machinery was adapted to that fibre.

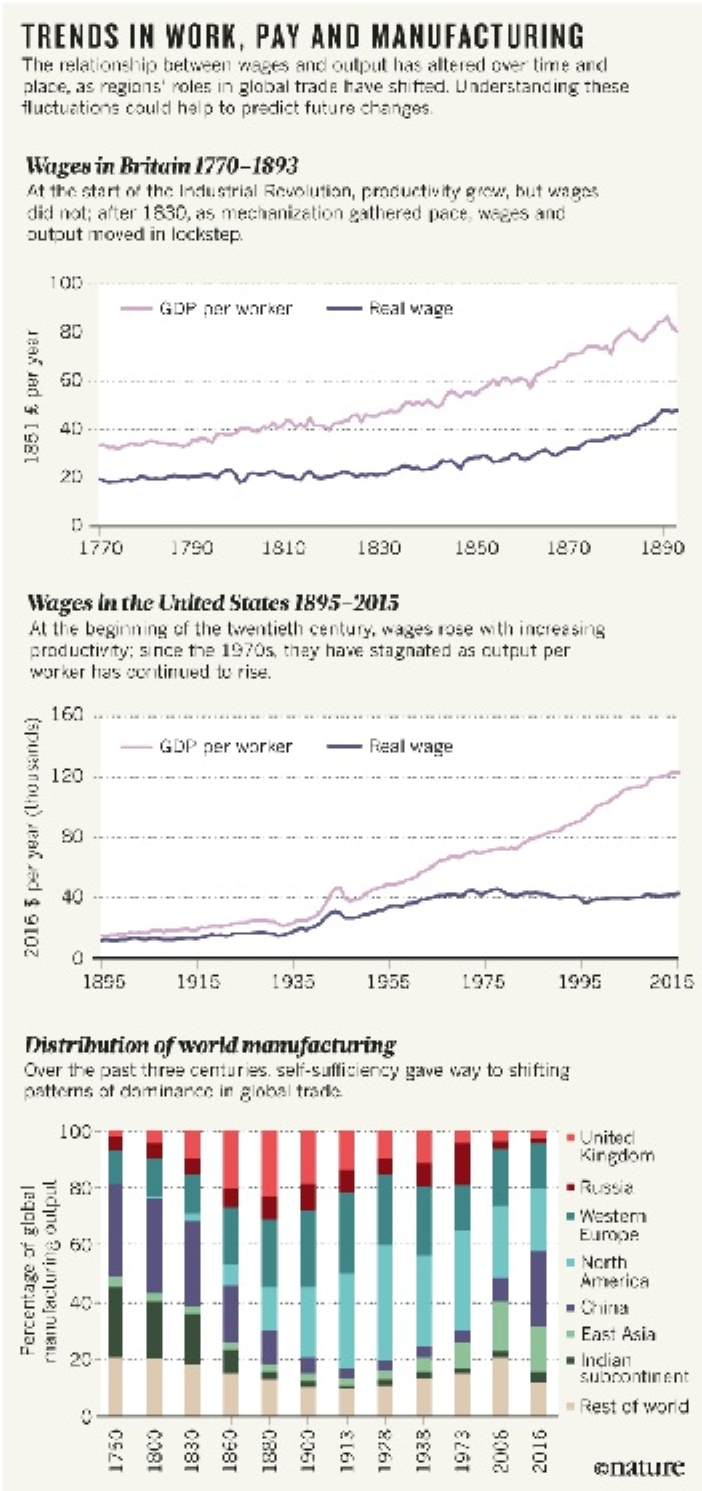
Soon jobs were lost from Casablanca to Canton. Investing in spinning machines made sense only in the high-wage economy of eighteenth-century England, thus they greatly increased English competitiveness without benefiting other nations. As jobs proliferated in the British cotton mills, massive technological unemployment spread across Africa and Asia[5]. The collapse of the Indian cotton trade around the 1830s led the British governor general to remark[6]: “The bones of the cotton-weavers are bleaching the plains of India.”

In 1820, the future of work for the wife of a farm labourer in England was an unhappy one. She had lost the opportunity to increase her family's income by spinning part-time, as her mother had done. The same impoverished fate befell a farmer's wife in the Ganges or Yangtze deltas. Some British women found work in the cotton mills (but a smaller number than had been employed to spin cotton by hand). By contrast, the future of work was auspicious for railway engineers, bricklayers and metal workers, to say nothing of the vast number of middle-class entrepreneurs and professionals who directed and serviced the industrial economy.

Machines were invented to save labour in most sectors of the economy in the first half of the nineteenth century. As one trade after another was eliminated in Britain, earnings collapsed in the affected trade, and that, in itself, lowered average national earnings. The displaced workers shifted into other trades, pushing down those wages. The Luddites and other opponents of

mechanization are often portrayed as irrational enemies of progress, but they were not the people set to benefit from the new machinery, so their opposition makes sense.

The implications were stark (see 'Trends in work, pay and manufacturing'). Although output per worker grew from 1770 to 1890, there was little growth in the real wage from 1770 to about 1830. During the Industrial Revolution (phase one) the 'normal' relationship was booming productivity and constant average wages — rather like the past 40 years.



Sources: See Supplementary Information

The western ascent to affluence

The average real wage only began to rise in the middle of the nineteenth century, when higher-productivity factory work replaced the hand trades. By 1850 Britain was the 'workshop of the world'. Comprising only around 3% of the world's population, the United Kingdom produced about half of the world's iron, for instance.

Industrial pre-eminence saw in the next phase of history. The new normal in the West was productivity and wages advancing together, as the Industrial Revolution spread across Europe and North America. Although there were shocks along the way owing to the depression of the 1930s and the Second World War, the period from the mid-nineteenth century to 1970 was one in which the working class benefited from the growth in productivity. Incomes became more equal. This is the economic performance that many have come to regard as normal.

How this favourable situation arose is a fundamental question. It seems that a positive-feedback system was in operation. Rising incomes led to the demand for fancier manufactured goods (for example, bicycles then cars) and more services (such as travel, retail trade and medical care). These created markets that encouraged technological change and led to jobs that were performed more effectively by educated people[7].

The need for educated workers led to the expansion of state provision of education. The increasing number of educated people prompted the invention of technologies that took advantage of education[8]. Those technologies led to further demand for education. At the same time, the public provision of infrastructure — roads and airports, for instance — was crucial for the development of industries involving cars and aircraft. Public support for research in medicine, agriculture and technologies with military applications, such as electronics and aircraft, underlaid many advances. The welfare state helped to spread the benefits of this economic development across the population.

The upshot was a pattern of economic growth in which technical progress benefited most people in the West.

The same was not true in Asia and Africa. Before the Industrial Revolution, China and India had the largest manufacturing sectors in the world because they had the largest populations, and nations were mostly self-sufficient in the pre-globalization era. As the Industrial Revolution gathered pace, Britain's share of goods manufactured worldwide increased, reaching a peak of about one-quarter in the late nineteenth century. Western Europe's share and that of North America also increased. In the same period, the shares of India and China collapsed. This drop represented absolute de-industrialization and not simply shifting percentages.

The technological revolution that spread prosperity in the West created modern 'underdeveloped countries' in the East (that is, Asia, Africa and South America). It converted them into economies that exported solely primary products — wheat, rice, bauxite, oil — rather than secondary ones such as cloth and porcelain.

By the 1830s, technological progress in the West meant a bleak future of work elsewhere.

The problem-ridden present

The past four decades have seen many job losses in the manufacturing sector in Western countries, static or falling real wages, and rising inequality as the gains from growth accrue to the top 1%. Did the 'new normal' end in 1970, or are the recent trends just a blip? Might what was 'normal' in 1850–1970 return soon — that is, the concurrent advance of productivity and wages?

Some people believe that the feedback loops between education and technology will kick in again, generating new knowledge-based, high-income jobs in the West to replace lost manufacturing jobs. Computers and robots will save us.

I am more pessimistic. The rise in real wages that began in the mid-nineteenth century and tracked the rise in output per worker ended in the 1970s (see 'Trends in work, pay and manufacturing'). Real wages rose at a slower rate than productivity in the 1980s and 1990s — or stagnated

altogether, as in the United States. In some cases (for example, the United Kingdom) wages have actually been falling in real terms over the past decade. A deviation of this magnitude from the trend suggests that the new pattern may not be transitory.

Similarly, the rebound in overall inequality in mature economies, such as the United States, over the past 40 years is unprecedented. Inequality rose in many countries as they industrialized and fell thereafter — this trend is called a Kuznets curve (after the Nobel laureate Simon Kuznets)[9]. The rise in inequality since 1970 has shown that this is a reversible feature of economic history.

Inequality is an area that has seen much recent research, with large data sets assembled and interrogated. Some scholars have focused on the share of total income going to the top 1% or 5%[10]. Others use indices that incorporate information from every level of the income distribution[11]. How we interpret the results depends on our breadth of vision. A common pattern in many countries is a fall in inequality from the early twentieth century to the 1970s and then a rise. This is true of the United States, the United Kingdom and China, for instance. At the global level, inequality increased steadily from 1820 to 1990 and then declined slightly. This pattern takes into account inequality between countries as well as within. Rising per capita incomes in the West in phase two increased global inequality. In phase three, global inequality fell even though inequality increased in many rich and poor countries[12].

Why are the feedback loops that led to general prosperity in the West between 1850 and 1970 seemingly inoperative now[13, 14, 15]? A big change is the industrialization of Asia — first Japan starting in the 1870s, then South Korea and Taiwan since the Second World War, and now China (see 'Trends in work, pay and manufacturing'). These countries have supplanted Western nations as the low-cost producers of manufactured goods. Trade flows have reversed, with Asia shipping textiles and steel to Europe rather than the other way around. Technological progress in Asia has raised incomes and levels of employment dramatically in the region.

The future of work to someone born in China in 1990 is bright indeed —

provided that the country can avoid environmental crises and resource depletion.

Globalization means that Asia's bright future causes havoc elsewhere. Imports of cheap Japanese steel and vehicles caused the collapse of the rust belt in the United States and its counterparts in Western Europe (with Germany as something of an exception). Western de-industrialization was the flip side of the East Asian miracles. And cheap Chinese imports may benefit Africans as consumers, but could blight their employment prospects as African industries struggle to compete. Indeed, China is now purchasing large areas of land in Africa to guarantee access to food and minerals. It is hard to believe that manufacturing or information technology will ever recover in the West, no matter how many robots are installed, visas rescinded, trade agreements ripped up or walls built.

We cannot forecast the future without an understanding of the relationships between science, technology and the economy, because technical change is such an important determinant of the future. I have studied these questions for the Industrial Revolution using business accounts and histories of inventions. The steam engine, for instance, was an application of seventeenth-century science (the discoveries that the atmosphere has weight and that condensing steam creates a vacuum). By contrast, the cotton mills owed little to science and much to attempts to cut costs of relatively expensive employment[16].

How has the balance between knowledge and incentives evolved? The more technology advances in response to economic incentives rather than 'random' scientific discoveries, the more feasible it is to direct the course of technical progress to benefit more people. Furthermore, the cotton mills of the Industrial Revolution increased the demand for workers without education, whereas more-recent technology requires more education. Why the difference? Will the recent trend of needing educated workers persist? If not, then the hope that a knowledge-based future will make everyone better off is doomed.

Journal name:
Nature
Volume:

550,
Pages:
321–324
Date published:
(19 October 2017)
DOI:
doi:10.1038/550321a

Supplementary information

PDF files

1. Supplementary Information 550321a (49K)

Comments

Commenting is currently unavailable.

The second Renaissance

18 October 2017

Ian Goldin calls on scientists to help society to weather the disruptive transformations afoot.

Jay Shaw Baker/NurPhoto/Getty

Workers protest in London in February.

The Renaissance that began in Europe in the mid-1400s and ended in the early 1500s brought a radical transformation of the sciences, the humanities and politics. Building on the invention of the printing press and cheap paper, information was democratized, there was a hunger for literacy and the Catholic Church's near-monopoly on knowledge was challenged. The

resulting breakthroughs took Europe from being one of the more backward regions of the world to being the most advanced by far, within just 80 years.

But it ended in tears. Extremists, pointing to growing inequalities and the corruption of the elite, called for a return to spiritual values. In Italy, thousands of artworks and books were burned, branded as irreverent. Across Europe, rising intolerance of scientists, intellectuals, foreigners and ethnic minorities became the norm, with religious wars and inquisitions playing out over the following centuries.

In my view, many parts of the world are now in the middle of a second Renaissance. This one is seeing even faster change than the last, and across the entire globe. History tells us that it will be disruptive. It will bring immense benefits and it will be highly destabilizing. We should expect more extremism and the rise of potentially catastrophic risks.

Innovation today is happening faster than ever, driven by the unlocking of individual and collective abilities in a booming population. On average, literacy levels, life expectancy and incomes have soared. Flows of goods, services, money, people and, most importantly, ideas across national borders — globalization — has unleashed unprecedented progress and a scientific and broader renaissance. They have also brought growing interdependence and new risks[1, 2].

The Internet helps to harness the global capacity for connectivity and innovation, but also brings us malware, cybercrime and the sacrifice of privacy. Airports are crucial to international integration of science and commerce, but they can also be super-spreaders of pandemics — just as explorers to the new world brought with them fatal diseases. Financial hubs create fresh opportunities for economies to prosper, but they simultaneously allow a financial crisis in one country to destroy jobs and pensions in distant parts of the world[3].

The tension between individual success and collective collapse is growing. As more people escape poverty and climb the energy curve, climate change and biodiversity loss accelerate. As more people benefit from better nutrition, ocean fisheries are at risk of collapse and forests are destroyed for cattle. Improvements in global health could soon be threatened by rapidly rising

antibiotic resistance.

Accelerating technological change will provide solutions for many challenges, from cancer to cleaner sources of energy. But our politics and our institutions are locked in past models that are increasingly unfit for purpose. Deep ethical issues arising from genomics research and the potential dangers of biological pathogens are not being adequately addressed. Improvements in computing and artificial intelligence will kill off many jobs. Breakthroughs in nanotechnology and materials science, augmented and virtual reality, 3D printing and other applications will also radically disrupt society. All are barely understood by politicians and most citizens.

Growing gap

Inequality is rising in almost all countries that are experiencing rapid change. The faster the pace of change, the more rapidly people are being left behind. The share of wealth enjoyed by the top 1% of citizens in the advanced economies has risen from an average of 17% in the late 1980s to more than 23% today (it is 39% in the United States). Countries starting from a more equal distribution of wealth, such as China and the nations of the former Soviet Union, have seen the most rapid rise in inequality[4].

John MacDougall/AFP/Getty

A robot sweeps food towards two dairy cows at an 'automated farm' exhibit at a food and agriculture fair.

Far from levelling the playing field and making the world more 'flat', as is alleged, globalization is making it more mountainous. Place matters more than ever. Cities hold a growing share of wealth and job opportunities, but it is increasingly difficult to afford to live in them. In dynamic ones, such as London, San Francisco, Paris, Berlin, Shanghai and Mumbai, house prices relative to average incomes are at an all-time high.

Technological change is already a key contributor to the growing inequality[5]. This is likely to be exacerbated as machine intelligence and automation take over a growing share of routine tasks in manufacturing and services, including retail, administration and call centres. Over the next 20 years, up to half of US jobs, one-third of jobs in the United Kingdom and the European Union and two-thirds of jobs in China and Mexico may be replaced by computers and robotics[6].

The future will bring new jobs, but their number will be small relative to those lost. And the quality of many of these new jobs will be inferior, in terms of the conditions of work and pay. Although it is tempting to imagine a world in which machines do dangerous and routine jobs, leaving more creative, stimulating and well-paid jobs for humans, this may not come to pass. The pace and scale of technological disruption, which far exceeds that of any previous industrial revolution, raises doubts about our capacity to keep up. We may not be able to redistribute enough funds from the wealthy, or come up with sufficiently creative changes to our systems of work and social safety, to prevent a further rise in inequality[6, 7]. Although this is a major issue for advanced economies, it is even more so for developing countries, because automation may remove key rungs of semi-skilled tasks from the development ladder.

Growing interdependence and complexity also mean that our politicians are increasingly unable to protect or shape our futures. Rather than pursue more cooperative politics, which enhance the benefits of connectivity and mitigate the risks, politicians increasingly blame foreigners and immigrants for the ills. This is profoundly misguided. Immigrants contribute disproportionately to the dynamism of our societies, as can be seen in the talent pool of leading universities, Silicon Valley firms, Nobel prizewinners and patent holders[8].

Those living in the fast-changing cosmopolitan cities of the world are embracing globalization and change: most Londoners did not support Britain's decision to exit from the European Union; people living in dynamic cities tended not to support US President Trump. The populist call for protectionism is driven by those in the United States who fear being left behind. This is not an irrational fear: as is evident from inequality, unemployment and health data, some people are being left behind. There is a correlation, for example, between those who voted for Trump and those whose jobs are vulnerable to having machines take over their jobs[9].

Alongside their anxieties about being left behind by globalization comes a deep mistrust of the 'experts' in charge of the global systems, and a rejection of evidence. Paradoxically, although we know more than ever, rising complexity and speed of change mean that experts are likely to be wrong more often. The financial system, for example, is home to numerous highly

qualified experts, housed in a formidable array of powerful institutions, who are handsomely paid to secure economic stability. Yet, as the 2008 financial crisis demonstrated, they have proved dismally unequal to the task. Similarly, experts in the European Commission seem to have failed to control reporting of emissions from leading car manufacturers. Little wonder that trust in authority has been severely eroded. When the evidence threatens entrenched elites, scepticism regarding expertise becomes particularly poisonous. Trump's dismissal of the science of climate change is an egregious example of this trend.

The flourishing of science was contested in the original Renaissance, too. Printing presses provided the means for experts and intellects to share knowledge, but also allowed fake news to flourish. In Medici Florence, fundamentalist Italian preacher Girolamo Savonarola circumvented the authority of popes and princes with the mass production of one-page pamphlets — the equivalent of today's tweets. Both Savonarola and the clergy denied that Earth went around the Sun, and that the heart was a pump.

Although history does not repeat itself, it does rhyme. In the United Kingdom, campaigners successfully used social media to convince people to support Brexit even when it was against their interests, as in the case of farmers who receive subsidies from the European Union. In the United States, social media that propagated fears rather than facts played a key part in shaping the outcome of the 2016 presidential election[10].

Rapid response

As societies change more rapidly, flexibility becomes more important. For individuals, it becomes more necessary to move to where the jobs are and to reskill. For governments, it is crucial to renew infrastructure and social safety nets. Regulatory frameworks also need to evolve rapidly, to address a widening range of risks — from the genetic enhancement of humans to geoengineering.

Unfortunately, at a time when the need to renew and invest in the future is rising, the ability of governments to keep pace with change is being

undermined. The use of off-shore tax havens — notably by companies at the frontier of technological change — as well as competition by governments to attract increasingly mobile individuals and companies by reducing taxes, together with austerity policies, have reduced the capacity of governments to invest in health, education, infrastructure, social security, research and other expenditures[11]. Lower investment leads to lower growth and political gridlock, as politicians fight over the allocation of fixed or diminishing resources.

Stronger safety nets are necessary to prevent poor and vulnerable individuals and families from being undermined by technological and other changes. If not, social cohesion will be eroded, fanning the flames of populist push-back against change and all things foreign.

Some Silicon Valley billionaires, fearing revolt against the growing wage gap, along with some social activists, have called for the introduction of a Universal Basic Income (UBI) for people working and not. But a UBI is not a panacea. The Organisation for Economic Co-operation and Development has shown that the policy could, perversely, increase inequality and poverty. And, because jobs are so important to our status and self-worth, having money alone does not protect against the increases in morbidity, criminal activity, opioid and alcohol abuse that have been associated with unemployment[12].

Instead, we need a broader change in attitudes towards work. We need to remove the stigmas associated with part-time employment, retirement and volunteer work. We should nurture a greater respect and pay for creative, caring and home-based activities.

There are reasons for optimism. There are more scientists alive today than all those who previously lived; citizen science adds millions more. As well as more minds at work, there are more-diverse collaborations, thanks to greater gender equality and the participation of more nations and peoples. The probability of unlocking mysteries and finding solutions to great challenges is rising, as is the global dissemination of the benefits. Cross-border collaborative projects, from the CERN particle-physics laboratory near Geneva, Switzerland, to the Human Genome Project, highlight the benefits of

cooperative activity, in stark contrast to isolationist politics.

Now, more than ever, scientists must engage and communicate, to ensure that science is not overrun by politics. Renaissance moments are associated with an intensifying battle of ideas. Scientists need to engage in this struggle over the development and application of their expertise and inventions.

In the first Renaissance, extremists won; reason and evidence did not prevail. In our second Renaissance, knowledge and enquiry must find a way to conquer prejudice and ignorance. Scientists know that they can never progress through isolationism or ignorance. Nor can our societies.

Journal name:
Nature
Volume:
550,
Pages:
327–329
Date published:
(19 October 2017)
DOI:
doi:10.1038/550327a

Comments

6 comments

1. *Pentcho Valev* • 2017-10-20 06:53 AM
   Up until recently there was still hope that physics might be resurrected. Scientists had decided to abandon Einstein's absurd spacetime: Nima Arkani-Hamed (06:09): "Almost all of us believe that space-time doesn't really exist, space-time is doomed and has to be replaced by some more primitive building blocks." https://www.youtube.com/watch?v=U47kyV4TMnE Nobel Laureate David Gross observed, "Everyone in string theory is convinced...that spacetime is doomed. But we don't know what it's replaced by." https://www.edge.org/response-detail/26563 What

scientific idea is ready for retirement? Steve Giddings: "Spacetime. Physics has always been regarded as playing out on an underlying stage of space and time. Special relativity joined these into spacetime... [...] The apparent need to retire classical spacetime as a fundamental concept is profound..." https://www.edge.org/response-detail/25477 "Splitting Time from Space - New Quantum Theory Topples Einstein's Spacetime. Buzz about a quantum gravity theory that sends space and time back to their Newtonian roots." https://www.scientificamerican.com/article/splitting-time-from-space/ "And by making the clock's tick relative - what happens simultaneously for one observer might seem sequential to another - Einstein's theory of special relativity not only destroyed any notion of absolute time but made time equivalent to a dimension in space: the future is already out there waiting for us; we just can't see it until we get there. This view is a logical and metaphysical dead end, says Smolin." http://www.guardian.co.uk/books/2013/jun/10/time-reborn-farewell-reality-review Spacetime is a consequence of Einstein's constant-speed-of-light postulate, and since the combination "true postulate, wrong consequence" is forbidden by logic, scientists were actually moving towards the conclusion that the postulate, the "root of all the evil" in fundamental physics, is false: "Special relativity is based on the observation that the speed of light is always the same, independently of who measures it, or how fast the source of the light is moving with respect to the observer. Einstein demonstrated that as an immediate consequence, space and time can no longer be independent, but should rather be considered a new joint entity called "spacetime." http://community.bowdoin.edu/news/2015/04/professor-baumgarte-describes-100-years-of-gravity/ Then extremely dishonest people called LIGO came to power in physics, "discovered" (actually, faked) gravitational waves (ripples in spacetime), and all hope for resurrection of physics died. If you have ripples in spacetime, you cannot claim anymore that "space-time doesn't really exist, space-time is doomed and has to be replaced", can you? Pentcho Valev

2. *Pentcho Valev* • 2017-10-21 06:32 AM

Towards a uniform LIGO science (any theory that in some way contradicts LIGO fakes is doomed): "The simultaneous detection of gravitational waves and light from a cosmic collision has left a few theories of dark matter and dark energy dead in its wake. These theories require gravitational waves - ripples in the fabric of space-time - to travel slower or even faster than the speed of light. But recent observations have proved otherwise. [...] The signals from the smash-up, now named GW170817, show that gravitational waves do indeed travel at the speed of light, to an accuracy of about one in 1 million billion. This seriously undermines some theories that modify Einstein's general relativity to explain the mysterious dark energy thought to be driving the accelerated expansion of our universe, and the invisible dark matter that we detect only through its gravitational pull on ordinary matter." https://www.newscientist.com/article/2151020-dark-energy-survives-neutron-star-crash-test-while-rivals-fail/ Pentcho Valev

3. *Pentcho Valev* • 2017-10-19 06:50 AM

   "Look, my lad, I know a dead parrot when I see one, and I'm looking at one right now." https://www.youtube.com/watch?v=RQhVLHu8HRk Physicists know a dead science when they see one, and they've been looking at one since January 2001: Joao Magueijo, Faster Than the Speed of Light, p. 250: "Lee [Smolin] and I discussed these paradoxes at great length for many months, starting in January 2001. We would meet in cafés in South Kensington or Holland Park to mull over the problem. THE ROOT OF ALL THE EVIL WAS CLEARLY SPECIAL RELATIVITY. All these paradoxes resulted from well known effects such as length contraction, time dilation, or E=mc^2, all basic predictions of special relativity. And all denied the possibility of establishing a well-defined border, common to all observers, capable of containing new quantum gravitational effects." http://www.amazon.com/Faster-Than-Speed-Light-Speculation/dp/0738205257 Neil Turok: "It's the ultimate catastrophe: that theoretical physics has led to this crazy situation where the physicists are utterly confused and seem not to have any predictions at all." http://www2.macleans.ca/2013/09/05/perimeter-institute-and-the-crisis-in-modern-physics/ Frank Close: "In recent

years, however, many physicists have developed theories of great mathematical elegance, but which are beyond the reach of empirical falsification, even in principle. The uncomfortable question that arises is whether they can still be regarded as science. Some scientists are proposing that the definition of what is "scientific" be loosened, while others fear that to do so could open the door for pseudo-scientists or charlatans to mislead the public and claim equal space for their views." http://www.prospectmagazine.co.uk/features/what-happens-when-we-cant-test-scientific-theories Sabine Hossenfelder: "Many of my colleagues believe this forest of theories will eventually be chopped down by data. But in the foundations of physics it has become extremely rare for any model to be ruled out. The accepted practice is instead to adjust the model so that it continues to agree with the lack of empirical support." http://www.nature.com.proxy.readcube.com/nphys/journal/v13/n4/f Sabine Hossenfelder (Bee): "The criticism you raise that there are lots of speculative models that have no known relevance for the description of nature has very little to do with string theory but is a general disease of the research area. Lots of theorists produce lots of models that have no chance of ever being tested or ruled out because that's how they earn a living. The smaller the probability of the model being ruled out in their lifetime, the better. It's basic economics. Survival of the 'fittest' resulting in the natural selection of invincible models that can forever be amended." http://www.math.columbia.edu/~woit/wordpress/?p=9375 Peter Woit: "As far as this stuff goes, we're now not only at John Horgan's "End of Science", but gone past it already and deep into something different." http://www.math.columbia.edu/~woit/wordpress/?p=7266 "But instead of celebrating, physicists are in mourning after a report showed a dramatic decline in the number of pupils studying physics at school. The number taking A-level physics has dropped by 38% over the past 15 years, a catastrophic meltdown that is set to continue over the next few years. The report warns that a shortage of physics teachers and a lack of interest from pupils could mean the end of physics in state schools. Thereafter, physics would be

restricted to only those students who could afford to go to posh schools. Britain was the home of Isaac Newton, Michael Faraday and Paul Dirac, and Brits made world-class contributions to understanding gravity, quantum physics and electromagnetism - and yet the British physicist is now facing extinction. But so what? Physicists are not as cuddly as pandas, so who cares if we disappear?" http://www.guardian.co.uk/science/2005/nov/22/schools.g2 Peter Woit: "If, as seems increasingly all too possible, we're now at an endpoint of fundamental physics, with the field killed off by a pseudo-scientific argument..." http://www.math.columbia.edu/~woit/wordpress/?p=9444 Peter Woit: "I think the worst thing that has happened to theoretical physics over the past 25 years is this descent into ideology, something that has accelerated with the multiverse mania of the last 10-15 years." http://www.math.columbia.edu/~woit/wordpress/?p=9375 The last quotation is correct, except for the number 25 - it should be replaced by 112 (note the "embarrassing question" that will have to be answered soon): "This paper investigates an alternative possibility: that the critics were right and that the success of Einstein's theory in overcoming them was due to its strengths as an ideology rather than as a science. The clock paradox illustrates how relativity theory does indeed contain inconsistencies that make it scientifically problematic. These same inconsistencies, however, make the theory ideologically powerful. [...] The gatekeepers of professional physics in the universities and research institutes are disinclined to support or employ anyone who raises problems over the elementary inconsistencies of relativity. A winnowing out process has made it very difficult for critics of Einstein to achieve or maintain professional status. Relativists are then able to use the argument of authority to discredit these critics. Were relativists to admit that Einstein may have made a series of elementary logical errors, they would be faced with the embarrassing question of why this had not been noticed earlier. Under these circumstances the marginalisation of antirelativists, unjustified on scientific grounds, is eminently justifiable on grounds of realpolitik. Supporters of relativity theory have

protected both the theory and their own reputations by shutting their opponents out of professional discourse. [...] The triumph of relativity theory represents the triumph of ideology not only in the profession of physics bur also in the philosophy of science." Peter Hayes, The Ideology of Relativity: The Case of the Clock Paradox http://www.informaworld.com/smpp/content~content=a909857880 And when ideology replaces science, bureaucrats replace scientists of course: Mike Alder: "It is easy to see the consequences of the takeover by the bureaucrats. Bureaucrats favour uniformity, it simplifies their lives. They want rules to follow. They prefer the dead to the living. They have taken over religions, the universities and now they are taking over Science. And they are killing it in the process. The forms and rituals remain, but the spirit is dead. The cold frozen corpse is so much more appealing to the bureaucratic mind-set than the living spirit of the quest for insight. Bureaucracies put a premium on the old being in charge, which puts a stop to innovation. Something perhaps will remain, but it will no longer attract the best minds. This, essentially, is the Smolin position. He gives details and examples of the death of Physics, although he, being American, is optimistic that it can be reversed. I am not. [...] Developing ideas and applying them is done by a certain kind of temperament in a certain kind of setting, one where there is a good deal of personal freedom and a willingness to take risks. No doubt we still have the people. But the setting is gone and will not come back. Science is a product of the renaissance and an entrepreneurial spirit. It will not survive the triumph of bureacracy. Despite having the infrastructure, China never developed Science. And soon the West won't have it either." https://www.highbeam.com/doc/1G1-172684821.html Pentcho Valev

4. *Pentcho Valev* • 2017-10-18 04:30 PM

   Fundamental physics is paralyzed, even killed, by blind faith in false principles. The falsehood of Einstein's constant-speed-of-light postulate is easy to prove but I'm not going to do this here. Let me just call the attention, by quoting Joao Magueijo, to the validity of the following conditional: If Einstein's constant-speed-of-light postulate is false, fundamental physics is dead. "The speaker Joao

Magueijo, is a Reader in Theoretical Physics at Imperial College, London and author of Faster Than the Speed of Light: The Story of a Scientific Speculation. He opened by explaining how Einstein's theory of relativity is the foundation of every other theory in modern physics and that the assumption that the speed of light is constant is the foundation of that theory. Thus a constant speed of light is embedded in all of modern physics and to propose a varying speed of light (VSL) is worse than swearing! It is like proposing a language without vowels." http://www.thegreatdebate.org.uk/VSLRevPrnt.html "...Dr. Magueijo said. "We need to drop a postulate, perhaps the constancy of the speed of light." http://www.nytimes.com/2002/12/31/science/e-and-mc2-equality-it-seems-is-relative.html "But the researchers said they spent a lot of time working on a theory that wouldn't destabilise our understanding of physics. "The whole of physics is predicated on the constancy of the speed of light," Joao Magueijo told Motherboard. "So we had to find ways to change the speed of light without wrecking the whole thing too much." http://www.telegraph.co.uk/technology/2016/12/06/speed-light-discovered/ Joao Magueijo, Faster Than the Speed of Light, p. 250: "Lee [Smolin] and I discussed these paradoxes at great length for many months, starting in January 2001. We would meet in cafés in South Kensington or Holland Park to mull over the problem. THE ROOT OF ALL THE EVIL WAS CLEARLY SPECIAL RELATIVITY. All these paradoxes resulted from well known effects such as length contraction, time dilation, or E=mc^2, all basic predictions of special relativity. And all denied the possibility of establishing a well-defined border, common to all observers, capable of containing new quantum gravitational effects." http://www.amazon.com/Faster-Than-Speed-Light-Speculation/dp/0738205257 Pentcho Valev

5. *Pentcho Valev* • 2017-10-18 05:19 PM

   Another science killer is the false second law of thermodynamics. Systems violating the second law are commonplace but scientists always turn the blind spot of the eye to them. Here is vigorous motion of water in an electric field, obviously able to produce work

- e.g. by rotating a waterwheel: "The Formation of the Floating Water Bridge including electric breakdowns" https://www.youtube.com/watch?v=17UD1goTFhQ "The water movement is bidirectional, i.e., it simultaneously flows in both directions." https://www.wetsus.nl/home/wetsus-news/more-than-just-a-party-trick-the-floating-water-bridge-holds-insight-into-nature-and-human-innovation/1 The work (rotating a waterwheel) will be done at the expense of what energy? The first hypothesis that comes to mind is: At the expense of electric energy. The system is, essentially, an electric motor. However close inspection would suggest that the hypothesis is untenable. Scientists use triply distilled water to reduce the conductivity and the electric current passing through the system to minimum. If, for some reason, the current is increased, the motion stops - such system cannot be an electric motor. If the system is not an electric motor, then it is a heat engine violating the second law of thermodynamics. Here arguments describing such heat engines as impossible, idiotic, etc. are irrelevant - the following conditional is valid: IF THE SYSTEM IS NOT AN ELECTRIC MOTOR, then it is a a heat engine violating the second law of thermodynamics. In other words, if the work is not done at the expense of electric energy, it is done at the expense of ambient heat. No third source of energy is conceivable. In the electric field between the plates of a capacitor, the same turbulent motion can be seen: " Liquid Dielectric Capacitor" http://www.youtube.com/watch?v=T6KAH1JpdPg In the capacitor system the rising water can repeatedly do work, e.g. by lifting floating weights. The crucial question is: The work (lifting floating weights) will be done at the expense of what energy? Obviously "electric energy" is not the correct answer - the capacitor is not an electric motor. Then the only possible answer remains "ambient heat". The system is a heat engine violating the second law of thermodynamics! Pentcho Valev

6. *Pentcho Valev* • 2017-10-19 07:03 AM

   Why scientists are unable to see the obvious violations of the second law of thermodynamics: Clifford Truesdell, The Tragicomical History of Thermodynamics, 1822-1854, p. 6: "Finally, I confess to a heartfelt hope - very slender but tough - that

even some thermodynamicists of the old tribe will study this book, master the contents, and so share in my discovery: Thermodynamics need never have been the Dismal Swamp of Obscurity that from the first it was and that today in common instruction it is; in consequence, it need not so remain." [...] p. 333: "Clausius' verbal statement of the "Second Law" makes no sense, for "some other change connected therewith" introduces two new and unexplained concepts: "other change" and "connection" of changes. Neither of these finds any place in Clausius' formal structure. All that remains is a Mosaic prohibition. A century of philosophers and journalists have acclaimed this commandment; a century of mathematicians have shuddered and averted their eyes from the unclean." https://www.amazon.com/Tragicomical-Thermodynamics-1822-1854-Mathematics-Physical/dp/1461394465 Jos Uffink, Bluff your way in the Second Law of Thermodynamics: "I therefore argue for the view that the second law has nothing to do with the arrow of time. [...] Before one can claim that acquaintance with the Second Law is as indispensable to a cultural education as Macbeth or Hamlet, it should obviously be clear what this law states. This question is surprisingly difficult. The Second Law made its appearance in physics around 1850, but a half century later it was already surrounded by so much confusion that the British Association for the Advancement of Science decided to appoint a special committee with the task of providing clarity about the meaning of this law. However, its final report (Bryan 1891) did not settle the issue. Half a century later, the physicist/philosopher Bridgman still complained that there are almost as many formulations of the second law as there have been discussions of it. And even today, the Second Law remains so obscure that it continues to attract new efforts at clarification." http://philsci-archive.pitt.edu/313/1/engtot.pdf Pentcho Valev

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Brazilian Amazon still plagued by illegal use of natural resources

Practices such as poaching and illegal logging are concentrated near inhabited areas and along rivers, study finds.

17 October 2017

Jeff Hutchens/Getty

An official with Brazil's environmental enforcement agency arrests poachers caught near Manaus.

Despite Brazil’s efforts to safeguard the Amazon rainforest by establishing protected areas and boosting law enforcement, illegal use of the region’s natural resources is still widespread, according to a study[1] published on 10

October in *PeerJ*.

The researchers looked at 4,243 law-enforcement records from between 2010 and 2015, across 118 federally protected areas of the Brazilian Amazon. Although the overall number of citations decreased over those five years, illegal activities still occurred in nearly every protected area. The analysis highlighted the need for improved monitoring and enforcement, says study co-author Érico Kauano, a conservation biologist at the Chico Mendes Institute for Biodiversity Conservation (ICMBio), the Brazilian agency responsible for the management of the federal protected areas.

Kauano and his colleagues grouped illegal activities into ten categories, and found that 37% of the infractions fell into the "suppression and degradation of vegetation" group, which included deforestation, logging of endangered tree species and the unauthorized use of fire. Illegal fishing was the next most common citation at 27%, followed by hunting at 18%. Most of the illegal activity occured in more accessible and densely populated areas.

Roads have a major role in opening up the tropics to colonization and exploitation[2]. Deforestation of the Brazilian Amazon increased after the construction of the Belém–Brasília Highway in the 1960s, and continued with the opening of the Trans-Amazonian Highway in 1970s. A 2014 study[2] using satellite images found that around 95% of the deforestation in Brazil's Amazon occurred within 5.5 kilometres of a road and within 1 kilometre of a navigable river.

Caught in the act

The availability and use of government data are what sets this study apart from others, says Emilio Bruna, a tropical ecologist at the University of Florida in Gainesville, who was not involved in the study. Past studies, including a paper[3] published last month in *Biotropica* (where Bruna is editor-in-chief), struggled to obtain even the most basic information, such as how many staff members were employed by the agency that manages protected areas, and how much they were paid, Bruna says.

Data from efforts on the ground are important because, although remote-sensing instruments such as satellites can detect deforestation, for example, they fail to identify threats present beneath the forest canopy. Law-enforcement records, when available, can complement remote-sensing data sets, the study authors say.

"You can actually tell what it is they're writing infractions for, and that's valuable," says Bruna. But he points out that, without knowing where law-enforcement efforts are being allocated, it's only a partial picture. "It could be that the reason certain protected areas have the most infractions is because those are the places that are under the greatest threat," he says. "Or it could be because that's where the greatest enforcement is being focused."

Greater enforcement

"We are still far from having adequate staff in the protected areas," Kauano says. In 2014, a local news outlet reported that the Brazilian Institute of Environment and Renewable Natural Resources had only 47 agents to monitor environmental crimes in Amazonas, the country's largest state in the Amazon region, which covers an area of about 1.6 million square kilometres.

Hiring more enforcement officials looks unlikely in the short term, however, owing to Brazil's ongoing political and economic crisis, says Kauano. "What ICMBio seeks to do to overcome this is to prioritize some regions with greater problems."

Bruna cautions against jumping to conclusions from the study's results, however. "Not all infractions are created equal," he says. It's important to differentiate between a resident fishing out of season and a fishing charter operator. Bruna worries that some may look at this study and think that the people living near protected areas are the problem. But they aren't the only ones breaking the law, he says. And the demand for the fruits of this illegal labour comes from all over the world.

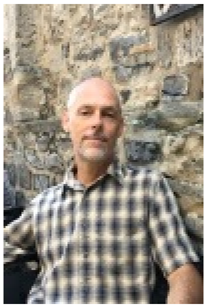
Local people can, in fact, be part of the solution. There is some evidence that people living in or near protected areas are helping with conservation, says

Kauano. But he adds that the government needs to make a greater effort to work with local communities.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22830

Comments

Commenting is currently unavailable.



Ellie R. Martinson

Give researchers a lifetime word limit

Brian C. Martinson[1] imagines how rationing the number of publications a scientist could put out might improve the scientific literature.

17 October 2017

A dirty truth pervades academic publishing: we write papers to gain credit in an academic marketplace. Almost a quarter of a century ago, academic worthies lamented that scholarly publications had become “the coins academics must use to get through the tollgates on their way to academic promotion” (D. Rennie and A. Flanagin *J. Am. Med. Assoc.* **271**, 469–471; 1994). In some cases, papers in flashy journals truly do bring in hard cash — reportedly more than US$40,000 at some universities in China. And plenty of people reading this will have felt they’d better squeeze a paper or two out soon to have any chance of getting their next grant proposal funded.

The purpose of authorship has shifted. Once, its primary role was to share knowledge. Now it is to get a publication — ‘pubcoin’ if you will. Authorship has become a valuable commodity. And as with all valuable commodities, it is bought, sold, traded and stolen. Marketplaces allow

unscrupulous researchers to purchase authorship on a paper they had nothing to do with, or even to commission a paper on the topic of their choice. ‘Predatory publishers’ strive to collect fees without ensuring quality.

I have spent much of my career studying how academic and clinical workplaces influence how carefully researchers conduct their studies. The commodification of authorship encourages all manner of corner-cutting, sloppiness in research, and other degradations in the quality of publications, not to mention an obvious motive for plagiarism. A quest for high-profile papers leads researchers to favour a spectacular result, even if it is specious. Authors cite themselves to boost the impact of publications, and cite colleagues to curry favour.

At this point, it is hard even to envisage a world in which the communication of knowledge could return to its rightful place as the focus of academic authorship. But if we cannot imagine something, we cannot attain it. So let me try. Imagine a world in which each scientist is allotted a fixed number of words that they can publish over her or his career. I’m not the first person to suggest this: the Australian writer Michael McGirr has proposed a word limit for every person.

What would happen? Might authorship regain its original purpose?

Lifetime limits would create a natural incentive to do research that matters. Researchers would have to ask themselves, “Is this project I’m pursuing worth the words it will cost me?” I see several articles in my own CV that did not contribute much knowledge to the world. I cannot help but think that I might have pursued better questions had a word limit been in place.

Ideally, limits would encourage researchers to ensure that research is conducted with the utmost care. (Imagine losing part of your allotment of words to a paper that is discredited or even retracted.) This would provide a counterweight to the pressure to publish quickly for priority. It would also lead to increased value being placed on concision and clarity, improving readability and efficiency. Honorary authorship would become much less attractive.

With less time needing to be spent on papers of low quality or containing

little new information, readers and editors would be able to give the smaller number of articles more attention. Editorial workload would be reduced by virtue of the lower volume and the higher quality of material. This might reduce editorial costs, enhance quality, and quite possibly enhance the job satisfaction and quality of life of editors and readers. Predatory publishers would vanish.

With a boost in the quality of scientific papers, the communal work of peer review would get easier. Individual researchers would be asked to carry out fewer reviews. Reviewing invitations would be for work of higher quality, making the job more enjoyable and less aggravating. And knowing the stakes for the authors in expending their precious words, reviewers themselves might be inclined to put more time and effort into their reviews, further improving quality.

The task of evaluating candidates for jobs, advancement and prizes would become less scattershot. With fewer publications per candidate, promotion and tenure committees could become less reliant on tallying counts of first-authored publications, and devote time to reading and critiquing the published work. This, in turn, should reduce their use of journal impact factors as proxies for quality.

Limits would of course bring a new set of problems: if we don't also address our own cognitive biases and penchant for compelling narratives, word limits could exacerbate tendencies to publish only positive findings, leading researchers to explore blind alleys that others' negative results could have illuminated. Researchers might skimp on a full description of caveats, previous work and methods. Some subjects and pursuits might be inherently wordier than others. Exceptions might have to be made for experts such as statisticians and bioinformaticians whose skills are required on many papers — but perhaps this would boost the quality of collaborations. Perhaps researchers could apply for word bonuses for careful reproductions, cautious interpretations and meticulously described methods.

Would these drawbacks be worse than the current incentives to publish as much as you can? We have lost sight of information sharing as the primary reason for publishing. Perhaps my flight of fancy is a rose-tinted remembrance of times past. Or perhaps it can serve as a guide to restore the

exchange of ideas to its rightful, pithy, place.

Journal name:
Nature
Volume:
550,
Pages:
303
Date published:
(19 October 2017)
DOI:
doi:10.1038/550303a

Comments

Commenting is currently unavailable.

Japanese research leaders warn about national science decline

Concern mounts over budget cuts and other changes that undermine basic science.

17 October 2017 Corrected:

1. 20 October 2017

Toru Hanai/Reuters

People gather for a rally in Fukushima, Japan, for Prime Minister Shinzo Abe and the Liberal Democratic Party.

As Japan heads towards a national election on 22 October, scientific leaders worry that the outcome will do little to address long-standing concerns about the country’s deteriorating research landscape. They say that a decline in funding and a shift away from basic research has undermined Japan’s capacity to compete against both established scientific powerhouses and emerging ones such as China.

Since 25 September, when Prime Minister Shinzo Abe called for a snap election, science has barely featured in the campaign. Debate has focused on the government’s plan to amend the constitution and increase taxes. The latest polls suggest that Abe’s conservative Liberal Democratic Party could lose some seats, but will retain enough to lead a coalition government.

If Abe is re-elected, he says, his government will pursue an innovation agenda. At a meeting of global science leaders in Kyoto on 1 October, Abe reaffirmed his pledge to turn Japan into “a cradle of innovation” by cutting regulations that impede new technologies.

Despite Abe’s lofty ambitions, the ruling party coalition has decreased the science and technology budget by more than 5% overall since it came to power in 2012. And the budget for universities has dropped by about 1% a year for a decade. “This has been pointed out as the major cause of the deterioration of research performance and, eventually, the global rank of Japanese universities,” says Takashi Onishi, president of Toyohashi University of Technology and a former president of the Science Council of Japan, which advises the government. In the past two decades, the country’s share of highly cited papers has stagnated, whereas those of many other leading nations are rising, according to publisher Elsevier’s Scopus database.

In an attempt to elevate Japan’s top research universities, the government has introduced reforms that categorize institutions according to their research or teaching focus, and that allocate funding on the basis of performance. The government wants leading research institutions to compete globally for the best students and faculty.

Atsushi Sunami, a science-policy specialist at the National Graduate Institute for Policy Studies (GRIPS) in Tokyo, agrees with this aim, but says that to succeed, the government will need to increase its research funding. And

money alone will not be enough, says Hiroshi Nagano, also a science-policy specialist at GRIPS. For universities to become world class, they need autonomy to decide their research and teaching focus, he says. “The current policy is oriented in the opposite direction.”

Basic research left behind

Changes to the university system implemented by Abe’s government are designed to make academia more responsive to the needs of society and industry, in the hope that it will boost low private-sector investment in research. Although scientists broadly encourage this increased collaboration, some say that it has compromised support for basic research. “The government should focus on the development of basic research to supply seeds or ideas to applied sciences,” says Onishi.

Science leaders point to other big concerns about the future of Japanese research. Michinari Hamaguchi, head of the Japan Science and Technology Agency in Tokyo, says that the domestic workforce will be insufficient to keep up with changes in science, technology and innovation, given the country’s rapidly ageing population. He says that policies are urgently needed to encourage more women and foreigners into science and to boost the number of students in doctoral courses, which has dropped by 18% since 2003.

Students who pursue research careers are finding it harder to get jobs. Budget cuts have depleted permanent research positions at universities, and fewer younger researchers are securing permanent posts: the number of research associates on short-term contracts more than doubled from 2007 to 2013.

Biologist and 2016 Nobel prizewinner Yoshinori Ohsumi has warned that the situation for young researchers will jeopardize the country’s chances of winning future Nobel prizes. Japan has the second-highest number of science laureates in the twenty-first century after the United States — but, Ohsumi says, that record is unlikely to hold.

Journal name:

Nature
Volume:
550,
Pages:
310–311
Date published:
(19 October 2017)
DOI:
doi:10.1038/550310a

Corrections

Corrected:

An earlier version of this story misspelled the name of Michinari Hamaguchi. Also, he is based in Tokyo, not in Kawaguchi.

Comments

Comments

There are currently no comments.

Reboot for the AI revolution

17 October 2017

As artificial intelligence puts many out of work, we must forge new economic, social and educational systems, argues Yuval Noah Harari.

Laura Lezza/Getty

A robot conducts the Orchestra Filarmonica di Lucca at Teatro Verdi in Pisa, Italy, this September.

The ongoing artificial-intelligence revolution will change almost every line of work, creating enormous social and economic opportunities — and challenges. Some believe that intelligent computers will push humans out of the job market and create a new 'useless class'; others maintain that

automation will generate a wide range of new human jobs and greater prosperity for all. Almost everybody agrees that we should take action to prevent the worst-case scenarios.

The automation revolution is emerging from the confluence of two scientific tidal waves. Computer scientists are developing artificial intelligence (AI) algorithms that can learn, analyse massive amounts of data and recognize patterns with superhuman efficiency. At the same time, biologists and social scientists are deciphering human emotions, desires and intuitions. The merger of infotech and biotech is giving rise to algorithms that can successfully analyse us and communicate with us, and that may soon outperform human doctors, drivers, soldiers and bankers in such tasks. These algorithms could eventually push hundreds of millions out of the job market.

Governments might decide to deliberately slow down the pace of automation, to lessen the resulting shocks and allow time for readjustments. But it will probably be both impossible and undesirable to prevent automation and job loss completely. That would mean giving up the immense positive potential of AI and robotics. If self-driving vehicles drive more safely and cheaply than humans, it would be counterproductive to ban them just to protect the jobs of taxi and lorry drivers.

A more sensible strategy is to create new jobs. In particular, as routine jobs are automated, opportunities for new non-routine jobs will mushroom. For example, general physicians who focus on diagnosing known diseases and administering familiar treatments will probably be replaced by AI doctors. Precisely because of that, there will be more money to pay human experts to do groundbreaking medical research, develop new medications and pioneer innovative surgical techniques.

This calls for economic entrepreneurship and legal dexterity. Above all, it necessitates a revolution in education.

Lifelong learning

To make use of the new opportunities, people will need radical, lifelong

retraining. The AI revolution won't be a single event after which the job market and the educational system will settle into a new equilibrium. Rather, it will be a cascade of ever-bigger disruptions. Even today, few employees expect to work in the same job for their entire life (see go.nature.com/2ymdvjs). By 2050, not just the idea of 'a job for life', but even the idea of 'a profession for life' might seem antediluvian. It will become increasingly difficult to know what to teach schoolchildren and university students.

Predicting the future was never easy. If you lived in China 1,000 years ago, there were many things you didn't know: the empire might collapse in 50 years; the Khitans might invade, or a new plague might kill millions. Nevertheless, you did know that most people would still work as farmers and weavers, rulers would still need men to fight in their armies and administer their taxes, women would still have few opportunities beyond marriage and life expectancy would still be about 40 years.

LISTEN

Reporter Benjamin Thompson finds out how lessons from the past can help explore the future of work.

You may need a more recent browser or to install the latest version of the Adobe Flash Plugin.

Hence, in 1017, poor Chinese parents taught their children how to plant rice or weave silk, and wealthier parents taught their boys how to read and write, or to fight on horseback, and their girls to be modest and obedient housewives. It was obvious that these skills would still be needed. In 2017, by contrast, we have no such certainties about the future of jobs, gender, economics or even death.

Human psychology, too, might turn out to be a key hurdle. Change is always stressful. Already we face an epidemic of stress and anxiety (see go.nature.com/2z96s57). As the volatility of the job market and of individual careers increases, we may wonder whether everyone will have the emotional

stamina necessary for a life of constant flux. We may need more-effective stress-reduction techniques — ranging from drugs through neurofeedback to meditation — to cope.

Creating new jobs might prove easier than retraining people to fill them. A huge useless class might appear, owing to both an absolute lack of jobs and a lack of relevant education and mental flexibility.

Test cases

It is particularly important to identify as early as possible the potential winners and losers from new technologies. Rosy overall statistics can hide growing gaps between disparate groups. Automation might have a very different impact on men and women, on 40-somethings and 20-somethings, on the university-educated and the illiterate.

The winners and losers are not the usual suspects. In the clinic, for example, automation might prove more of a threat to doctors than to nurses. Many physicians focus almost exclusively on processing information: they absorb medical data, analyse them and produce a diagnosis. Nurses also need good motor and emotional skills, to give a painful injection, replace a bandage and listen with care. We will probably have an AI family doctor on our smartphone years before we have a reliable nurse robot[1].

Exploring the relationship between intelligence and consciousness will also be crucial to understanding the economic, professional and ethical rapport between future computers and humans. We are seeing a tremendous development in computer intelligence, but zero development in computer consciousness. Just as aeroplanes fly faster than birds without ever developing feathers, so computers could come to solve problems and even to analyse human feelings much better than humans, without ever developing feelings. Studying these differences will help us to predict what AI can and cannot do, and to decide what should be kept out of its control.

There are a few areas in which AI has already made significant strides that, in my view, offer test cases for the impact of modern automation on the world

of work.

In chess, it has been 20 years since IBM's Deep Blue computer thrashed Gary Kasparov. Yet humans still play chess, and 'centaur' teams of humans-plus-AIs can outperform both. This seems at first to bode well for the future: the job market could nurture people who can leverage, rather than compete with, AI. Yet the balance of power in centaur teams is constantly shifting. Computers are becoming so good at chess that the humans are gradually losing value, and could soon become irrelevant. The same thing might happen in other human–AI teams[2].

Laura Lezza/Getty

A woman with a robot at an Italian nursing home in 2015.

Self-driving vehicles are another important test case. The race to produce self-driving vehicles now pits old steel giants such as Mercedes-Benz against new silicon giants such as Google. Transport leverages one of the core advantages of AI: connectivity. Even if a single computer-driven car is less

competent than a good human driver, a network of computer-driven cars is still likely to be much safer and more efficient than the chaos of fallible human drivers that currently dominates the roads.

Today, about 1.25 million people are killed annually in car accidents[3], more than 90% of which are estimated to be caused by human errors[4]. When two human drivers approach the same junction, they might miscommunicate and collide. But computer-driven vehicles can be connected — the chances that they might miscommunicate and collide are therefore much smaller. Similarly, it is easier to ensure that automated vehicles comply with rules such as speed limits (not to mention the ban on drink driving), even as those rules change[5, 6, 7].

Self-driving vehicles illustrate two important points. First, that in some fields it might make sense to replace all humans with robots and computers, even if individually some humans do a better job. Second, that when change comes to some realms, it might do so suddenly, not step-wise.

The military is another important bellwether, because armies are early adopters of much technology. Human soldiers carry a very high economic and political price tag, so replacing people with computers on the battlefield has proved attractive. The most advanced armies now increasingly rely on relatively small numbers of experts coupled with sophisticated and autonomous technologies, such as drones, robots, smart bombs, cyberworms and algorithms that sift through a mass of data[8, 9].

This shift has produced new classes of military jobs in maintenance, remote control, programming and cybersecurity. The US armed forces need 30 people to operate every Predator or Reaper drone flying over Syria, and analysing the harvest of information occupies at least 80 more. A careful study of the military job market might tell us a lot about potential future developments in the civilian economy.

New order

With insights gleaned from early warning signs and test cases, scholars

should strive to develop new socio-economic models. The old ones no longer hold. For example, twentieth-century socialism assumed that the working class was crucial to the economy, and socialist thinkers tried to teach the proletariat how to translate its immense economic power into political clout. In the twenty-first century, if the masses lose their economic value they might have to struggle against irrelevance rather than exploitation.

One new model has been gaining increasing attention and popularity: universal basic income (UBI). UBI suggests that the government should tax the rich and big corporations to provide every person with a stipend covering his or her basic needs. This will cushion the poor against job loss and economic dislocation, and protect the rich from populist rage. It will also free the masses to engage in more creative forms of work that might not currently have economic value, or to pursue further education.

In January 2017, Finland began a 2-year experiment, providing 2,000 unemployed citizens with €560 (US$657) per month, irrespective of whether they work. Similar experiments are under way in the Canadian province of Ontario, in the Italian city of Livorno and in several Dutch cities[10].

Of course, such national and municipal schemes might not solve the worst problems. Globalization has made people in one country utterly dependent on markets in others, and automation might unravel large parts of this global trade network with disastrous consequences for the weakest links. AI might generate immense wealth in hi-tech hubs such as Silicon Valley and Bangalore, while devastating the economies of underdeveloped countries that rely on cheap labour, such as Honduras and Bangladesh.

US voters might conceivably agree that taxes paid by tech giants Amazon and Google for their US business should be used to give stipends to unemployed coalminers in Pennsylvania or jobless taxi-drivers in New York. But they are unlikely to send their taxes to Honduras. We are still far from having any feasible models for a post-work economy, society or political system, and we don't have much time to formulate them.

In the nineteenth century, the Industrial Revolution created new conditions and problems that none of the existing social, economic and political models could cope with. Consequently, humankind had to develop completely new

models — liberal democracies, communist dictatorships and fascist regimes. It took more than a century of terrible wars and revolutions to experiment with these, separate the wheat from the chaff and implement the best solutions.

The challenges posed in the twenty-first century by the merger of infotech and biotech are arguably bigger than those thrown up by steam engines, railways, electricity and fossil fuels. Given the immense destructive power of our modern civilization, we cannot afford more failed models, world wars and bloody revolutions. We have to do better this time.

Journal name:
Nature
Volume:
550,
Pages:
324–327
Date published:
(19 October 2017)
DOI:
doi:10.1038/550324a

Comments

Comments

There are currently no comments.

Nature News

周四, 05 10月 2017

Nature News

[周四, 05 10月 2017]

- **Nature News**

Nature News

Nature is a weekly international journal publishing the finest peer-reviewed research in all fields of science and technology on the basis of its originality, importance, interdisciplinary interest, timeliness, accessibility, elegance and surprising conclusions. Nature also provides rapid, authoritative, insightful and arresting news and interpretation of topical and coming trends affecting science, scientists and the wider public.

- **Antikythera shipwreck yields statue pieces and mystery bronze disc** [周三, 04 10月 08:00]
  Archaeologists think that at least seven life-sized sculptures are hidden nearby.
- **Cryo-electron microscopy wins chemistry Nobel** [周三, 04 10月 08:00]
  Jacques Dubochet, Joachim Frank and Richard Henderson share the prize for developing a technique to image biomolecules.
- **Crash in sea-turtle births stumps ecologists** [周三, 04 10月 08:00]
  Leading suspect — climate change — doesn't fully explain what is happening to leatherback turtles in the US Virgin Islands.
- **Scientists plead with Brazilian government to restore funding** [周三, 04 10月 08:00]
  If officials don't act soon, research institutions could start shutting down next year.
- **Supercomputer redesign of aeroplane wing mirrors bird anatomy** [周三, 04 10月 08:00]
  Bird-bone structures emerge from an evolution-like algorithm.
- **Elite Hungarian university may be saved** [周三, 04 10月 08:00]
  Hungary-New York agreement could allow Central European University to sidestep law change.
- **Science without walls is good for all** [周三, 04 10月 08:00]
  International mobility and collaboration are linked to stronger research.
- **Nobel prizes, giant telescope and buried treasure** [周三, 04 10月 08:00]
  The week in science: 29 September–5 October 2017.
- **Why fake islands might be a real boon for science** [周三, 04 10月 08:00]
  The seasteading movement is getting close to building its first prototype, an artificial archipelago where people will live, play and do research.
- **How fracking is upending the chemical industry** [周三, 04 10月 08:00]
  As shale-gas compounds flood the market, chemists are working out the best ways to convert them into the ingredients of modern life.

- **[Scientists have most impact when they're free to move]** [周三, 04 10月 08:00]
  An analysis of researchers' global mobility reveals that limiting the circulation of scholars will damage the scientific system, say Cassidy R. Sugimoto and colleagues.
- **[Open countries have strong science]** [周三, 04 10月 08:00]
  Caroline S. Wagner and Koen Jonkers find a clear correlation between a nation's scientific influence and the links it fosters with foreign researchers.
- **[Neuroscience: The mother lode of invention]** [周三, 04 10月 08:00]
  Dan Jones compares three studies on the origins and fruits of human creativity.
- **[Health: The war on germs]** [周三, 04 10月 08:00]
  Tilli Tansey hails a history of Joseph Lister's drive to vanquish post-operative infection and putrefaction.
- **[New in paperback]** [周三, 04 10月 08:00]
  Highlights of this season's releases
- **[Sustainability: China's path to ecotopia]** [周三, 04 10月 08:00]
  Xuemei Bai critiques a critique of the country's eco-city initiative.
- **[Ornithology: All eyes on the 10,000 species]** [周三, 04 10月 08:00]
  Stuart Pimm considers the obsessive, sometimes dark side to the joyous pursuit of watching birds.
- **[Theoretical physics: When the doer met the dreamer]** [周三, 04 10月 08:00]
  Graham Farmelo applauds a study on the productive friendship of two very different physicists.
- **[Technology: Into cyberia]** [周三, 04 10月 08:00]
  Li Gong weighs up three tomes on Silicon Valley's vast influence, for good or ill.
- **[Fossil fuels: Heed local impact of coal mining]** [周三, 04 10月 08:00]
- **[Hurricanes: rescue natural defences]** [周三, 04 10月 08:00]
- **[Hurricanes: enlist nature's protection]** [周三, 04 10月 08:00]
- **[World Heritage Site: UNESCO honour for Polish mining facility]** [周三, 04 10月 08:00]
- **[Food supply: Blockchain could boost food security]** [周三, 04 10月 08:00]
- **[Collaborative software development made easy]** [周三, 04 10月 08:00]
  Save time and protect critical code with 'continuous integration' services.
- **[A taste of Toolbox]** [周三, 04 10月 08:00]
  Nature 's technology editor, Jeffrey Perkel, started blogging about workplace technology in science in 2016. Here are some highlights.
- **[The daughter you've always wanted]** [周三, 04 10月 08:00]

Family matters.

- **[South Korea cracks down on dirty air]** [周二, 03 10月 08:00]
  Despite huge clean-up effort, scientists say country’s pollution problem could get worse over next five years.
- **[Xenon view, butterfly wings and a strange squid]** [周二, 03 10月 08:00]
  September’s sharpest science shots, selected by Nature ’s photo team.
- **[Europe’s Joint Research Centre, although improving, must think bigger]** [周二, 03 10月 08:00]
  External report criticizes lack of exploratory research.
- **[Make plans to eliminate cholera outbreaks]** [周二, 03 10月 08:00]
  Governments must stop denying the occurrence of cholera and unite in long-term prevention strategies, says Anita Zaidi.
- **[Ethics of Internet research trigger scrutiny]** [周二, 03 10月 08:00]
  Concern over the use of public data spurs guideline update.
- **[Gravitational wave detection wins physics Nobel]** [周二, 03 10月 08:00]
  Rainer Weiss, Barry Barish and Kip Thorne share the 2017 prize for their work at LIGO to detect ripples in space-time.
- **[Risk of human-triggered earthquakes laid out in biggest-ever database]** [周一, 02 10月 08:00]
  Geologists track hundreds of quakes caused by people and the projects that set them off.
- **[Discoveries have awkward first dates]** [周一, 02 10月 08:00]
  Fuzzy timings over a plate-tectonics anniversary highlight the rolling nature of scientific discovery.
- **[Chinese scientists fix genetic disorder in cloned human embryos]** [周一, 02 10月 08:00]
  A method for precisely editing genes in human embryos hints at a cure for a blood disease.
- **[Medicine Nobel awarded for work on circadian clocks]** [周一, 02 10月 08:00]
  Jeffrey Hall, Michael Rosbash and Michael Young unpicked molecular workings of cells' daily rhythms.
- **[Parakeet invasion of Mexico driven by Europe’s ban on bird imports]** [周五, 29 9月 08:00]
  Attempts to stop the spread of bird flu and protect wildlife had unintended consequences.
- **[Time capsule buried to preserve science for the ages]** [周五, 29 9月 08:00]
  Message in a bottle sums up state of research in 2017.
- **[Tsunami wreckage serves as liferafts for invasive species]** [周五, 29 9月 08:00]
  Hundreds of species can subsist for years on tsunami debris.

- **[Tropical forests may be carbon sources, not sinks]** [周五, 29 9月 08:00]
  Combination of satellite images and on-the-ground data enables more complete tracking of forest carbon flows.
- **[French government proposes big science-spending boost]** [周五, 29 9月 08:00]
  President Emmanuel Macron’s 2018 draft budget would raise research funds by 6%.
- **[Toad tadpoles turn homegrown poisons on each other]** [周五, 29 9月 08:00]
  Young amphibians are the first animals thought to use toxins against rivals of their own species.
- **[Controversial Thirty Meter Telescope gets go-ahead to build in Hawaii]** [周五, 29 9月 08:00]
  State board issues construction permit for project, but legal fight over telescope continues.

Antikythera shipwreck yields statue pieces and mystery bronze disc

Archaeologists think that at least seven life-sized sculptures are hidden nearby.

04 October 2017

Brett Seymour/EUA/ARGO 2017

Archaeologist Brendan Foley discovers a bronze disc, at first thought to be part of the Antikythera mechanism.

Marine archaeologists investigating the ancient shipwreck that yielded the Antikythera mechanism — a complex, bronze, geared device that predicted eclipses and showed the movements of the Sun, Moon and planets in the sky

— have recovered a wealth of treasures, including bronze and marble statue pieces, a sarcophagus lid and a mysterious bronze disc decorated with a bull. The artefacts were trapped under boulders in a previously unexplored part of the site near the island of Antikythera, Greece, and the researchers think that large parts of at least seven statues are still buried nearby.

The discoveries are “extremely exciting”, says Kenneth Lapatin, curator of antiquities at the J. Paul Getty Museum in Los Angeles, California. Only a handful of bronze statues survive from the ancient world, and they have almost invariably been treated and altered by previous conservators, undergoing processes that destroyed much of the information scientists might have gleaned from them. “Technology has improved so much,” says Lapatin. “We can learn from these untreated finds.”

The first-century-BC cargo ship, discovered in 1900 by sponge divers, is famous for yielding a heavily encrusted and corroded geared device that used to predict eclipses and chart the skies. The sponge divers also retrieved many other priceless items, including luxury glassware, jewellery and a two-metre-tall bronze statue, dating from the fourth century BC, nicknamed the ‘Antikythera youth’.

Statue search

Courtesy of ARGO 2017

The bronze arm was one of the most significant recent findings.

The recovery of multiple ‘orphan’ statue pieces — limbs without matching heads or bodies, for example — suggested that several statues still lie buried here. So an international team of archaeologists and divers, co-led by Brendan Foley of the University of Lund in Sweden and Theotokis Theodoulou of the Greek Ephorate of Underwater Antiquities in Athens, is now re-excavating the 50-metre-deep wreck site to look for them.

The team has made a stream of discoveries since work began in 2014, including wine jars, giant anchors, gold jewellery and a human skeleton, which is now being analysed for DNA. But the statues have remained hidden until now.

On 4 October**,** the team announced that during a 16-day dive season the previous month, they found several major statue pieces, including two marble feet attached to a plinth, part of a bronze robe or toga, and a bronze male arm, with two fingers missing but otherwise beautifully preserved. A slim build and “turning hand” gesture suggest that the arm may belong to a philosopher,

says Theodoulou.

In 1900–01, the sponge divers salvaged orphan limbs from a minimum of six bronze statues. The newly discovered arm pushes that total to at least seven, says Theodoulou. The team is particularly excited because the statue pieces were found in an area undisturbed by any previous excavations, buried beneath large boulders dislodged from Antikythera’s steep cliffs over the course of 2,000 years by periodic earthquakes. “We think this means that everything is down there still,” says Foley.

The discovery of seven bronze statues, if they could be recovered, would significantly boost the world’s total from this time period, which stands not much greater than 50, Lapatin estimates. Few of those are complete. And although these ancient figures might look beautiful, they are hard to study because the aggressive treatments by generations of conservators have altered and damaged the bronze.

Technological advances

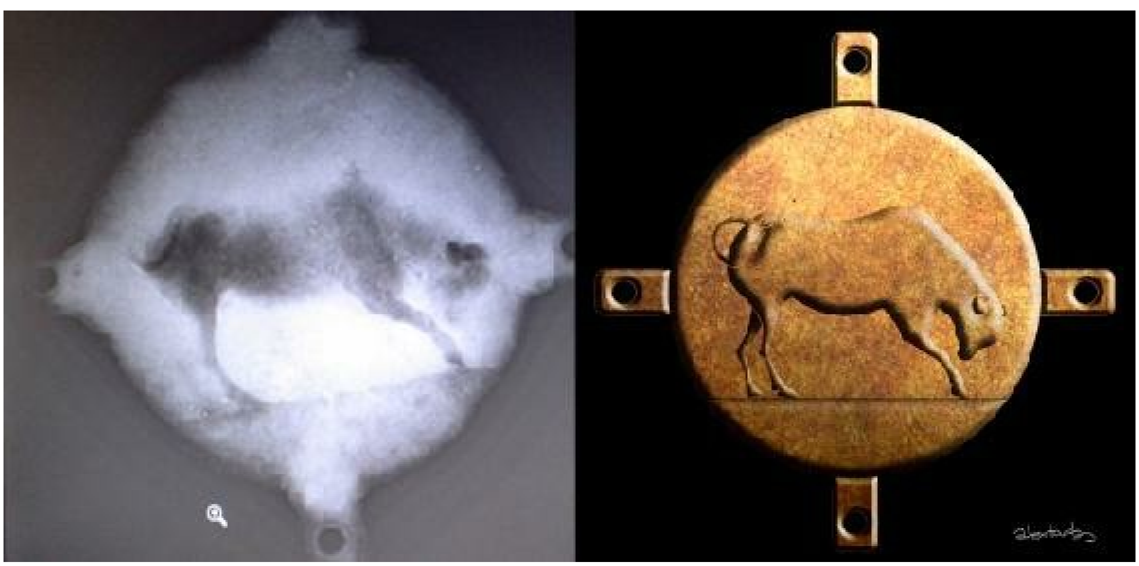
Fresh, untreated finds such as those from Antikythera will give researchers the opportunity to use modern techniques to study a significant aspect of ancient Greek life — for example, by looking at casting methods, which precise alloys were used and whether the statues were made for export or had been previously displayed. Meanwhile, any heads found might enable researchers to identify the people depicted, and to compare their likeness with any existing portraits, for example, marble statues or images etched on coins.

Brett Seymour/EUA/ARGO 2017

The bronze disc, which researchers at first thought might contain some of the lost gears of the Antikythera mechanism.

Foley and Theodoulou’s team also recovered an intriguing bronze disc or wheel, about eight centimetres across, attached to four metal arms with holes for pins. A layer of hardened sediment hides its internal structure, but it superficially resembles the Antikythera mechanism, and researchers had initially hoped that it might be part of that ancient device: perhaps the gearing that calculated the positions of the planets, which is missing from the find.

But preliminary X-ray imaging conducted in an Athens hospital on 25 September revealed a surprise: instead of gear wheels, the image of a bull appeared. The object might have been a decorative element, says Lapatin, perhaps attached to a box or a statue’s shield, or even — because of its sturdy construction — to the doomed ship. More-detailed radiography is planned for the next few weeks.



Left: EUA. Right: Alexander Tourtas.

The X-rays of the bronze disc, and artist's reconstruction of the bull.

Other discoveries this season include a sarcophagus lid made from fine, red marble, more human remains and wooden ship planks and frames that the researchers hope will reveal information about the vessel’s size and shape.

The team plans to return to Antikythera in May 2018, to break up the boulders and excavate beneath. “It’s going to be a major operation,” says Foley. “But we think it will be spectacular.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22735

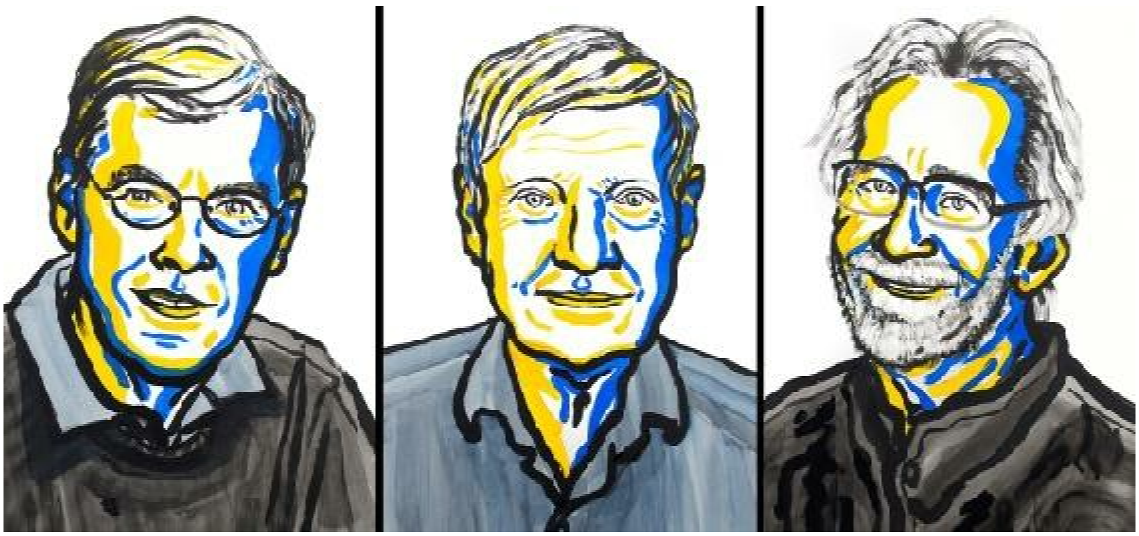
Comments

Commenting is currently unavailable.

Cryo-electron microscopy wins chemistry Nobel

Jacques Dubochet, Joachim Frank and Richard Henderson share the prize for developing a technique to image biomolecules.

04 October 2017



Niklas Elmehed/Nobel Media AB 2017

From left: Richard Henderson, Joachim Frank and Jacques Dubochet helped to develop cryo-electron microscopy.

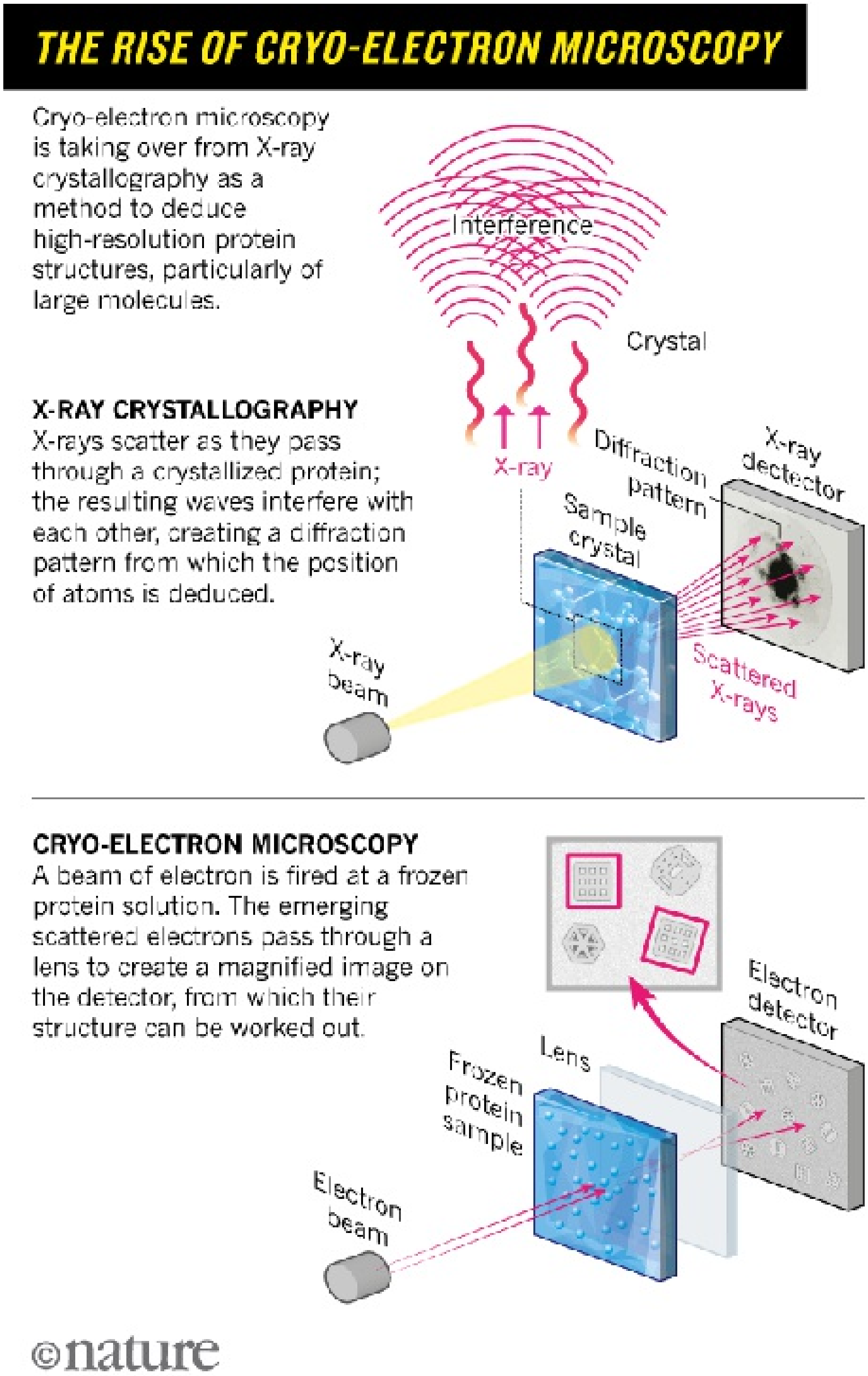
The 2017 Nobel Prize in Chemistry has been awarded for work that helps researchers see what biomolecules look like.

Jacques Dubochet, Joachim Frank and Richard Henderson were awarded the prize on 4 October for their work in developing cryo-electron microscopy (cryo-EM), a technique that fires beams of electrons at proteins that have been frozen in solution, to deduce the biomolecules' structure.

For decades, biologists have used X-ray crystallography — blasting X-rays at crystallized proteins — to image biomolecular structures. But labs are now racing to adopt the cryo-EM method, because it can take pictures of proteins that can't easily be formed into large crystals. The tool has "moved biochemistry into a new era", says the Royal Swedish Academy of Sciences, which awards the prize.

Imaging solutions

In the 1970s, Henderson, a molecular biologist who works at the MRC Laboratory of Molecular Biology in Cambridge, UK, and his colleague Nigel Unwin were trying to determine the shape of a protein called bacteriorhodopsin. The molecule, which uses light energy to move proteins across a cell membrane, proved unsuitable for crystallography. So the researchers turned to electron microscopy (see 'The rise of cryo-electron microscopy') and, in 1975, produced their first 3D model of the protein[1].



During the same decade, Frank, a biophysicist who is now based at Columbia University in New York City, and his colleagues developed image-processing software to make sense of the fuzzy pictures that are produced when an

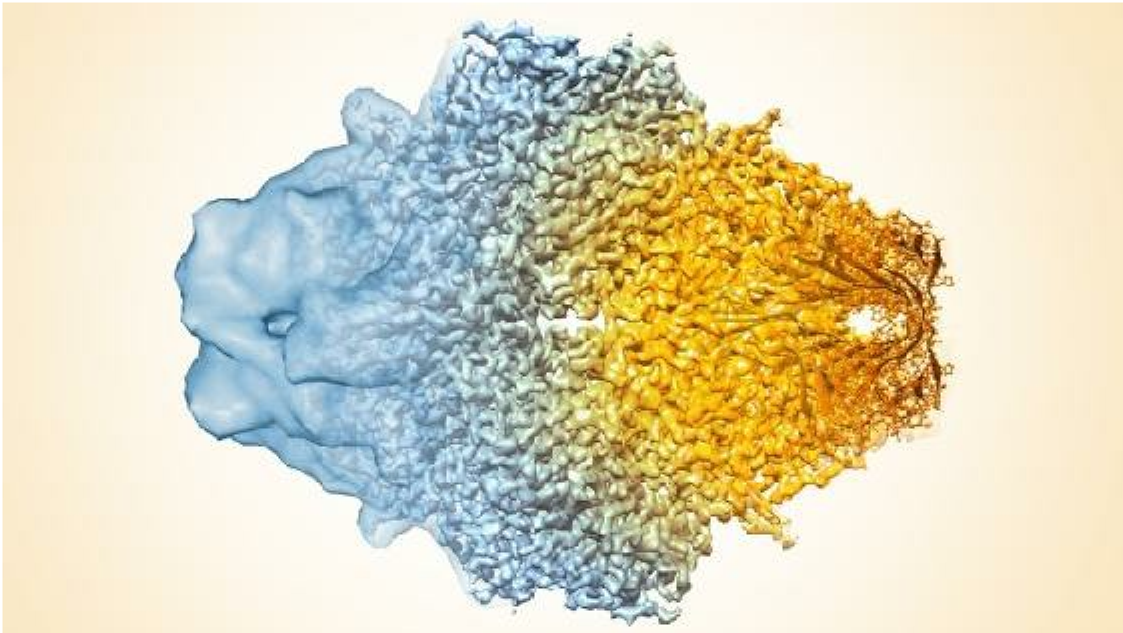
electron microscope is aimed at a protein, and to convert these two-dimensional blurs into 3D molecular structures.

In the early 1980s, a team led by Dubochet, who is now an honorary professor at the University of Lausanne in Switzerland, worked out how to prevent water-soluble biomolecules from drying out in the vacuum of an electron microscope, allowing the molecules to retain their natural shape during imaging. His team found a way to flash-freeze solutions of proteins using liquid ethane, keeping the molecules relatively still when they were pummelled with electrons. This allowed researchers to use electron microscopes to determine the structures of proteins at much higher resolution than before.

These and other improvements enabled Henderson to create the first atomic-resolution images of a protein using cryo-EM in 1990[2].

Resolution revolution

Although the research recognized by the Nobel Committee was conducted in the 1970s and 1980s, it laid the groundwork for what many scientists have dubbed a revolution in recent years. Subsequent improvements in the sensitivity of electron microscopes and in software used to transform their images into 3D structures have caused many labs to favour the technique over X-ray crystallography.



V. Falconieri, S. Subramaniam, NCI-NIH

Cryo-electron microscopy of proteins such as this β-galaxtosidase enzyme has progressed from the low-resolution density map on the left to the atomic coordinates on the right.

Frank told journalists gathered at the Royal Swedish Academy of Sciences in Stockholm that technological innovations can have a larger impact than discoveries. “Cryo-electron microscopy is about to completely transform structural biology,” he said. He added that the ribosome — the machinery that makes proteins inside cells — was the “coolest” molecule he had imaged.

Venki Ramakrishnan, a structural biologist at the Laboratory of Molecular Biology who shared the 2009 Nobel Prize in Chemistry for his work to reveal the structure of the ribosome using X-ray crystallography, is one of many converts to cryo-EM. After learning about the award from a *Nature* journalist, he said: “Oh, fantastic! Those are exactly the people I thought should win the Nobel prize.”

Benoît Zuber, a structural biologist at the University of Bern in Switzerland, who did his PhD with Dubochet, says his mentor was always confident that

cryo-EM would become a vital tool, even as others derided the field as “blobology” for the low-resolution molecular images it captured.“He had a vision and he was convinced about it, even when everybody was telling him that this was just a dream," says Zuber.

“It’s a great recognition for all the developments that have happened in the past. It’s fantastic,” says Sjors Scheres, a cryo-EM specialist who works alongside Henderson. The two were returning from a conference in Leicester, UK, yesterday, when Scheres asked Henderson whether he would keep his phone close in case the Nobel Committee called. “He said, ‘I think they should give it to Jacques Dubochet.’ He would never say that he should get one,” Scheres says. “It’s a well-deserved trio.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22738

Comments

Commenting is currently unavailable.

Crash in sea-turtle births stumps ecologists

Leading suspect — climate change — doesn't fully explain what is happening to leatherback turtles in the US Virgin Islands.

04 October 2017

Jurgen Freund/NPL/Getty

While buried in the sand, sea-turtle eggs are very sensitive to several environmental conditions that affect whether they hatch or not.

The mystery behind a dramatic fall in the number of leatherback sea-turtle (*Dermochelys coriacea*) hatchlings in the US Virgin Islands remains unsolved, despite the latest efforts of researchers. Rising temperatures and

changes in rainfall patterns — the top two suspects — don't seem to be connected to the decline, according to a study published on 4 October[1]. The finding contradicts previous work, leaving researchers scratching their heads over what could be happening.

The latest study focused on a nesting beach in the Sandy Point National Wildlife Refuge on St Croix island in the Caribbean Sea. The researchers found that about 74% of the leatherback sea-turtle eggs laid there in 1990 hatched, but that rate had plummeted to 55% by 2010.

The study analysed detailed temperature and precipitation data at these nests over the 20 years, and found no corresponding trend in either climate-change factor that could fully account for the decline. The researchers reported their results in *Royal Society Open Science*.

Increases in temperature and more-erratic precipitation patterns do affect the nests, but they aren't the sole reason for the hatching declines, says Anthony Rafferty, a marine biologist at Monash University in Melbourne, Australia, and a study co-author.

This trend is especially confusing in light of the increase in the adult sea-turtle population. "The number of nesting females and the population size has been trending upwards at this site," Rafferty says. "But there's been a decrease in hatching success that we are worried about." That could have negative effects on leatherback populations within one or two decades, he says, when those hatchlings come of age.

Conundrum continues

"It's hard to say how much of that is happening because of climate change," says Vincent Saba, a climate scientist at the US National Oceanic and Atmospheric Administration in Princeton, New Jersey. He co-authored a 2015 study[2] that did find a relationship between air temperature, precipitation patterns and declines in leatherback hatching success. That study examined data from 1982 to 2010 and looked at seasonal rainfall, unlike the latest paper, which analysed rainfall only during the nesting season. The study predicted that, by 2100, Sandy Point would have the most unfavourable climate conditions out of all leatherback nesting sites around the world.

“I like the study. They looked at the effect of climate in finer detail,” says Pilar Santidrián Tomillo, a marine biologist and science director of the Leatherback Trust, based in Playa Grande, Costa Rica. She was a co-author on the 2015 study, and appreciates the fuller picture of what could be happening at Sandy Point that the most recent study has provided.

Sea-turtle eggs are exquisitely sensitive to climate because heat, carbon dioxide, oxygen and water all pass freely through their permeable shells. The surrounding temperatures determine the sex of the hatchlings: warmer conditions produce more females, whereas cooler conditions yield males. And rainfall can influence hatchling development and their ability to escape the nest, says Rafferty. Too little rain might mean that the sand is too dry for the young turtles to climb out of it; too much rain during the early stages of egg development might lead to a reduction in oxygen supplies to the growing embryo.

“I think changes in precipitation levels or patterns could explain the decline in hatching success partially, but there could be other reasons, too, like decline in fertility or increase in pollutants, for example,” Santidrián Tomillo says.

Rafferty, who specializes in embryo research, now plans to look at how the age and health of a female sea turtle might affect her fertility, or where she lays her eggs.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22748

Comments

Comments

There are currently no comments.

| 章节菜单 | 主菜单 |

Scientists plead with Brazilian government to restore funding

If officials don't act soon, research institutions could start shutting down next year.

04 October 2017

Leonardo Benassatto/Reuters

Protests against Brazilian president Michel Temer's policies have consumed the country amid severe budget cuts this year.

Anxiety is growing in Brazil over the country’s collapsing research budgets. President Michel Temer had slashed funding for science by 44% in March and has proposed additional decreases for 2018 — even as some science

institutes run out of money for basic needs, such as paying electricity bills. The 2017 science budget, at 3.2 billion reais (US$1 billion), is the lowest the country has seen in at least 12 years.

On 3 October, the government announced that it will release 440 million reais to science agencies to help keep them afloat until the end of this year. But the money is only about 20% of what's needed, said the Brazilian Society for the Advancement of Science in a statement.

Researchers continue to voice their alarm, with a march scheduled for 8 October in São Paulo — the third such demonstration this year protesting the funding shortfalls. And on 10 October, a public awareness campaign called *Conhecimento Sem Cortes* (Knowledge without cuts) will deliver a petition to Congress with more than 80,000 signatures protesting both the cuts and a 2016 constitutional amendment that put a 20-year cap on federal spending.

Last week, 23 Nobel laureates and nine of the country's scientific societies warned Temer that continued budget reductions will seriously jeopardize Brazil's future. They say that the ongoing uncertainty over science funding risks dismantling research groups and prompting a brain drain.

They all hope to influence a revision of the 2018 budget proposal — first submitted to Congress by the executive branch in August — which included a 16% cut to the Ministry of Science, Technology, Innovations and Communications (MCTIC). The Temer administration has promised to release a revised budget in the coming weeks.

On life support

If the 16% cut remains, it would leave a total of about 2.7 billion reais for 22 federal laboratories and research institutes, 73 National Science and Technology Institutes and Brazil's major science funding agencies, the National Council for Scientific and Technological Development (CNPq) and the Funding Authority for Studies and Projects. "This means institutions will shut down by August next year", says physicist Luiz Davidovich, president of the Brazilian Academy of Sciences.

Davidovich's estimate is based on what has happened this year. MCTIC started 2017 at 5 billion reais, its smallest budget in a decade when adjusted for inflation. In March, after the 44% cut, the ministry was left with 2.8 billion reais, not including money for special projects such as the Sirius synchrotron. The budget rises to 3.2 billion reais with those projects. As a result, institutions began running out of cash in September.

“We don’t have money for electricity bills or for buying radiopharmaceuticals”, says José Augusto Perrotta at the federal Institute of Nuclear and Energy Research. Perrotta is the coordinator of the multi-purpose reactor, a 1.6-billion-reais project that is facing delays because of a lack of funding. This year, the reactor was supposed to receive 106 million reais but got nothing.

The Brazilian Center for Physics Research isn’t doing much better. “We‘ll be able to see it through December without layoffs, but next year I’ll have to cancel all equipment maintenance contracts”, says Ronald Shellard, the centre’s director. The institution’s proposed 2018 budget is 7.8 million reais — well below the 12.7 million reais Shellard says it needs to survive.

Brazil’s 1.6-billion-reais Sirius synchrotron is also in jeopardy. The 2018 budget proposal doesn’t provide funding for the facility’s construction, which is slated for completion in mid-2018.

The build is still on schedule after science minister Gilberto Kassab unfroze 85 million reais this month, says Antonio José Roque da Silva, director of the Brazilian Synchrotron Light Laboratory and head of the project. However, the synchrotron will need an additional 331 million reais to complete construction. “I pay contractors with cash, not with promises,” says Roque.

A skeleton crew

Also at risk is Brazil’s collaboration with CERN, Europe’s particle-physics laboratory near Geneva in Switzerland. The 2017 budget cuts eliminated Brazil’s financial support for CERN, and the proposed 2018 budget doesn’t resume those payments.

The biggest threat, however, is to CNPq, Brazil's main source of federal research grants. The agency hasn't paid out the grants it green-lit last year, didn't launch its annual call for project proposals this year and is 400 million reais short of what it needs to honour its commitments in 2017. If the situation isn't sorted, Marcelo Morales, a CNPq executive director, fears a repeat of 2016, when scholarships for undergraduates and scientists abroad were suspended.

The continuing funding crisis is already driving away students and young scientists. Sergio Ferreira, a neuroscientist at the Federal University of Rio de Janeiro, runs a lab whose budget has gone downhill since 2014. It's now an average of 85,000 reais — one-tenth of what it used to be. This year, five of Ferreira's graduate students had to spend six months abroad working with his collaborators because he couldn't afford the materials the students needed for their research.

"In my group I have several people who have left or are about to leave for good, with no plans to come back", Ferreira says. "I can't keep a skeleton colony of students."

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22757

Comments

Comments

There are currently no comments.

Supercomputer redesign of aeroplane wing mirrors bird anatomy

Bird-bone structures emerge from an evolution-like algorithm.

04 October 2017

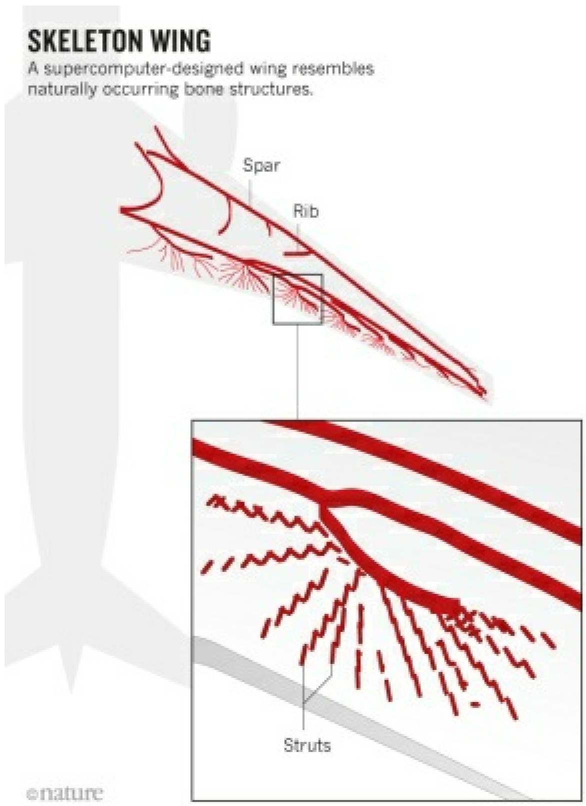
Samuel Taylor/Alamy

Conventional aeroplane wings are supported by straight bars and struts, but a supercomputer has suggested a more organic design.

Engineers have used a supercomputing technique that mimics natural selection to design the internal structure of an aircraft wing from scratch. The

resulting blueprint is not only lighter than existing wings, it also resembles natural formations, such as bird wing bones, that are not present in current aeroplanes. The organic-looking product is as stiff as a conventional aircraft wing but lighter, which could save up to 200 tonnes of fuel per year per plane.

“This is a really nice illustration of how to employ computing-based optimization methods at immensely high resolution,” says Matthew Santer, an aerospace engineer at Imperial College London. The method could feed into the design process, although there are a number of hurdles to using it in aerospace applications in its present form, he adds.



Engineers have been using these kinds of optimization techniques for around 20 years, but only for smaller-scale problems, such as individual wing components, or much simpler structures, says Niels Aage, an engineer at the Technical University of Denmark, near Copenhagen, who led the work[1]. Aage and his colleagues used the Curie supercomputer in Bruyères-le-Châtel near Paris to increase the resolution, enabling them to model the entire 27-metre-long wing of a Boeing 777.

The team started with a wing outline already optimized for maximum lift and minimum drag, known as an aerofoil, and split it into 1.1 billion 3D pixels or ‘voxels’. Each is about the size of the smallest Lego brick — a resolution roughly 200 times greater than previous efforts. The algorithm began by simulating the force exerted on every block and distributing material in response to where the wing experienced a load. Without any human guidance, the program then repeated the analysis several hundred times, adding or removing material depending on the strain felt by each brick, until it reached a final optimum design. “The structure evolves through each design cycle," says Aage. "The process has many similarities to nature’s own evolution."

Organic flight

Unlike conventional wings, the resulting structure did not contain the usual straight beams running the length of the wings, interspersed by crossing supports. Instead, the design looks organic, says Aage. Curved supports fan out at the trailing edge of the wing, resembling the bones in birds’ wings, and intricate support structures in the leading edge look like the internal structure of a beak.

Without compromising stiffness (resistance to deformation), the design weighs 2–5% less than conventional wing structures. That translates into 200–500 kilograms per wing, potentially saving each plane between 40 and 200 tonnes of fuel per year, say the authors. The technique could also be applied to other industries, says Aage, for example, to design high-rise buildings in earthquake-prone zones that maintain their stiffness yet can withstand the dynamics of a quake. It could be used to optimize acoustics, ventilation systems and antennas, as well, he adds.

The technique’s high resolution, which allows the computer to design structures that include features that range in size from millimetres up to tens of metres, could lead to more-innovative designs in these other disciplines, says Liang Xia, a computational engineer at the Huazhong University of Science and Technology in Wuhan, China. But he stresses that running the algorithm requires a heavy computing burden — the equivalent of running a single standard computer for 100 years. This computing cost could be reduced, however, if the team were to employ more-advanced simulation methods, used in artificial intelligence, which in effect model only parts of the wing in such high resolution.

The design is also too intricate to be made by existing manufacturing methods, and would require a giant 3D printer to build. But for now, key aspects of it could be fed into structures produced using conventional methods, says Aage. “We’re speeding up evolution rapidly, meaning we can see how designs should be, and then extract the key features — or those we can afford.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22759

Comments

Comments

There are currently no comments.

Elite Hungarian university may be saved

Hungary-New York agreement could allow Central European University to sidestep law change.

04 October 2017

Bernadett Szabo/REUTERS

Seventy thousand people protested in Budapest last April against a law apparently targeting the Central European University.

The prestigious Central European University (CEU) in Budapest, Hungary, seems to have found a way around a threat to close it down. The university had been affected by a law change that is widely thought to be politically

motivated.

The threat arose in April, when the government rushed through an amendment to its higher-education law, requiring that all international universities operating in Hungary had also to operate as higher-education institutes in their countries of origin.

The law change seriously affected only the CEU, which is legally registered in New York state. The university was founded in 1991 by Hungarian-born philanthropist George Soros, whom Hungarian Prime Minister Viktor Orbán has described as an enemy, because of Soros's statements in support of refugees, which run counter to Orbán's policies. The revised law, which includes other, smaller amendments, comes into effect on 11 October.

New York connection

A CEU spokesperson said on 3 October that the university has now signed a Memorandum of Understanding with Bard College in Annandale-on-Hudson, New York, to provide educational activities. She added that negotiations between the State of New York and the government of Hungary, which opened at the end of June, have now concluded, although the agreement still has to be signed off by Hungary's government and Parliament.

The law change sparked immediate protest last April, when 70,000 protestors took to the streets in Budapest, and the Hungarian Academy of Sciences expressed concern. The European Commission is pursuing an infringement procedure against what it sees as an illegal restriction of academic freedom, and an investigation by legal experts of the Council of Europe, a powerful human-rights organization with 47 member states, published a preliminary opinion in August indicating that the law was inappropriate.

"It's no secret that it has been a hell of a way to treat a university," says CEU rector Michael Ignatieff.

The university has nearly 1,500 mostly postgraduate students from more than a hundred countries, including a large number from Hungary. It operates mainly in the humanities, but recently expanded to include the cognitive and

network sciences.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22761

Comments

Comments

There are currently no comments.

Science without walls is good for all

International mobility and collaboration are linked to stronger research.

04 October 2017

David Williams/Bloomberg/Getty

New studies highlight how closing borders would be bad for science.

Some US biotechnology labs have responded to President Donald Trump’s attempts to restrict immigration by releasing contrasting group photographs showing what less-open international borders would do to their workforces. A first image typically shows everyone who works in the lab. A second image includes only those who are permanent US residents, then just US citizens, and then only those who were born in the United States and whose parents also were (see, for example, go.nature.com/2ft02xj). The shrinkage

from the first to the last image is striking — in some cases, about two-thirds of staff are lost. This reflects a widespread reality in research. A 2012 analysis showed that more than 60% of postdocs in the United States grew up overseas (see *Nature* **490,** 326–329; 2012).

When it comes to co-authorship, researchers in Europe are the most international. In 1981, only about one in six papers by a European scientist included co-authors from a different country. By 2011, that had risen to one in two. Papers with authors from more than one country also tend to be more highly cited (J. Adams *Nature* **497,** 557–560; 2013) .

This week, *Nature*'s Comment section publishes two bibliometric analyses that suggest international mobility has similar science-boosting effects.

The first finds that researchers build strong links between nations as they travel around the world. The authors track 16 million individuals who published papers in 2008–15. Only about 4% of these people changed countries, but those who did had 40% higher average citation rates than those publishing solely in one region, a trend that held true across 13 regions. Importantly, mobile scientists retained ties in the countries they left.

The second argues that countries with mobile scientific workforces produce papers that are more highly cited. (These are the same countries that have the greatest fraction of internationally authored papers.) The analysis shows that a nation's willingness to let scientists cross borders was a better predictor of highly cited papers than was the proportion of its gross domestic product that it spent on research.

These are complex issues. Citation rates are not necessarily a sign of quality, influence or long-term importance. And many confounding factors hamper attempts to link policies to impact. Still, such studies are necessary to provide evidence for policies on how to best support the scientific system.

The benefits of international movement are not entirely clear-cut. Leading scientists who change institutional affiliation (but not country) seem to boost both output and impact (G. Halevi *et al. Publ. Res. Q.* **32,** 22–37; 2016). Further work could reveal whether international papers — or more-open countries — prompt more innovative or worthy science. Details of the

relative benefits of collaboration, or how the effects of an international move are mediated by discipline or career stage, must be teased out. So must the effects of particular policies, such as the ease with which potential trainees and working scientists acquire visas or other travel support.

There is a bigger question: does the flow of leading scientists into a country bring tangible benefits for the citizens whose taxes fund their work? What about when one country's funds flow to a scientist's international collaborators? Evidence from patents and technological advances suggests that such investment is rewarded. But attention must be paid to ensure that a nation's connection to elite international scientists also supports work on local interests and needs.

Meanwhile, the scientific powerhouses of the United States and the United Kingdom seem determined to close their doors. US travel restrictions put in place last week tell working scientists from eight countries to stay away. And Britain's departure from the European Union puts scientific collaboration and access to European funds at serious risk.

Many nations with more-welcoming attitudes are poised to benefit. One long-term trend is clear: existing scientific powerhouses are not destined to stand forever. The picture can change — and quickly.

Journal name:
Nature
Volume:
550,
Pages:
7–8
Date published:
(05 October 2017)
DOI:
doi:10.1038/550007b

Comments

Comments

There are currently no comments.

Nobel prizes, giant telescope and buried treasure

The week in science: 29 September–5 October 2017.

04 October 2017

Events | Research | Funding | Facilities | People | Trend watch

EVENTS

Antikythera wreck yields more treasures Marine archaeologists investigating an ancient shipwreck near the island of Antikythera, Greece, announced on 4 October that they have recovered bronze and marble statue pieces, a sarcophagus lid and a mysterious bronze disc decorated with a bull. The cargo ship, which dates to the first century bc and was rediscovered in 1900, is famous for yielding the Antikythera mechanism, a complex bronze geared device that showed the movements of the Sun, Moon and planets in the sky. A team led by archaeologists Brendan Foley of Lund University, Sweden, and Theotokis Theodoulou of the Greek Ephorate of Underwater Antiquities in Athens found the latest artefacts under boulders in a previously unexplored part of the site. They think that at least seven complete statues are still buried nearby.

Brett Seymour/EUA/ARGO 2017

The bronze disc found near the shipwreck.

Volcano threats More than 100,000 residents on the Indonesian island of Bali have reportedly been evacuated to shelters following increased seismic activity from Mount Agung. The government's Center for Volcanology and Geological Hazard Mitigation said on 29 September that, on the basis of the latest information, an eruption was still a probability. Meanwhile, in Vanuatu, the government ordered the evacuation of all residents of Ambae island — about 11,000 people — on 28 September, after Manaro Voui started ejecting lava, poisonous gas and ash. On 1 October, the Vanuatu Meteorology and Geo-hazards Department said the volcano's activity was settling, and a large eruption was less likely. However, as *Nature* went to press, evacuations continued.

Time capsule On an Arctic island, scientists have buried a stainless-steel tube stuffed with artefacts that they say sum up science and technology in 2017. The time capsule, placed in an out-of-use borehole near the Polish

Polar Station in Hornsund, Svalbard, contains samples that include DNA, silicon-based electronics, an ancient meteorite fragment and other items to inform a future discoverer of our present understanding of technology, geology and biology. A team with the Polish Academy of Sciences described the capsule — created to celebrate the sixtieth anniversary of Poland's polar station — in a report in *Gondwana Research* on 28 September.

RESEARCH

Space-time ripples Physicists have announced the first discovery of gravitational waves made together by observatories in Europe and the United States, and the fourth-such discovery overall. At a 27 September press conference, researchers said that on 14 August, both the Virgo observatory near Pisa, Italy, and the twin laboratories of the US Advanced Laser Interferometer Gravitational-Wave Observatory (LIGO) in Livingston, Louisiana, and Hanford, Washington, had picked up gravitational vibrations emanating from a pair of merging black holes 540 million parsecs (1.8 billion light years) away. Observing the event with three detectors, rather than LIGO's two, enabled scientists to pinpoint the location of and distance to the black holes with much greater accuracy. Virgo rejoined the hunt for the waves only on 1 August, after a five-year upgrade.

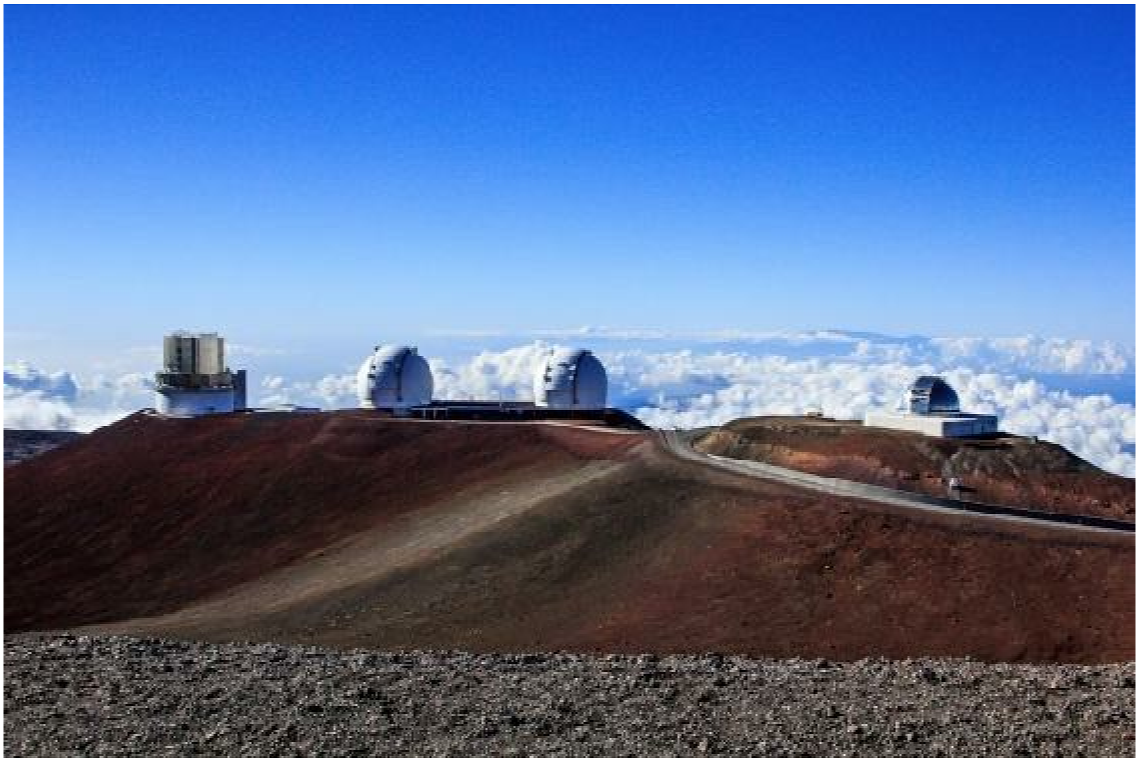
Monkey research The US Food and Drug Administration (FDA) has suspended a study on the effects of nicotine on monkeys after activists, including primatologist Jane Goodall, decried the experiments as cruel. On 25 September, FDA commissioner Scott Gottlieb responded to a 7 September letter from Goodall that called the experiments unnecessary, given that the effects of smoking are well known. The study, which began in 2014 at the FDA's lab in Jefferson, Arkansas, allows monkeys to self-administer nicotine. Gottlieb told Goodall that it would be halted while a team of experts assesses the monkeys' health and determines whether more precautions are needed. The team will also decide whether the study should resume.

FUNDING

French budget French research funding is set for a heartening increase in the country’s first budget under President Emmanuel Macron, if draft 2018 plans released on 27 September are voted into law. The research portfolio of France’s ministry of higher education, research and innovation would rise by more than 6%, to €8.4 billion (US$9.9 billion) in 2018. And a giant economic-recovery plan unveiled on 25 September by Prime Minister Edouard Philippe should divert an extra €2.4 billion to research over the next five years. Separately, in a 26 September speech, Macron backed the idea of a European Union funding agency to accelerate the commercial applications of basic science, an idea also suggested by EU research commissioner Carlos Moedas.

FACILITIES

Hawaii telescope Hawaii’s board of land and natural resources granted a new construction permit to the Thirty Meter Telescope (TMT) on 28 September, reviving the chances that it could be built on the Hawaiian mountain of Mauna Kea. Some Native Hawaiians oppose the TMT, saying that its construction would further violate the sacred mountain, which already hosts multiple telescopes. Hawaii’s supreme court invalidated the TMT’s first construction permit in December 2015, ruling that the board had not followed appropriate procedures. The new permit gives the project the right to proceed on Mauna Kea, but telescope opponents have filed motions that would put the permit on hold until the state supreme court can hear an appeal.



Julie Thurston/Getty

PEOPLE

Nobel prizes Three biologists were awarded this year's Nobel Prize in Physiology or Medicine for their work on circadian clocks. Jeffrey Hall and Michael Rosbash, both at Brandeis University in Waltham, Massachusetts, split the award with Michael Young at Rockefeller University in New York City. The physics prize was awarded to Rainer Weiss, at the Massachusetts Institute of Technology in Cambridge, and Barry Barish and Kip Thorne, both at the California Institute of Technology in Pasadena, for their work on detecting gravitational waves. *Nature* went to press before the chemistry prize was awarded, but full details will be available at go.nature.com/chem2017.

Science adviser On 26 September, Canadian prime minister Justin Trudeau appointed biochemist Mona Nemer as his country's chief government science adviser, fulfilling his campaign promise to establish the position. Nemer was

most recently vice-president of research at the University of Ottawa and director of the Molecular Genetics and Cardiac Regeneration Laboratory there. Her scientific work has focused on the genetics of cardiovascular disease and birth defects. In her new role, Nemer will have a budget of Can$2 million (US$1.6 million) and report to Trudeau and science minister Kirsty Duncan. The country has been without a science adviser for nearly a decade; the last time such a post existed was from 2004 to 2008.

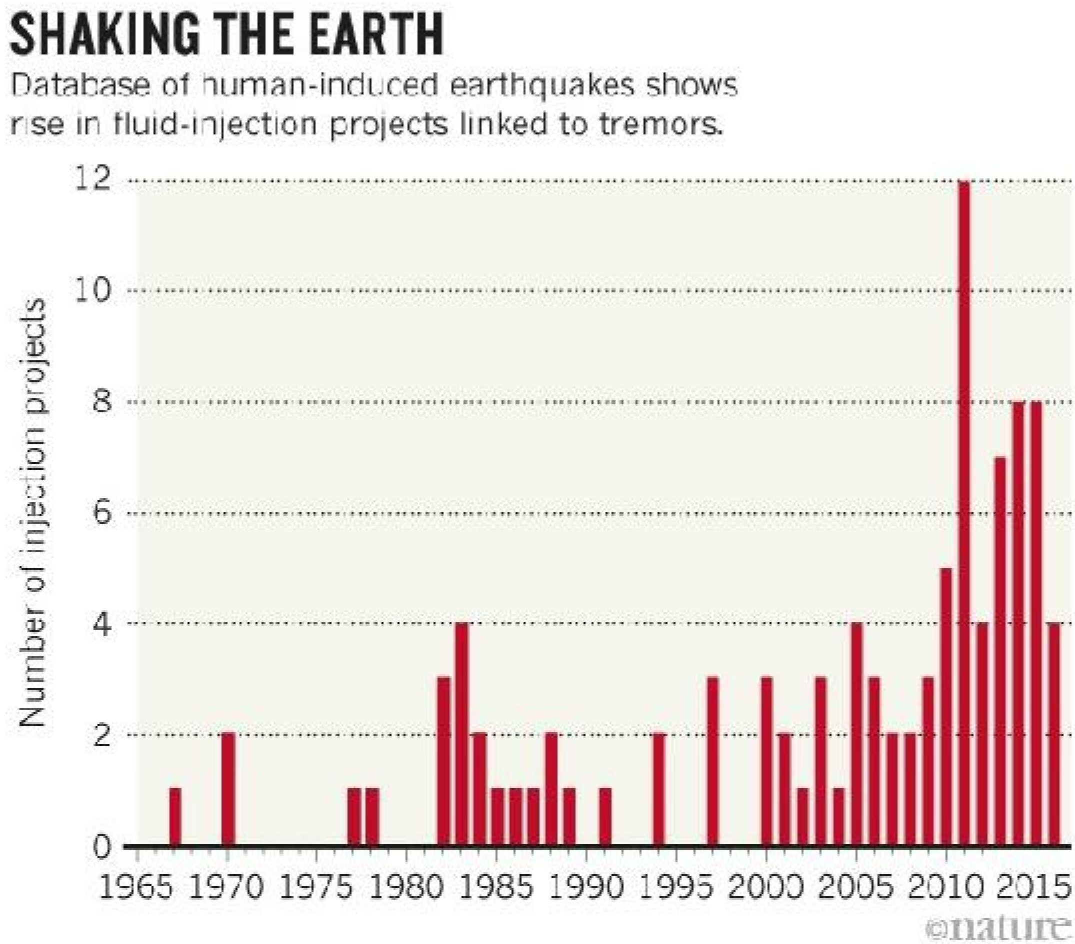
Russian academy After almost six months without a head, the Russian Academy of Sciences (RAS) has a new president: Alexander Sergeyev, a laser physicist and director of the RAS Institute of Applied Physics in Nizhny Novgorod. The academy, which operates a network of hundreds of institutes, is undergoing controversial reforms. In March, its planned presidential elections were unexpectedly cancelled at the last minute, allegedly following a row over voting procedures (see *Nature* **543,** 601; 2017). In the latest elections announced on 26 September, Sergeyev won a majority of votes from the academy's general assembly. A new state law requires that Russia's president Vladimir Putin must also approve the post, which he did the following day.

Defraud alert The FBI has charged bioengineer Yiheng Percival Zhang with defrauding the US government and his employer, the university Virginia Tech in Blacksburg. Zhang was arrested on 20 September and will remain in custody pending a trial, according to court documents. In an affidavit in support of a criminal complaint filed on 18 September, the FBI alleged that Zhang and two of his colleagues at the Tianjin Institute of Industrial Biotechnology in China — Zhiguang Zhu and Chun You — conspired to win US National Science Foundation (NSF) grants for studies that had already been completed in China. The affidavit also claims that Zhang withheld a portion of funds owed to his university from NSF and Department of Energy grants.

TREND WATCH

A database of human-induced earthquakes reveals a rise in tremors linked to wastewater injected into the ground by oil and gas operations. Such projects

spiked in the early 2010s, particularly in the central United States. The HiQuake database is described in *Seismological Research Letters*. Of 728 entries, 37% are linked to mining, 23% to water piling up behind a dam and 15% to conventional oil and gas development. Just 4% are linked to hydraulic fracturing, or fracking, for oil and gas.



Source: M. P. Wilson et al. Seismol. Res. Lett. http://dx.doi.org/10.1785/0220170112 (2017)

Journal name:
Nature
Volume:
550,
Pages:

12–13
Date published:
(05 October 2017)
DOI:
doi:10.1038/550012a

Comments

Comments

There are currently no comments.

Why fake islands might be a real boon for science

The seasteading movement is getting close to building its first prototype, an artificial archipelago where people will live, play and do research.

04 October 2017

Blue Frontiers

Early designs for a floating island in Tahiti aim to mimic a natural landscape.

The view is unbeatable. To the right, steep volcanic mountains, draped in green, rise up from a beachside coconut grove. To the left, the Pacific Ocean glitters turquoise under the midday sun. It is here in this Tahitian lagoon that a group of entrepreneurs plans to build an artificial island — three-quarters of a hectare of floating housing and research space, made up of linked platforms. If the team is successful, the vision could become reality by 2020. But it would be just the first step, says self-described “seavangelist” Joe Quirk. The ultimate goal is to build whole sovereign nations on the open seas, composed of modular floating units.

“French Polynesia has all the stepping stones: lagoons, atolls, shallow waters

right next to deeper waters,” Quirk says.

Quirk, one of five managing directors for the company behind the project, and his colleagues propose that artificial islands could serve as laboratories for testing out new technologies and exploring different social structures, or act as life rafts for coastal peoples displaced by sea-level rise.

The non-profit Seasteading Institute was founded by former Google engineer Patri Friedman in 2008, and it has garnered support from influential people in the linked worlds of Silicon Valley, libertarian politics and the anything-goes desert festival, Burning Man. Most media reports have been sceptical, however. The project has been characterized as the dream of “two guys with a blog and a love of Ayn Rand”[1] and “a hacker's approach to government with a *Waterworld*-esque conception of Manifest Destiny”[2].

But the Seasteading Institute and the new for-profit spin-off, Blue Frontiers, have racked up some real-world achievements in the past year. They signed a memorandum of understanding with the government of French Polynesia in January that lays the groundwork for the construction of their prototype. And they gained momentum from a conference of interested parties in Tahiti in May, which hundreds of people attended. The project's focus has shifted from building a libertarian oasis to hosting experiments in governance styles and showcasing a smorgasbord of sustainable technologies for, among other things, desalination, renewable energy and floating food-production. The shift has brought some gravitas to the undertaking, and some ecologists have taken interest in the possibilities of full-time floating laboratories.

LISTEN

Reporter Geoff Marsh investigates ambitious plans to build artificial floating cities.

You may need a more recent browser or to install the latest version of the Adobe Flash Plugin.
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But the project still faces some formidable challenges. The team must convince the people of French Polynesia that the synthetic islands will benefit them; it must raise enough money to actually build the prototype, which it estimates will cost up to US$60 million; and once it is built, the group must convince the world that artificial floating islands are more than just a gimmick. Producing solid science and broadly useful technology would go a long way towards making that case.

“What we are dreaming is that this structure will be a scientific laboratory,” says Winiki Sage, head of the Economic, Social, and Cultural Council of French Polynesia in Tahiti, who has been concerned about brain drain from his country.

Aesthetic appeal

Designs are surfacing for the prototype island, and its look is a key part of Blue Frontiers's public-relations strategy. The company's current plans don't entirely align with the concept art on the Seasteading Institute's website, which swings from tiki bar to Tomorrowland in various iterations. Bart Roeffen, a 'water pioneer' at the Dutch design firm Blue21 in Delft, has been drawing up new plans that fit with the landscape and culture.

“We are working together with Tahitian designers to make something that is not like an alien invasion,” Roeffen says. In particular, he plans to take cues from Polynesian shipbuilding. The elegant outrigger canoes, or *va'a*, used by islanders are stable and light; oceangoing versions are the type of boat rowed by the Tahitian voyagers who discovered Hawaii and New Zealand around AD 1100. Linked platforms would be arranged to ensure that no coral below is completely shaded and killed. The goal is to actually expand the habitat for reef species (see 'Seasteaders in paradise').

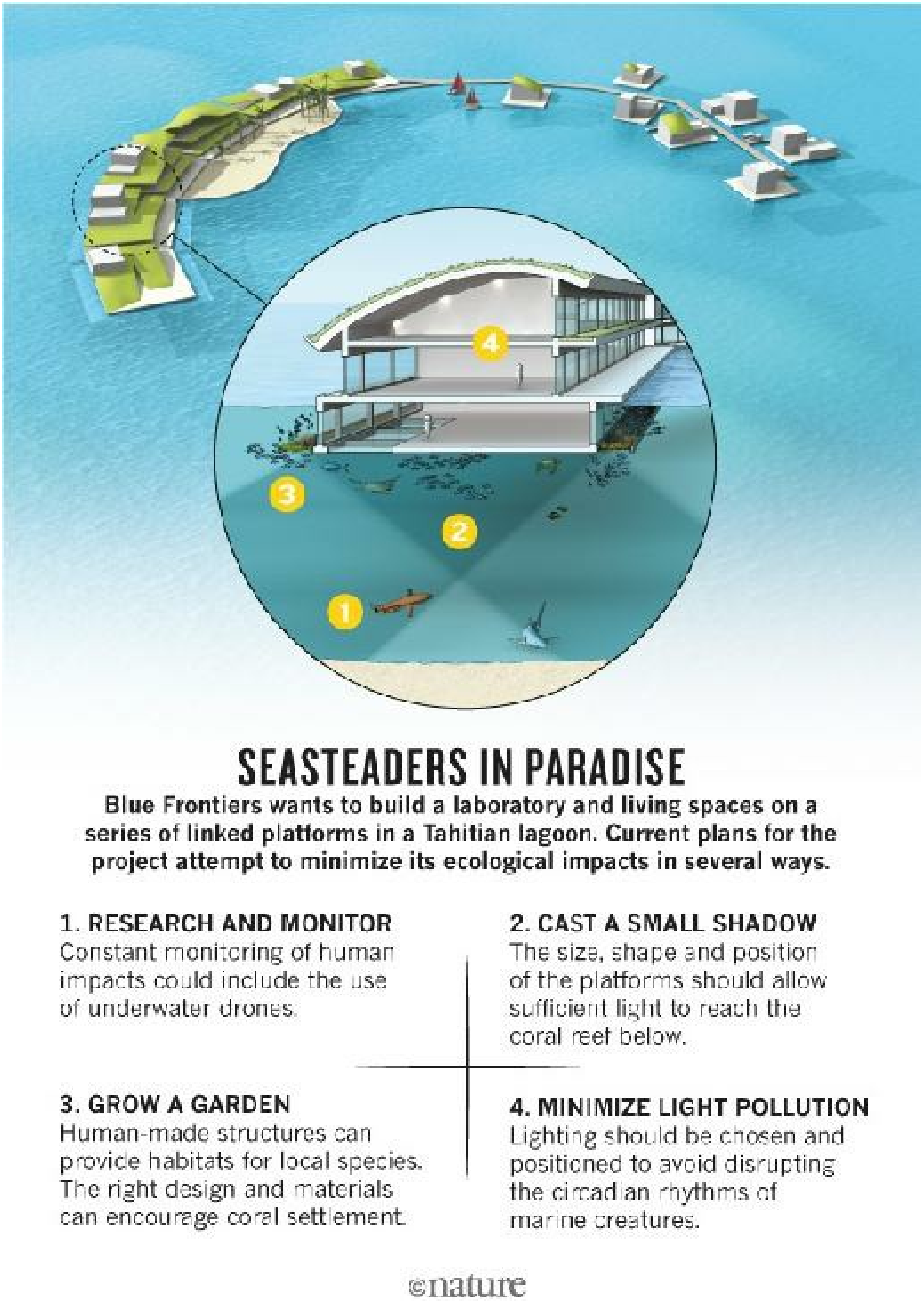


Illustration by Emily Cooper

The team would not provide direct information about funding. Paypal

founder and one-time Donald Trump enthusiast Peter Thiel provided a reported $1.7 million to the Seasteading Institute, but he last contributed to the project in 2014, and any recent investors are keeping a low profile. Quirk says that they have “a nice amount” of seed money and are preparing for what is called an initial coin offering — an investment mechanism that uses digital cryptocurrency. Looking ahead, the company hopes to generate revenue by renting out space on the island and acting as consultants for other would-be island builders. Along with hiring Quirk and the other four managing directors, Blue Frontiers has recruited ten staff members and commissioned environmental, legal and economic studies on the impacts of the project for investors and the government.

The “why?” — everyone's first question about seasteading — is answered differently by everyone involved. Some are captivated by the project because it is an excuse to push sustainable design to the next level. For people on low-lying islands, it looks like a life raft. Félix Tokoragi, mayor of Makemo, an atoll in the Tuamotu archipelago in French Polynesia, told Blue Frontiers that he's interested. The Tuamotus have experienced widespread flooding, and Tokoragi is worried that his people will become climate-change refugees. “We are attached to our atoll; we are attached to our culture,” he says. “We are not against this idea, since the technology can respond to the problems that we face.”

For others, the pull of the project comes down to autonomy and self-reliance, particularly with respect to governance: anyone who decides their island's political style is not for them can detach and depart for another system that they like better.

For at least one scientist advising the project, Neil Davies, executive director of a field station of the University of California, Berkeley, on the neighbouring island of Moorea, the island's appeal is as a base for research that would “fill the gap between oceanographic-research vessels and coastal marine labs”. Ships are on the water, but they are “phenomenally expensive”, he says, and they don't stay put. Coastal labs can gather long time-series of data in one place, but don't provide access to deeper water. Davies dreams about floating “sea stations” that would allow low-cost, long-term access to the ocean for research, especially for students in tropical countries “where

natural systems are among the most sensitive to human activities", he says. Experiments could include modifying pH or temperature on small sections of a reef to simulate future environmental conditions, and 'planting' different corals to investigate which will thrive best in the future. Data could be gathered using semi-permanent sensors and cameras, along with regular biological-sample collection.

Some scientists not involved in the project see value in the concept, as well. "If you have a floating island and you want long-term study, that is a perfect way to do it," says Ross Barnes, marine-operations superintendent at the University of Hawaii Marine Center in Honolulu, who oversees two large research vessels and on-shore labs. The university has been conducting research at a spot in the ocean that it calls Station ALOHA, which scientists have visited nearly 300 times by boat since 1988. A floating platform, he says, would mean that scientists could leave behind some instruments — and that some of them could stay as well — allowing for continuous measurement. "It's a good idea," Barnes says.

Currently, Davies is advising the seasteaders on site selection and environmentally positive design choices. He also plans to help them to document the installation's performance using sensors that measure things such as energy expenditure and waste generation on the platforms, as well as water temperature and quality. And he sees it as a great teaching opportunity for the many students who visit his station. "Seasteading raises many social, legal, ethical, environmental issues, even if it never gets anywhere," he says.

Whether the seasteaders make progress depends on whether the project is embraced by French Polynesia, a largely autonomous 'overseas collectivity' of France with a population of 287,000 on 67 islands spread out across an area nearly the size of Europe. At one level, a grand floating project could appeal to a nation of voyagers and boat builders. But French Polynesia has been burnt by big-science and technology projects before. From 1966 to 1996, France conducted 193 nuclear tests in its Polynesian possessions, many in the atmosphere. In February 2016, then-president of France François Hollande admitted that the testing had harmed the environment and human health. And the place is littered with defunct projects and closed hotels.

"We have a history of being taken for fools," says Pauline Sillinger, a

sustainable-development specialist at Te Ora Naho, a federation of environmental groups in French Polynesia, who took a job with Blue Frontiers this year, and also teaches Tahitian dance. “Nuclear testing, big hotels, nice, smiling, white, intelligent people telling us it'll be good for us.”

But their wariness vies against their desperation for new revenue streams, Sage says. After winding down nuclear testing, France began paying French Polynesia more than US$100 million per year in compensation for lost income from military activity. But in 2016, that amount was reduced. Meanwhile, tourism revenues have never recovered from the 2008 recession. Thanks to increased political stability and other factors, things have improved since 2014, when the collectivity was so broke that it risked not being able to pay its civil servants, according to Sage. But it is still dangerously reliant on a small number of income sources — tourism, pearls, coconut oil. Unemployment stands at nearly 18%. “We are looking for new ideas,” Sage says. “We are really open to any ideas, any investors.”

If Sage is sceptical but willing to give it a shot, there are others who have had enough of grandiose project ideas. Among them is a religious leader in Tahiti, Frère Maxime Chan, who heads Association 193, which advocates on behalf of those harmed by nuclear testing. Chan is also vice-president of Te Ora Naho. (Sage, incidentally, is the organization's president.) Chan says that his old friend Sage and the rest of the government are “dazzled” by the flash and money of the Seasteaders. He talks about recent projects — including a tourist resort, an aquaculture scheme and an eco-resort — that were all announced with fanfare and optimistic job projections, only to be cancelled, scaled back or put on indefinite hold. Chan wishes the government would admit that the standard of living for the average Tahitian has been artificially inflated by nuclear-test payments and must come down. This can be done without suffering, Chan contends, by gracefully returning to a version of the pre-1960s subsistence economy. “Small is beautiful,” he says.

Convincing French Polynesia to support the project will fall mainly to Marc Collins, another managing director of Blue Frontiers. Collins is Tahitian and lives there now, but in the early 1990s he lived in Silicon Valley, and fell in love with its fast-paced culture of big ideas and endless possibility. Ever since, he's kept his toe in those waters in part by maintaining a subscription to

Wired magazine. In May 2015, the digital lifestyle glossy ran a story[3] about how the seasteading movement planned to scale back its grand, high-seas concept, reorienting towards safer, shallower waters and looking for “cost-reducing solutions within the territorial waters of a host nation”.

Collins, a serial entrepreneur who has dabbled in every major French Polynesian industry, from hotels to black pearls and telecommunications, saw an opportunity to, as he puts it, “bring some of the DNA of Silicon Valley to Tahiti”. Tahiti joined the world of high-speed Internet in 2010, with the completion of an undersea fibre-optic cable linking it to Hawaii. It has calm lagoons aplenty and daily flights from Los Angeles, California, and, as a minor bonus, is widely regarded as paradise on Earth. Collins fired off a LinkedIn request to the Seasteading Institute's executive director, Randolph Hencken.

The Seasteaders were interested in Collins's pitch, but they wanted a more official gesture of support. So Collins, who served as French Polynesia's minister of tourism in 2007 and 2008, began working his government contacts. By August, the president of French Polynesia, Édouard Fritch, signed a letter formally inviting the Seasteaders to present their ideas. A delegation of nine took him up on the offer the next month, and by January, a memorandum of understanding with pledges of cooperation was signed.

The next step in making the island a reality will be the passage of a law defining the 'special economic zone' that will cover the synthetic island. Blue Frontiers isn't asking French Polynesia for any subsidies to build the island, but it is asking for a 0% tax rate, among other regulatory exceptions. It has hired French firm GB2A, based in Paris, to prepare legal research and a set of requests, which Blue Frontiers presented to the government at the end of September. The team hopes to see a bill emerge before the end of the year.

In the meantime, the Seasteading Institute is building excitement and courting potential investors with a series of gatherings. In May, it held talks, networking events and tours in Tahiti. Speakers included Fritch; Tony Hsieh, chief executive of online retailer Zappos in Las Vegas, Nevada; Tua Pittman, a master canoe navigator from the Cook Islands; and engineers, nanotechnologists and a 'blockchain strategist', a specialist in the distributed information systems behind cryptocurrencies. The seasteaders hope to use

such systems to handle their financials, as well as any scientific data that they generate. But the event wasn't all work. An announcement for a party on outrigger canoes cheerfully suggested: “Do not wear heels. Bring a swimsuit for an optional moonlight swim.”

On 22–29 October, Blue Frontiers will hold an Insiders Access Week for supporters and potential investors, a mix of tours, discussion and morning yoga with Hencken. Always ambitious, the team hopes to have draft legislation from the Polynesian government by then, and some detailed architectural plans. The goal is to break ground — or rather, sea — in 2018.

While all this work goes on behind the scenes, the lagoon remains fairly quiet. On a day in July, locals compete in a stand-up paddle-board race while families play on the shore and young women drink beer with their feet in the waves. By the roadside, freshly caught tuna are for sale. On one level, it is hard to imagine this place being improved upon.

Time will tell whether the Seasteaders' island becomes a refuge for Polynesians facing rising seas and an incubator for Polynesian science and business, or merely a playground for wealthy foreigners who want to dodge bothersome regulations. That is, if it materializes at all.

Journal name:
Nature
Volume:
550,
Pages:
22–24
Date published:
(05 October 2017)
DOI:
doi:10.1038/550022a

Comments

Comments

There are currently no comments.

How fracking is upending the chemical industry

As shale-gas compounds flood the market, chemists are working out the best ways to convert them into the ingredients of modern life.

04 October 2017

Jeff J Mitchell/Getty

A ship carrying US shale gas, the *Ineos Insight*, approaches port in Scotland in September 2016.

As the *Ineos Intrepid* cruised slowly through the sapphire waters of Norway's Frierfjord, chaperone tugboats sprayed jets into the sky to herald her arrival. In giant refrigerated tanks below decks, the ship carried 27,500 cubic metres

of liquid ethane — enough to fill 11 Olympic swimming pools. *Intrepid* also brought a message, painted in giant capital letters along her side: “SHALE GAS FOR PROGRESS”.

The vessel's arrival in March 2016 brought the first ever shipment of shale gas from the United States to Europe — and marked the start of a burgeoning business. More of these 180-metre-long 'Dragon'-class vessels have followed in her wake, forming a 'virtual pipeline' for ethane across the Atlantic Ocean. This gas, which is extracted from the ground through the hydraulic fracturing of shale deposits, isn't destined to fuel power stations or domestic stoves. Instead, it will be transformed into the chemical building blocks needed to make a panoply of products, including plastics, clothes, adhesives and medicines.

Intrepid's voyage is a striking demonstration of how cheap US shale gas is reshaping the chemical industry and changing the origin of countless manufactured objects. For decades, the industry's raw ingredients have mostly come from crude oil. Chemical plants break down long hydrocarbon molecules in crude to produce a smorgasbord of smaller molecules, such as ethene, propene and benzene — all important precursors to polymers.

But shale gas, which is composed mainly of methane, ethane and propane, is turning that pathway on its head. The abundance of the gas has slashed the costs of these molecules. As a result, some are now usurping large hydrocarbons as the preferred starting point for industrial synthesis.

This shift from oil to gas brings enormous opportunities. According to the American Chemistry Council, a trade group based in Washington DC, the shale boom has attracted about US$160 billion in investment from the US chemical industry since 2011, and will help to create half a million jobs in plastics manufacturing over the coming decade[1]. But it also poses huge challenges. Some of the main techniques that are used to turn the components of shale gas into more valuable compounds — processes generally known as upgrading — are decades-old, dirty and energy-intensive. And they rarely produce the same mix of chemicals as conventional oil-based routes, which means that some relatively minor, yet valuable, chemicals such as butadiene, an ingredient of synthetic rubber, are becoming scarcer.

These challenges are driving an intensive research effort, spanning industry and academia, to develop catalysts and reactors that can transmute small hydrocarbons in cleaner, cheaper and more efficient ways.

Translating that research into commercial production will depend on the finely balanced economics of a changeable market. It will also require a reliable supply of gas. The US Energy Information Administration predicts that natural-gas extraction in the United States will continue to grow until at least 2040, but that might be too optimistic (see Nature 516, 28–30; 2014). Meanwhile, concerns that fracking can contaminate groundwater — along with the broader climate implications of extracting fossil fuels — continue to dog the technology. If the glut does persist, however, it could usher in technologies that would form the foundations of a much more sustainable chemical industry. “We could totally redesign our chemical plants,” says Bert Weckhuysen, a chemist at Utrecht University in the Netherlands.

The ethane revolution

Shale gas is extracted from kilometres below ground, and typically contains about 70–95% methane, less than 15% ethane and less than 5% propane. After traces of oil, water and other impurities are cleaned out, the gas is chilled so that ethane and propane can be separated in liquid form, leaving methane behind.

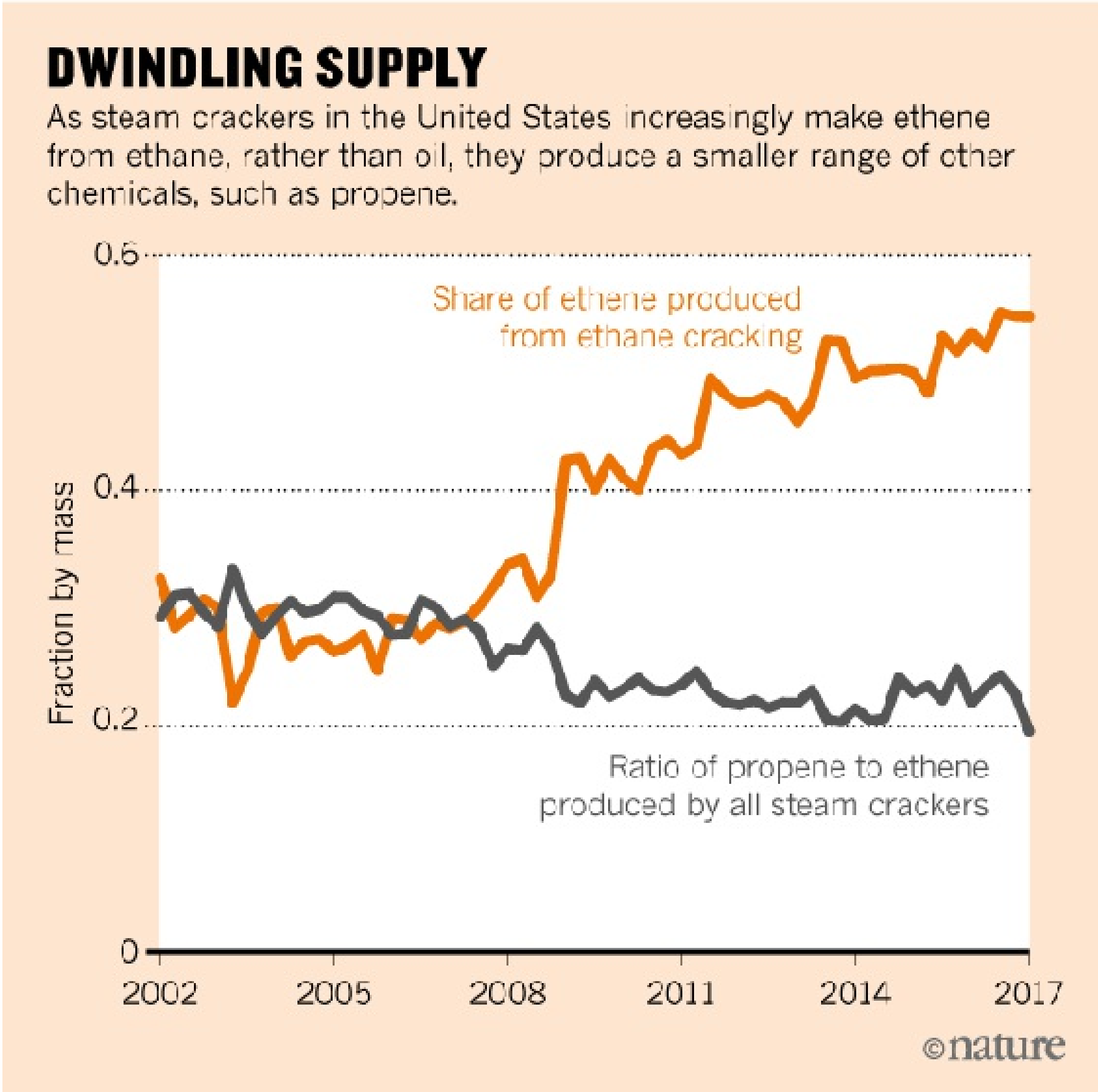
Although ethane makes up a small proportion of shale gas, it has so far had the biggest impact on the chemical industry. That's because chemists can easily use it to make ethene, also known as ethylene. Ethene is used to make various types of polyethylene and the precursors to other plastics, such as polyvinyl chloride (PVC) and polystyrene. So voracious is the world's appetite for these plastics that the chemical industry produces roughly 150 million tonnes of ethene every year, more than any other chemical building block.

Most processes in the chemical industry use catalysts. But ethene can be produced simply by steam cracking ethane or larger hydrocarbons. First developed in the 1920s, steam cracking is a blunt, energy-intensive process

that requires little more than water and 850 °C temperatures. “You basically just heat the snot out of it,” says Jeffrey Plotkin, an industry analyst at IHS Markit in New York City. “The heart and soul of the thing is this gigantic furnace, that's where all the chemistry happens.”

The boom in shale-gas-derived ethane has driven the chemical industry to invest nearly $45 billion in extra steam-cracking capacity[2]. But the transition to this feedstock is also creating a headache. When steam crackers are fed with mixtures of long hydrocarbons from crude oil, they make an array of useful by-products. But when they are supplied with ethane, the output is almost entirely ethene. “So there is a shortage of other building blocks,” says Weckhuysen.

One of those building blocks is propene, arguably the second most important product of the chemical industry after ethene. Propene is turned into polypropylene, a plastic used in packaging and textiles, along with other polymer ingredients such as acrylic acid. But by one estimate, propene production by US steam crackers dropped by almost half between 2005 and 2014, even as global demand rose (see 'Dwindling supply').



Source: S&P; Global Platts

To combat the shortfall, the industry is rolling out alternative ways to make propene. One of the leading routes starts with the shale-gas component propane. A combination of heat and a catalyst to remove two hydrogen atoms can be used to turn it into propene.

The conversion is becoming more profitable: more than 20 of these propane-dehydrogenation units are already operating worldwide, and at least 40 more have been ordered since 2011. But Weckhuysen says that there is much scope to improve the process, which tends to chew up catalysts quickly, requires a

time-consuming and costly catalyst-regeneration step, and can use harsh reagents.

The methane question

Although ethane and propane are already making waves as commercial feedstocks, the big prize for chemists is to upgrade the most abundant component of shale gas: methane.

Most of the world's methane is currently burnt as fuel, its lowest-value application. The gas can also be used as a chemical feedstock, but it contains strong carbon–hydrogen bonds that are difficult to break in a controlled way. When methane is converted into other molecules, it is done mainly through an inefficient sledgehammer of a process called steam reforming. First commercialized in the 1930s, this involves smashing methane and water together at up to 1,100 °C, over a metal catalyst. It produces an extremely useful mixture of carbon monoxide and hydrogen called syngas — and also emits several hundred million tonnes of carbon dioxide per year, accounting for roughly 3% of all industrial emissions[3].

Syngas is the world's principal source of hydrogen, much of which goes to make the ammonia in fertilizer. Syngas can also be used to produce longer hydrocarbons, such as basic components of diesel and waxes.

Such upgrading is typically done through a technique called the Fisher–Tropsch (FT) process, which uses cobalt or iron catalysts and heat to create daisy-chains of carbon atoms. FT was developed in Germany in the 1920s to make petrol and a wide range of other hydrocarbons from syngas derived from coal.

Producing transport fuels in this way is generally more expensive than refining oil. There are just six large-scale FT plants in the world, made economical only thanks to their proximity to huge coal or gas fields and the mind-boggling scale of the plants themselves: the world's largest, in Qatar, cost $19 billion to build and munches through 45 million cubic metres of methane every day, on a par with the natural-gas consumption of Belgium.

Courtesy Velocys

A plant in Oklahoma City owned by ENVIA Energy uses compact reactors developed by Velocys to turn methane-derived gas into products such as diesel.

But the shale boom has prompted chemical engineers to take a fresh look at the FT process. Shale-gas wells typically don't produce enough gas to support a conventional FT plant, so research teams and companies have been developing smaller reactors that can process modest gas flows. One of those is Velocys, based in Houston, Texas, which developed a 5-metre-long reactor that can convert syngas into substances such as naphtha, diesel and wax. Its reactor technology is being used in Oklahoma City in the first commercial mini-FT plant in the United States. The plant, which is owned by ENVIA Energy, started production earlier this year.

Temperature control is a big challenge for the FT process: the reaction kicks in at about 180 °C, then generates huge amounts of heat. If not carefully controlled, it will run away with itself, turning carbon atoms into useless soot. To address this, Velocys's reactor contains corrugated layers of channels that

are alternately stuffed with catalyst or filled with water. This keeps the reaction running at a steady 200 °C, so that the reactor can use an efficient catalyst without risking a runaway reaction. “It allows you to pack a lot of reaction in a very small space,” says Neville Hargreaves, business-development director for Velocys in Oxford, UK.

The reactor in Oklahoma City pulls methane from a landfill site, an activity that comes with renewable-energy credits. But Hargreaves thinks companies could ultimately profit by tapping remote and relatively small natural-gas reserves that are unlikely to get a pipeline. Another potential target is unwanted gas from oil wells, which is often simply burnt off. Such 'flaring' puts about 350 million tonnes of CO_2 into the atmosphere every year. According to the World Bank, it carries enough energy to meet Africa's entire current electricity requirements.

The direct route

The high temperatures involved in producing syngas will always make it a costly way to create complex chemicals — as well as a major source of CO_2 emissions. Researchers have spent decades looking for ways to convert methane directly to methanol or other products, cutting syngas out of the route altogether. The shale boom has given this effort fresh urgency, along with a burst of investment in research and development in both academia and industry.

Turning methane into methanol — itself a key precursor to a wide range of other compounds — involves adding only a single oxygen atom. But first, one of methane's strong carbon–hydrogen bonds must be broken, and the high temperatures or strong oxidants needed to do that can set the molecule on a one-way journey down a thermodynamic roller coaster with a messy end. Methanol sits on a brief crest about halfway down, but it is all too easy to race downhill as the reaction goes too far, producing a mixture of other molecules, including formaldehyde, formic acid or carbon monoxide.

In 2005, however, a team led by Robert Schoonheydt at the University of Leuven in Belgium, found[4] that copper seeded onto a porous material called a

zeolite could unite oxygen and methane to make methanol at less than 200 °C. Crucially, the methanol became trapped in the zeolite's pores, preventing further reactions. But extracting methanol from the pores and reactivating the catalyst would have proved expensive and impracticable in a commercial setting.

Since then, research groups have developed a range of copper–zeolyte catalysts that are more industry-friendly. Others have focused on completely redesigning chemical reactors. The European Union-funded project Adaptable Reactors for Resource- and Energy-Efficient Methane Valorisation, for example, aims to build small reactors that use renewable electricity, rather than heat generated from fossil fuels, to turn methane into compounds such as ethene and methanol. One approach uses microwaves to generate intense hotspots in the catalyst, lowering the heating requirements for the incoming gas.

Another approach to direct methane upgrading aims to couple pairs of the molecule together to make ethene. Since 2015, Siluria Technologies, a start-up in San Francisco, California, has been running a demonstration plant for this process in La Porte, Texas. It relies on a catalyst made of metal-oxide nanowires that collectively offer a surface area of about 200 square metres per gram of catalyst, hundreds of times more than a bulk catalyst could offer.

The company builds its catalysts in a unique way, based on a technique[5] developed by co-founder Angela Belcher, a materials scientist at the Massachusetts Institute of Technology in Cambridge. First, viruses are genetically engineered to express proteins that bind to dissolved metal ions. The ions form orderly arrangements as they stick to the surface of the virus. When the biological template is burned away, it leaves behind a highly stable, crystalline nanowire.

Rahul Iyer, Siluria's vice-president of corporate development, says that the process is cost-competitive with steam cracking ethane, and produces far fewer CO_2 emissions than steam reforming methane. Siluria has already licensed the technology to some chemical companies, and expects the first commercial facilities to be operating in 2019.

Plotkin says that Siluria is currently in the lead in the race to commercialize direct methane upgrading, and is backed by multimillion-dollar investments from big players in the industry. “People are keeping a watchful eye on it,” he says.

Gas that's greener

The shale-gas boom is credited with spurring a major renaissance in the US chemical industry, which has invested heavily in chemical plants and other infrastructure, as well as research and development. Enthusiasm for shale-gas upgrading has fostered major collaborations between academia and industry.

Translating laboratory results into commercial production is an ongoing challenge, although the trend towards small, modular reactors is helping to make it less daunting. The chemical industry is notoriously conservative: if a process succeeds in the lab but fails at commercial scale, tonnes of catalyst can be wasted and a plant shut down for months. “Industry will not take the risk unless they are sure it will work,” says Weckhuysen.

Despite these challenges, he is optimistic that gas upgrading could have a huge impact — not only on the chemical industry's processes, but also on its environmental footprint. Some of the reactor technologies being developed to feed on shale gas could be adapted to use bio-based feedstocks, such as methane from landfills, as Velocys has found. Meanwhile, shortages in some compounds caused by the shift to shale gas could improve the economic case for starting with ethanol from crops, or lignin from wood[6]. There has already been movement along these lines. In 2013, for example, French tyre-maker Michelin and partners launched a €52-million (US$61-million) project to make butadiene from bioethanol.

But for now, US shale ethane continues its relentless march around the world. More chemical companies are commissioning ships to transport the gas to destinations in Europe, Brazil and India. By 2022, according to one estimate, about 8 million tonnes of ethane will flow through these virtual pipelines each year. They will carry this revolution in the US chemical industry to the rest of the globe — both its challenges and its opportunities.

Journal name:
Nature
Volume:
550,
Pages:
26–28
Date published:
(05 October 2017)
DOI:
doi:10.1038/550026a

Comments

Commenting is currently unavailable.

Scientists have most impact when they're free to move

04 October 2017

An analysis of researchers' global mobility reveals that limiting the circulation of scholars will damage the scientific system, say Cassidy R. Sugimoto and colleagues.

Spencer Platt/Getty Images

Measuring the global movements of researchers will help to assess the effects of political actions on science.

Recent political upheavals portend an era of increased isolationism in

science, with a chilling effect on collaboration and mobility. Last month, US President Donald Trump issued his third travel ban in a year, suspending entry of individuals from several countries into the United States, and placing restrictions on many more for visa renewals. These orders have stranded scholars abroad and prevented those who were in the country from engaging in international work. In March, UK Prime Minister Theresa May began the process of formally severing ties with the European Union. As a result, British institutions face a potential exodus of non-resident EU researchers and will have to overcome barriers to participating in and receiving funding for European collaborative projects. The list of countries engaging in these isolationist actions, and the list of actions themselves, grows longer.

To assess the impacts of such political actions, we need better ways to measure researcher mobility. Although the size and composition of the scientific workforce is fairly well established through national surveys and registries[1], less is known about how often researchers move, where they go, what networks they form, and how important their movement is to the scientific impact of their work[2].

We present here a new analysis based on the records of 14 million papers from nearly 16 million unique individuals who published between 2008 and 2015. In our study, some 96% of researchers had only one country of affiliation; we classed these as non-mobile. About 4% (more than 595,000 researchers) were mobile — meaning that they had more than one affiliation during that period. Our analysis revealed surprising trends.

Chain reaction

Over the study period, Europe and Asia saw a dramatic net loss of researchers, whereas North America saw large gains. Many commentators have anguished about 'brain drain' or 'brain gain', assuming that receiving countries get the lion's share of scientific capital at the expense of the nations from which researchers originate. The reality is more complicated (see 'Brain circulation').

We found that the majority of scientists didn't cut ties with their country of

origin but instead built a chain of affiliations that linked nations together. Many researchers returned to their home country. Brain circulation may be a more apt term for the movement of contemporary scholars[3].

Different nations have different roles in the circulation of elite scholars (for which our proxy is highly cited researchers). But wherever they are, wherever they stop off and wherever they come from, mobile scholars have about 40% higher citation rates, on average, than non-mobile ones (see Supplementary Information; Table S7). Closing borders takes these elite scholars out of circulation.

Origin stories

Our study looks at the country stated in a researcher's affiliation when they published their first paper, and uses this as their country of scientific origin (this should not be confused with where they were born). We then track whether they moved or gained new affiliations in other countries over the eight years of this study.

The conventional idea of mobility focuses on migrant researchers — those who begin publishing in one country and then move to another, at some point discontinuing their attachment to the previous country. This group made up less than one-third of the mobile researchers in our study (27.3%, or 162,519 researchers). By far the largest proportion were those we call travellers: scholars who retain a footing in their country (or countries) of scientific origin throughout their career, while gathering up more international affiliations to add to their name (72.7%, or 433,375 researchers). Nearly half of the travellers are 'non-directional': they have more than one affiliation in their first year of publication, and they retain all these affiliations in each publication year.

Circulation networks that map the number and flow of researchers reveal the importance of the United States, United Kingdom, France, Canada and Germany as prominent nodes in the global scientific network (see Supplementary Figure S2). Isolation of these countries would have dramatic consequences. Although the United Kingdom is not particularly central to researcher migration in the European Union, it serves a crucial function in providing a bridge for European scientists to other areas of the world (see Supplementary Figure S2). Isolationist policies in the United Kingdom could deconstruct this network, redirecting scholars through other countries.

More patterns emerge if we look only at migrants and directional travellers who moved between and within continents, who first published in 2008, and who published at least eight papers during the study period. Admittedly, our short time window means that we focus on junior scholars. But it avoids conflating them with senior scholars whose movement and networking are likely to differ.

This group comprised 12,046 researchers. Europe provides the largest share (35%) followed by about one-quarter each from Asia and North America (see 'Making tracks'). The relationship between these latter continents is strong:

the majority of mobile scholars associated with an Asian address in their first publication in 2008 have a North American address by 2015, and more than one-third of mobile North American scientists end up in Asia. Both of these trends can probably be explained by the same underlying phenomenon — the influx of Asian students into the United States (some of whom publish before their arrival, and others of whom do so afterwards), and their subsequent moves back to Asia.

We see a 22% net loss of researchers from Europe, a 20% loss from Asia, and a nearly 50% gain for North America (see Supplementary Table S4). European scholars make up the largest population of mobile scholars in nearly every country, with the exception of Asian countries, where most scholars are drawn from North America (see 'Scientist shuffle').

It is also of interest to know the degree to which certain countries are responsible for the production and cultivation of high-impact scholars. We assess this by looking at citation scores for mobile researchers before and after their moves (see 'Trip adviser').

Countries in North America and Northern Europe act as strong producers: they put into circulation scholars who are well-cited before they move. The same countries are also strong cultivators, identifying talent early and providing fertile ground for scholars to achieve high impact once they arrive. Asian regions are strong recruiters, gaining affiliations with established scholars who were well-cited before their arrival. Oceania is a notable incubator, affiliated with scholars who realize high potential once they move on.

Some migratory routes tend to be associated with highly cited scholars. Those from North America with the highest impact tend to land in Northern and Western Europe and, to a lesser extent, in Southeastern Asia. Mobile, high-impact Northern Europeans are recruited to Southern Europe; mobile, high-impact Western Europeans are recruited to Oceania and Eastern Asia.

Mobile scholars from Oceania produce particularly high-impact work when they arrive in North America and Southern Europe. Central and Western Asian scholars (including those from countries implicated in the US immigration ban) realized their highest citation rates for work done in North

America and Europe. Barring scholars from these countries is likely to displace high-impact ones to other nations.

Regardless of region, mobility pays in terms of citations. Across all regions, mobile scholars are more highly cited than their non-mobile counterparts. The advantage varies by region. Mobile North Americans see only a 10.8% boost in citations over their non-mobile colleagues. For Eastern European scholars, the gulf is 172.8%.

Mobility measures

Of course, our method has limitations. We cannot tell if our 'country of academic origin' represents country of birth, of academic training or of academic employment — it reveals solely where an individual began publishing. If researchers from some countries tend not to publish first in a journal indexed in the Web of Science, then our measures would underestimate mobility from these places. Those we have counted as 'non-mobile' might really be 'pre-mobile' — meaning that they have not yet moved. Furthermore, examining less than a decade of papers, focusing on journal articles and adding restrictions for number of publications may privilege certain disciplines in the analysis. And our study does not look at mobility rates within each country: for large nations such as the United States, these might be significant and interesting.

Internationally comparable mobility indicators for the scientific workforce are particularly necessary in an era in which mobility is growing, complicated and increasingly threatened. We need indicators that provide more nuanced and dynamic assessments of the exchange of human capital and the effect of this exchange on the knowledge economy, particularly given that the 'travellers' in our analysis account for the majority of mobile scholars. This study provides a start.

It might be argued that collaboration can continue, even when mobility is restricted. However, despite advances in computing, collaboration tends to be initiated and sustained through interactions that happen in person[4]. Limiting mobility is likely to have adverse effects on the scientific system, which is

increasingly dependent on international collaboration[5].

Disruption of the existing network would have serious effects on many nations, including large science producers and cultivators such as the United States. The country benefits significantly both from its centrality in the global knowledge network, and from the educational investments of other countries. Its exceptional contributions are disproportionately made by researchers who are both foreign-born and foreign-educated[6]. Disconnection would also seriously affect those nations that benefit from the United States' role as a cultivator — it invests in researchers who come from Asia and elsewhere and later return home.

Some countries may see benefits, however: isolationism among central countries can lead to advantages for other competitive nations. For example, the number of graduate-student applicants to Canada has risen since the change in the US administration (see go.nature.com/2fjc4i). However, if adequate scientific capacity does not exist in these other countries, global talent will not be cultivated to the extent it is today. With good bibliometric standards to measure the impact of mobility, we can test the effects of these political changes in the decades to come.

One thing is already clear. Internationally mobile scholars are in the minority, yet show the highest impact across the globe. Limiting the circulation of scholars will damage the entire scientific system.

Journal name:
Nature
Volume:
550,
Pages:
29–31
Date published:
(05 October 2017)
DOI:
doi:10.1038/550029a

Supplementary information

PDF files

1. Supplementary information (1.6M)

Comments

Comments

There are currently no comments.

Open countries have strong science

04 October 2017

Caroline S. Wagner and Koen Jonkers find a clear correlation between a nation's scientific influence and the links it fosters with foreign researchers.

Spencer Platt/Getty

Nations that welcome international researchers and encourage cross-border collaboration tend to produce papers with high scientific impact.

International projects account for at least 20% of national government spending on scientific research. Some countries spend as much as 50% of these funds on international collaborations[1, 2]. The number of internationally co-authored papers is growing rapidly[2]. For countries at the forefront of

research, the fraction of papers that are entirely 'home grown' is falling[3].

Is there a connection? We analysed publication and citation data for 36 nations, along with government expenditures on science. We found that although government spending on research and development (R&D;) does correlate with the number of publications produced, it does not correlate with scientific impact — at least as assessed by citations, one of the few practical metrics available. What does correlate with impact is a country's openness, which we approximated by combining metrics of international co-authorship and the mobility of each nation's research workforce.

In 2016, we partnered with Jeroen Baas, head data scientist at Elsevier, the publication house that also runs the citation database Scopus, to examine nearly 2.5 million publications that were published in 2013 across all scholarly fields and that had three years' worth of citation data available. Publications and a field-weighted citation index were apportioned to countries according to authors' locations. (So if two-thirds of the authors on a publication were in the United Kingdom and one-third in Singapore, those fractions were applied to determine the publication count and citations assigned to those countries for that paper.)

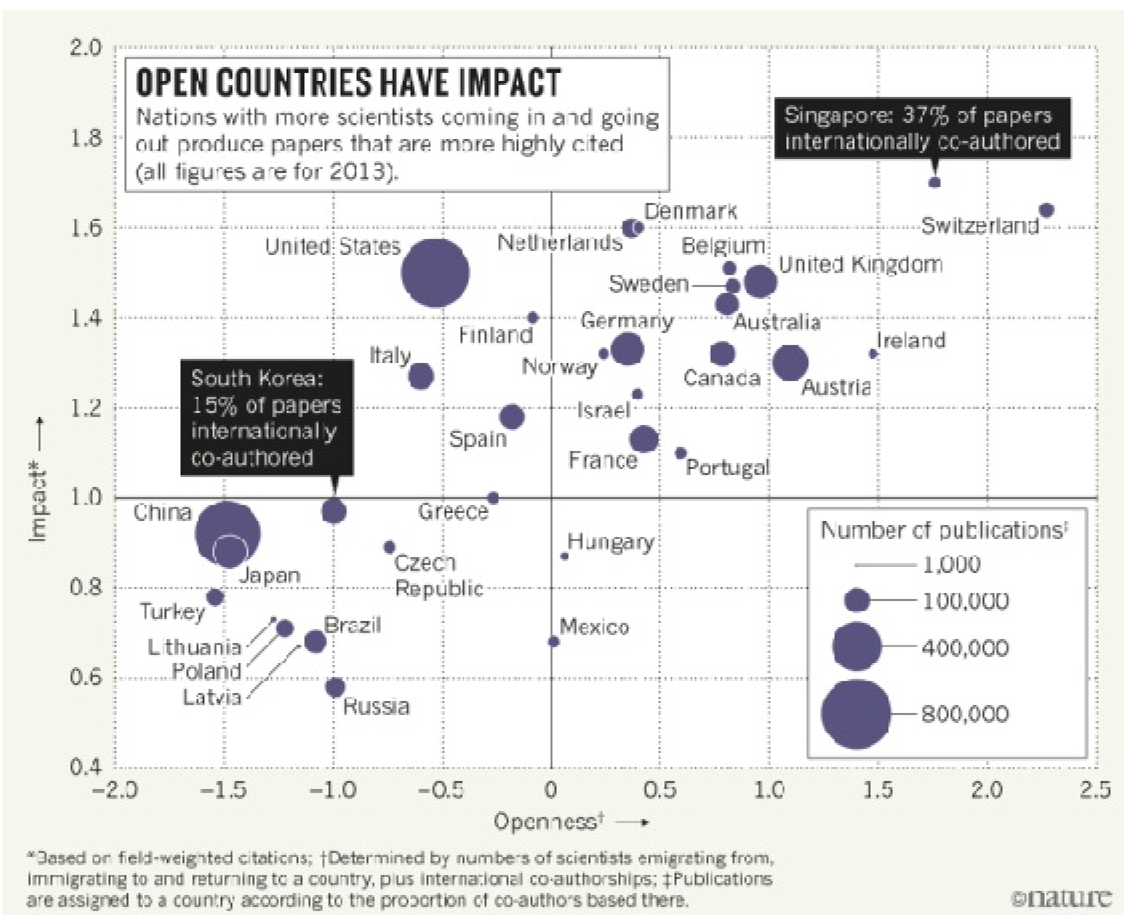
In terms of papers published, the United States and China dominate. For 'international papers' (those with authors from more than one country), the United States still leads, followed by the United Kingdom, China, Germany, France and Canada. When international papers are considered as a percentage of all of a country's papers, Switzerland (42%) appears as the most connected country, followed by Belgium (38%), Singapore (37%), Austria (36%) and Denmark, the Netherlands and Sweden (all 34%). In terms of impact for international papers, Singapore tops our list, followed by the United States, and then Sweden, Belgium, Switzerland and the Netherlands.

We looked for factors that could explain this. In addition to international collaboration, scientific mobility was expected to contribute to impact[4]. So we also considered new researchers coming in, returnees and emigrating researchers, all of which are tracked by the Organisation for Economic Co-operation and Development (OECD). These variables, together with collaboration, proved to be highly correlated as measures of international

engagement; so we used them to create an index of openness and were able to assign values to 33 of the countries that we looked at (data available at go.nature.com/2fzrnt3).

To assess whether government R&D; spending (as tracked by the OECD and Eurostat, the statistical office of the European Union) and our openness measure explained the relatively higher impact for smaller countries, we used a Pearson correlation analysis, which allows comparisons to be made across a large quantitative range, such as the publication output of the United States versus that of Singapore.

Public R&D; funding is tied to publication output: the more money spent, the more articles produced (counting sole-authored, co-authored and internationally co-authored). But we found only a weak correlation between spending and impact. In other words, more government funds spent does not necessarily result in more citations.



Countries that are highly 'open' and that produce high-impact research seem to benefit from participating in international collaboration. This is seen in the higher impact of smaller nations, which cluster in the top-right quadrant of the graphic (see 'Open countries have impact'). Singapore, the United Kingdom, the Netherlands, Switzerland, Sweden and Denmark all scored highly on this measure as well as on citations. The correlation between openness and citation impact was tight ($r^2 = 0.7$ according to a regression analysis) regardless of R&D; spending or numbers of articles published.

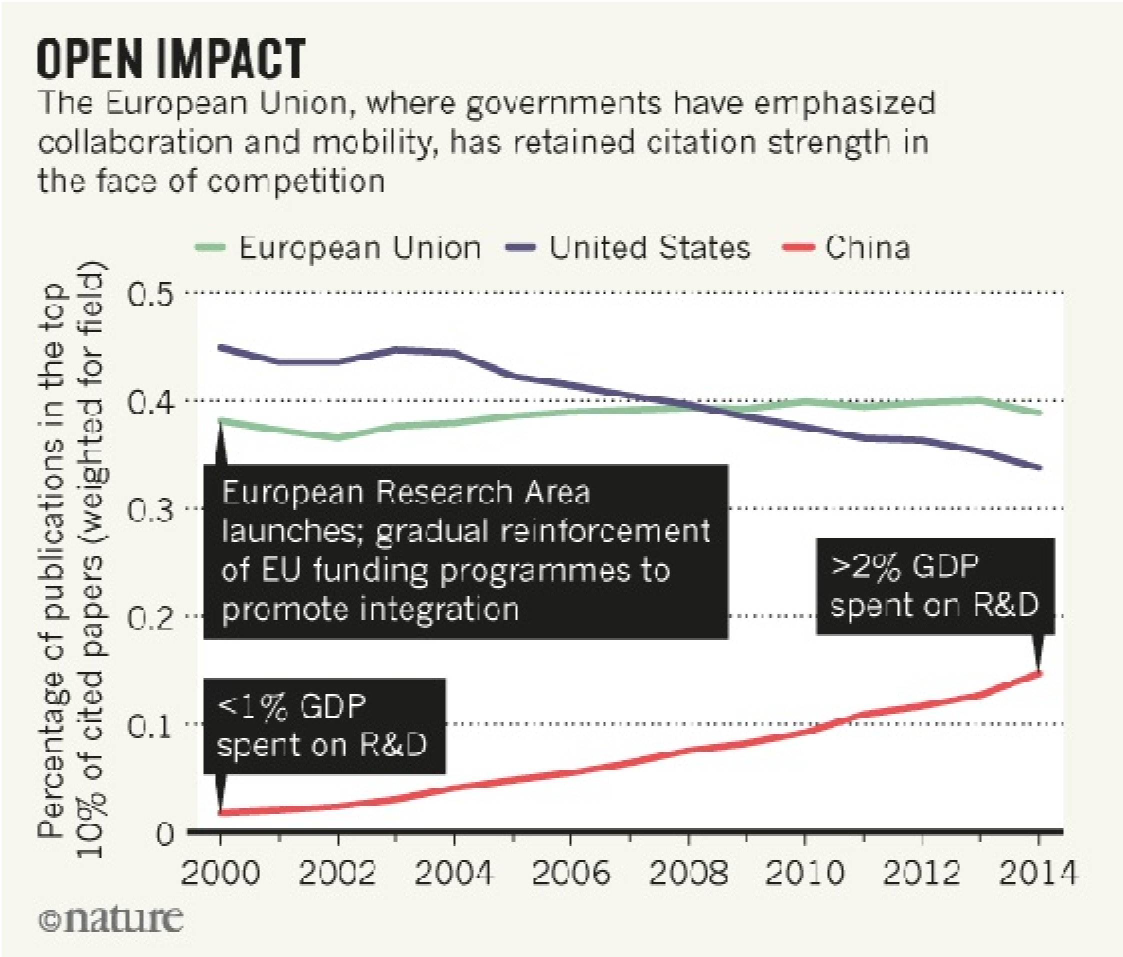
Countries with low openness and low impact include Russia, Turkey and Poland, China, Japan, Latvia, Lithuania, the Czech Republic and, against expectations, South Korea (which spends a higher percentage of its GDP on R&D; than almost every country, including the United States) These countries are shown in the lower-left quadrant.

The United States scores highly on impact, but less so on openness — perhaps because of the magnitude of its scientific enterprise and its geographic distance from possible collaborators. Of our 33 countries, only 4 (the United States, Italy, Spain and Finland) have low openness and high impact, and only 2 (Hungary and Mexico) have high openness and low impact.

Our analysis suggests that openness is related to impact, although we recognize that correlation is not causation. Nevertheless, we note that many of the countries whose scholarship has high impact, and whose policies encourage international engagement, are from Europe. The EU has established the European Research Area (ERA). Its governments have been implementing measures to strengthen domestic research systems while also promoting both international collaboration and mobility. The EU's Framework programmes have similar aims — one of the current stated objectives of EU research policy is to be more “open to the world”.

Analysis of citation strength for countries in Europe shows that they have greatly enhanced their impact compared with the United States (see 'Open impact'). As a bloc, the EU now outperforms the United States. Both far exceed China in impact, although China's share of high-impact papers is growing rapidly[5]. Other countries that promote openness also perform well in

terms of impact: examples include Singapore and Australia.



EU Joint Research Centre Tools for Innovation Monitoring, based on Scopus data release August 2016

Some will argue that citation is not synonymous with quality or importance, but it does signal engagement and recognition. Studies dating as far back as 1992 show that international papers are, on average, more highly cited[6]. The countries that are engaging internationally are seeing a dividend in terms of attention to their research.

It may be that the exchange of ideas encourages greater creativity, or that a virtuous cycle of quality work attracts others to work with those in higher-impact countries. In fact, we had very similar results when we considered each component in our openness metric separately, although most of the

effect of the mobility variables is mediated by international collaboration. Analytically, it makes sense to combine these into a single variable. However, other factors — such as the ease of obtaining visas or support to study in a country — are not explicitly incorporated.

In Japan, especially, output and citation impacts have remained flat since 2000. Japan is also among the least internationalized of leading nations, and this could be dragging on its performance. Lack of professional mobility, as well as language barriers, may be hindering engagement.

Our analysis suggests that national funding programmes should, whenever possible, move away from policies that fund only national researchers. In the longer term, countries could benefit more by funding the best science, wherever it is, and ensuring that domestically based scientists are linked with it. Restricting the movement of researchers — by limiting exchange opportunities or imposing visa restrictions, for example — could be counterproductive.

Just as industries make 'build or buy' decisions, so governments must make 'link or sink' decisions about research investment. Our data add to a growing body of work about the changing science system, indicating that science policymakers who seek to enhance impact should prioritize international exchange.

Journal name:
Nature
Volume:
550,
Pages:
32–33
Date published:
(05 October 2017)
DOI:
doi:10.1038/550032a

Comments

Commenting is currently unavailable.

Collaborative software development made easy

Save time and protect critical code with 'continuous integration' services.

04 October 2017

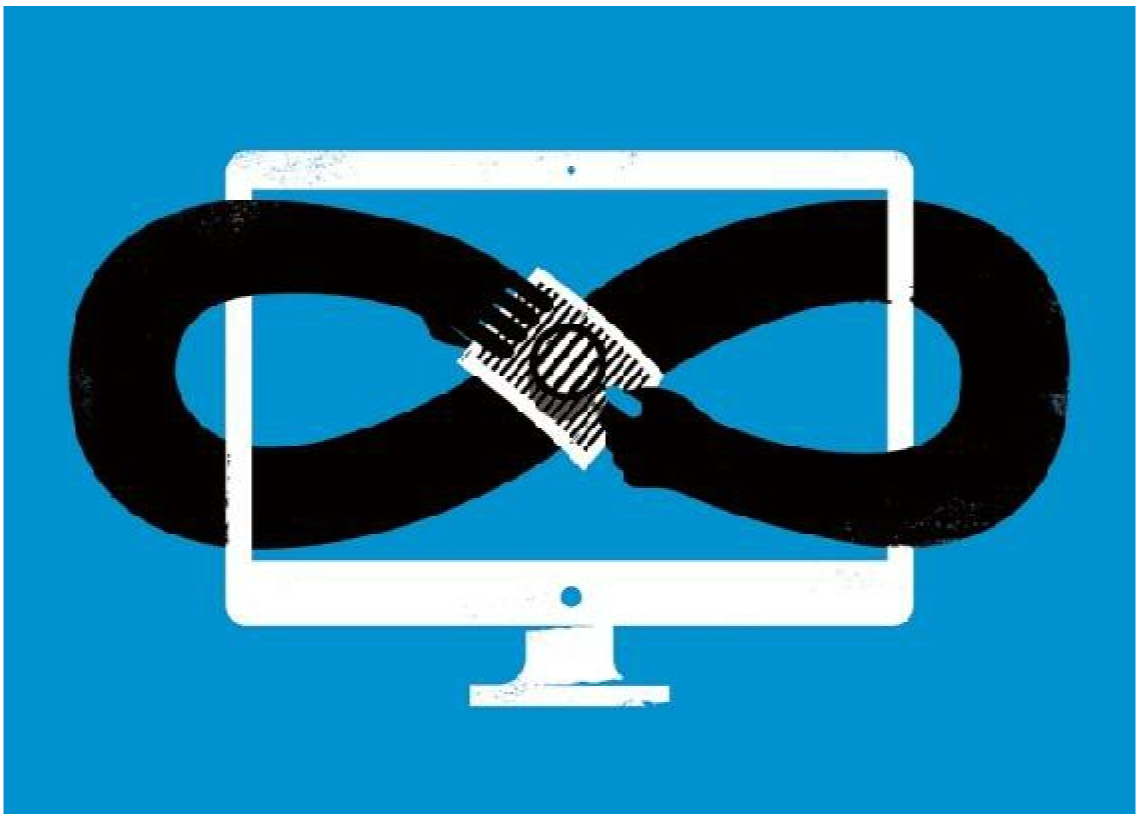


Illustration by the Project Twins

Sebastian Neubert, a particle physicist at Heidelberg University in Germany, leads a group studying subatomic particles called pentaquarks. The six team members all have access to the software code used to run their multi-step analyses, and the programmers update it daily with new features and bug fixes. With each code change, however, they run the risk of introducing

inadvertent errors that foul the underlying algorithms.

To prevent that, the team checks and rechecks the analyses, and uses error-checking algorithms, functions they can call whenever a change is proposed, to ensure that their software works as intended. One test, for example, verifies that a noise-cancelling algorithm gives the correct output when it is run on practice data.

In 2015, in an effort to save time and resources, the team took inspiration from the technology industry, automating their testing using a process called 'continuous integration'.

In continuous integration, changes to software code automatically trigger repetitive tasks, such as error-checking. Fundamentally, the process simplifies a task that diligent coders already perform. Programmers usually write lists of tests that they will run periodically to ensure that their code still works, just as Neubert's team do. But a busy team might forget or lack the time to run them, allowing errors to creep in. Continuous integration automates that process so those checks run whenever a change is proposed, saving team members the time they would spend hunting down an error. A team running genomic analyses could spend more time at the bench, while a group developing climate-prediction software could better refine its models. That said, the resulting peace of mind is only as good as the tests themselves: a poorly designed test can still allow mistakes to pass undetected.

The process is common in the commercial and open-source sectors. A study presented at the 2016 IEEE/ACM International Conference on Automated Software Engineering in Singapore found that about 40% of the 34,544 most-popular open-source projects hosted on the coding collaboration site GitHub used continuous integration in some form.

Only a few of those open-source projects might be considered scientific software, but an increasing number of scientists are looking to continuous integration to automate all sorts of time-consuming tasks, from testing code to updating documents with the latest data.

Researchers at institutions such as CERN, Europe's particle-accelerator laboratory near Geneva, Switzerland; the Pacific Northwest National

Laboratory in Richland, Washington; and the Ontario Institute for Cancer Research in Toronto, Canada, have embraced the practice, but adoption in the scientific sector remains relatively sparse.

For Neubert, continuous integration ensures that the pipeline's behaviour remains correct and consistent as his team refines its code, providing an “incredibly valuable” safeguard. “There is a real danger of just missing something or making a slight mistake,” he says.

Exceptions

A variety of continuous integration services exist. These include the open-source Drone, and commercial options such as CircleCI, Codeship, GitLab, Shippable and Travis CI, all of which offer pricing tiers based on the desired testing behaviour, number of users and whether the project is public or private. Travis CI, for instance, is free for open-source projects; private projects cost from US$69 per month. Shippable offers a free basic service for public projects, but charges $25–150 per month for support for private projects and greater computing power, among other features.

Researchers should consider what is a suitable and worthwhile investment, however. Not every project needs continuous integration and setting up and configuring a service can be challenging. Further difficulties can arise if the services need to interact with software or data with legal restrictions on its use, says Daniel Himmelstein, a data-science postdoc at the University of Pennsylvania in Philadelphia.

Also, code is often used only once, making the cost even less worthwhile. “For day-to-day research coding, the amount of code is not large enough to make continuous integration valuable,” says Andrea Zonca, a specialist in high-performance computing at the University of California, San Diego. He uses Travis CI when publishing code, but most that he writes is for his own one-time use and is not executed again.

Computing costs can also mount if code is being constantly updated and requires repeated testing, which is why Neubert's lab only tests its most

critical data analyses after code changes.

Despite these challenges, continuous integration services tend to improve code quality, says Björn Grüning, a bioinformatician at the University of Freiburg in Germany, especially on large projects such as Galaxy, a bioinformatics toolkit that Grüning, along with about 160 others, contributes to.

According to Grüning, continuous integration has shortened the turnaround time for approving contributions to the Galaxy project and given programmers more confidence when submitting new features and fixes. Before these services were available, it was often impractical for researchers in such projects to test every new feature collaborators proposed because they didn't have the time, he says.

Some researchers use continuous integration to automate non-programming tasks. In April, as part of a project studying how ecosystems change over time, Ethan White, an ecologist at the University of Florida in Gainesville, helped to configure Travis CI to update tables and plots automatically with new field or weather-station data, saving the research team up to 5 hours a month.

Continuous integration helps Himmelstein automate revisions to scientific papers, citations and web pages following text or code updates. Without continuous integration, he says, human maintainers would probably “get lazy and update the manuscript less frequently than every change”.

Initializing

Whether hosted externally by a third party or on a user's own machine, the continuous integration service is controlled with a custom set of instructions. This configuration file defines the tasks to be run and sets up the server with the correct environment — the operating system and software libraries — required to run them. The service then executes those instructions at set times or on receipt of a code or data update.

University of Pennsylvania bioinformatician Casey Greene, who uses

continuous integration to rerun his data analyses, has tested many of today's most popular services. “The good news about all of these services is that they're quite similar,” he says.

Subtle differences do exist, for instance in the number of concurrent jobs users can run, or the amount of computing power available to run them. “I'd encourage people to dig into the limits of each service to make sure they are compatible with their workflows,” advises Greene.

Although continuous integration adoption in science right now is small, it is growing, and more researchers should get on board, Greene says. Getting up to speed takes time, he acknowledges, but often, the effort is worth the reward. “Scientists analysing data should have it in their toolbox.”

Journal name:
Nature
Volume:
550,
Pages:
143–144
Date published:
(05 October 2017)
DOI:
doi:10.1038/550143a

Comments

Comments

There are currently no comments.

A taste of Toolbox

Nature's technology editor, Jeffrey Perkel, started blogging about workplace technology in science in 2016. Here are some highlights.

04 October 2017

From stadiums to genomes

Most bioinformaticians are either biologists skilled in programming or programmers with an interest in biology. Mike Goodstadt, the programmer behind the 3D genome-visualization tool TADkit, took a different approach. In the early-to-mid 1990s, Goodstadt was a student at the University of Bath, UK. His course of study? Architecture, with an emphasis on 3D modelling. After graduation, he helped to design and build a 61,500-seat stadium. But a faltering economy and newly acquired programming skills helped to steer him towards biology.

Lorena Barba, reproducibility champion

Lorena Barba, a mechanical and aerospace engineer at George Washington University in Washington DC, has long championed research reproducibility. “I've always believed that the open-source model is ideal for science, as it exposes the complete sequence of steps that produces a given result,” she says. In January, she travelled to Chile to run a week-long course on reproducible research computing. The month before, she had been awarded a 2016 Leamer-Rosenthal Prize, which celebrates those “working to forward the values of openness and transparency in research”. In this Q&A;, she talks flying snakes, 'repro-packs' and copyright.

The sound of DNA

With an alphabet comprising just four letters, a DNA sequence isn't much to look at. So when sequence-analysis tools want to highlight key elements, they typically do so using colour or font, or by overlaying other types of information. In the not-too-distant future, there may be another option. Molecular biologist and part-time drummer Mark Temple at Western Sydney University, Australia, describes DNA sonification, “an auditory display tool” for DNA: sequence in, audio out. “I'm not saying audio by itself is the bees' knees for interpreting DNA sequence,” Temple says, “but surely audio can contribute to your visual interpretation.”

Journal name:
Nature
Volume:
550,
Pages:
144
Date published:
(05 October 2017)
DOI:
doi:10.1038/550144a

Comments

Comments

There are currently no comments.

South Korea cracks down on dirty air

Despite huge clean-up effort, scientists say country’s pollution problem could get worse over next five years.

03 October 2017

Ed Jones/AFP/Getty

South Korea's capital, Seoul, ranks among the world's most polluted cities.

In a major attempt to clean its increasingly dirty air, South Korea’s government last week unveiled a five-year, 7.2 trillion won ($6.3 billion) plan to close down old coal plants, get diesel vehicles off the road and curb polluting emissions from industrial plants, construction sites and ships.

Although much of the spending had already been pledged, researchers say that the new strategy, announced on 26 September, is the country's most ambitious attempt yet to scrub its air. But because it omits controls on a class of chemicals called volatile organic compounds (VOCs), the initiative might make air quality worse before it improves.

The plan fulfils a key campaign pledge by President Moon Jae-in, who was elected in May by a Korean public increasingly concerned about their country's worsening air quality. At times this year, Seoul ranked among the world's top three most polluted cities. And the Organisation for Economic Co-operation and Development (OECD), based in Paris, reports that in 2015 South Korea's average exposure to fine-dust particles under 2.5 micrometres in size was the highest of all OECD member nations. This particulate matter, known as PM2.5, is small enough to enter the lungs and can cause respiratory illnesses.

The government hopes to cut domestic emissions of PM2.5 by 30% before 2022. Moon's administration has already focused on shutting down coal plants, temporarily closing eight of them in June and beginning the permanent shutdown of three in July. And the previous administration of Park Gyun-Hye had pledged 5 trillion won by 2020 to speed the adoption of electric cars to replace diesels.

NOx-ious crackdown

But the new strategy also aims to crack down on emissions of nitrogen oxides (NOx), which can react with other atmospheric compounds, including VOCs, sulfides and ammonia, to form ozone and fine-dust particles. Large industrial facilities such as steel plants and petroleum refineries will be fitted with monitoring equipment and held to a cap on their NOx emissions starting in 2019, the environment ministry's deputy director JaeHyun Kim says.

That approach has been informed in part by data released in July from a joint US–South Korean study called KORUS-AQ[1], says Kim. The most comprehensive examination of air quality in the region, it involved more than 580 researchers from the United States and South Korea, as well as several

research aircraft, including a NASA DC-8 jet that [flew across the Korean peninsula and the Yellow Sea]. Researchers found that South Korea was emitting more NOx and VOCs than its own ministry estimated, and recommended reductions in these chemicals. This highlighted the importance of addressing South Korea's domestic pollution, says Kim, at a time when many in the country were more concerned about pollution blowing over from China.

The focus on NOx means the new plan is "a lot better than before", says Kyung-Eun Min, an atmospheric chemist at the Gwangju Institute of Science and Technology. But she and other scientists point out that it says little about curbing VOCs. These are typically aromatic molecules produced for activities such as painting, printing and dry cleaning. A compound called toluene, used to manufacture solvents, is particularly instrumental in producing fine dust and ozone, the KORUS-AQ study found. The VOCs often leak during production, or while being stored or used by small businesses.

Ozone up?

Paradoxically, Min says, reducing NOx without reducing VOCs is likely to increase ozone across much of South Korea. That is because, according to the KORUS-AQ results and Min's own work, relative levels of NOx are so high in Korea — especially in car-filled Seoul — that they restrict the efficiency of ozone production, much as an over-rich fuel mixture makes an engine sputter. The quickest way to cut ozone is to starve it of both NOx and VOCs, "but the VOC part is not really there," Min says. However, regions downwind of Seoul may benefit more quickly from NOx reductions, says Rokjin Park, an air chemist at Seoul National University.

Tracking VOC emissions is particularly difficult, because there is no clear way to monitor or regulate small businesses such as painters and dry cleaners. A first step would be to collect data to nail down where South Korea's VOCs are coming from, Min says. In the longer term, she suggests developing technology that can capture dirty air from such emissions sites so that it can be purified at treatment facilities — in a process analogous to sewage treatment.

Yong Pyo Kim, an environmental scientist at Ewha Womans University in Seoul and an author of the KORUS-AQ report, says he thinks that both ozone and fine dust could get worse for the next five years. “In my opinion, the environment ministry did not learn from the KORUS-AQ results seriously,” he says. The South Korean environment ministry has not responded to requests for comment from *Nature* about the criticisms.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22448

Comments

Comments

There are currently no comments.

Xenon view, butterfly wings and a strange squid

September's sharpest science shots, selected by *Nature*'s photo team.

03 October 2017

CRISPR catches

Richard Wallbank/Smithsonian Institution and University of Cambridge

The beauty of butterfly wings owes much to just two genes, researchers revealed this month. They used the CRISPR gene-editing system to turn off the genes, called *WntA* and *optix*, to show how their absence dulls the colours

of these fleeting flyers. Left are the wings of an unmodified Sara longwing (*Heliconius sara sara*) from the study; right is a gene-edited version.

Inside Xenon

Image Slideshow

1. 

   Winner of a gold award in the 2017 [International Images for Science](#) competition, this picture by Enrico Sacchetti shows the interior of the Xenon1T experiment at Italy's Gran Sasso Laboratory, which hunts for dark matter.

   Enrico Sacchetti/Royal Photographic Society

2. 

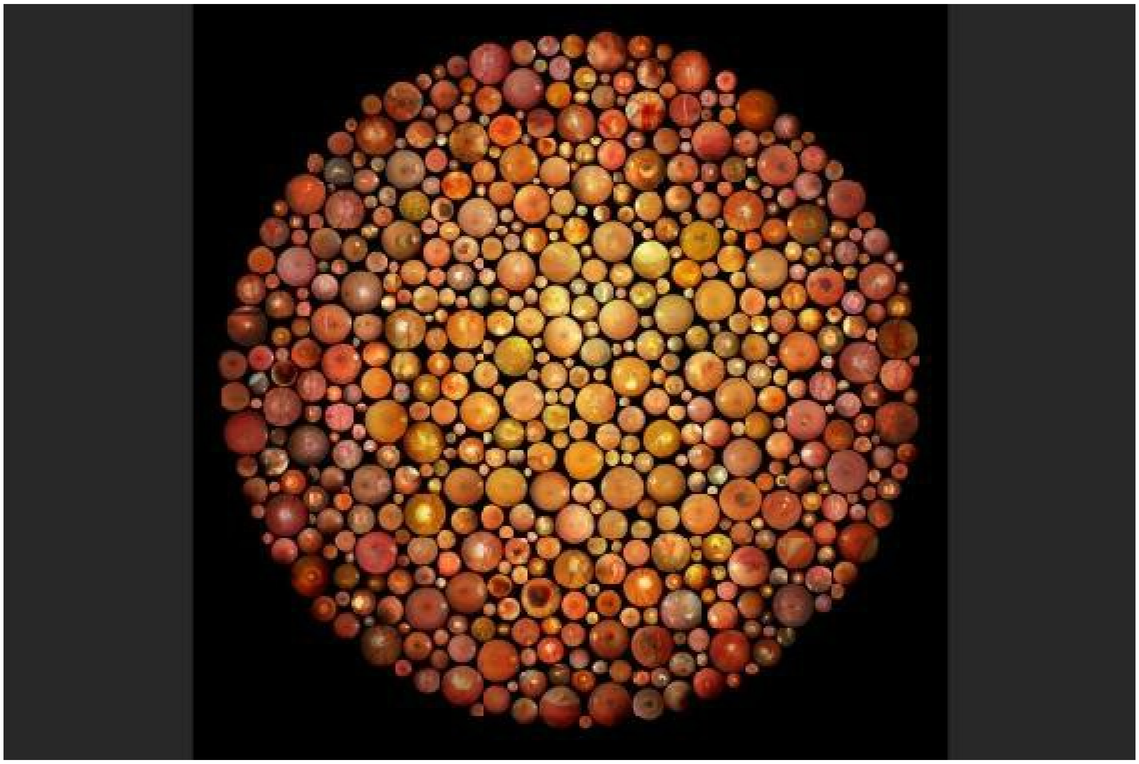
Another gold-award winner, this one taken by Teresa Zgoda. What looks like a frightening visage is actually a close-up of a pork tapeworm (*Taenia solium*), showing in detail the suckers that allow it to stick to the inside of humans and grow — and grow, and grow.

Teresa Zgoda /Royal Photographic Society

3. 

These legs belong to impalas (*Aepyceros melampus*); the black patches are glands used for scent marking. This image from Morgan Trimble won a bronze award in this year's competition.

Morgan Trimble/Royal Photographic Society

4. 

This shot is a combination of hundreds of images of retinas shot by Jonathan Brett, and assembled to mimic a colour-vision test chart. The eyes took a silver award.

Jonathan Brett/Royal Photographic Society

Coming down…

Bill Ingalls/NASA

At the start of the month, this Soyuz capsule brought back three astronauts to Earth, landing near Zhezkazgan in Kazakhstan. Among them was Peggy Whitson, who spent 288 days in space aboard the International Space Station.

… and going up

Bill Ingalls/NASA

Ten days after Whitson and her colleagues returned to this planet, another three people left it when this Soyuz left for the space station from Baikonur Cosmodrome.

A complex cloud

Artem Mironov

This nebula — called the Rho Ophiuchi cloud complex — is 140 parsecs (460 light years) from Earth. Photographer Artem Mironov took three nights to capture this image of it, which went on to win this year's Insight Astronomy Photographer of the Year award.

Seamount squid

NOAA Office of Ocean Exploration and Research

On 17 September, the crew of the US National Oceanic and Atmospheric Administration's ship *Okeanos Explorer* were exploring the Musicians Seamounts, a formation of undersea mountains in the Pacific Ocean, with remotely operated submersibles when they spotted this cranchiid squid. You can see more pictures of weird and wonderful deep-sea denizens on their diary site.

Bee bounty

Image Slideshow

1. 

The USGS Bee Inventory and Monitoring Lab in Laurel, Maryland has long been among our favourite purveyors of online insect images. Among the latest additions to its catalogue is this *Hoplitis fulgida*.

Anders Croft/USGS Bee Inventory and Monitoring Lab

2. 

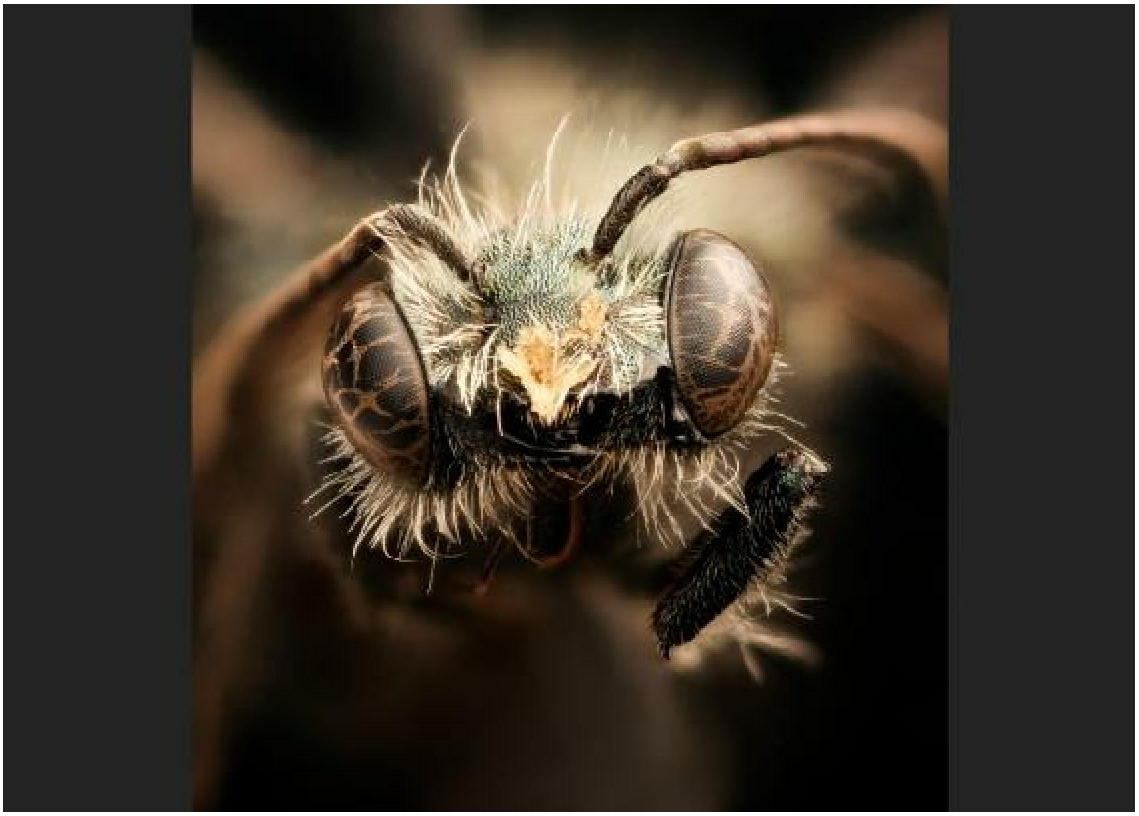
Another shot of *H. fulgida*, collected in Yosemite National Park, California.

USGS Bee Inventory and Monitoring Lab

3. 

Dianthidium singulare glues rocks together to make little houses for its eggs. The lab calls it a “boss looking bee”, and it’s hard to disagree.

USGS Bee Inventory and Monitoring Lab

4. 

The lab says this mason bee *Osmia subarctica* is a terrible specimen, but it has photographed beautifully.

USGS Bee Inventory and Monitoring Lab

Cassini comedown

NASA/Joel Kowsky

It is finally over. The Cassini mission this month dived into Saturn’s atmosphere, destroying itself. In this photo, Cassini programme manager Earl Maize packs up his workspace at mission control in the Jet Propulsion Laboratory in Pasadena, California. on 15 September.

They grow up so fast

Online Tracking of Arabidopsis Root

Arabidopsis thaliana, or thale cress, is widely used as a model organism in labs. Daniel von Wangenheim of the Institute of Science and Technology Austria in Klosterneuburg won first place in the Nikon Small World in Motion Photomicrography Competition for this remarkable time-lapse video of the root tip of one *A. thaliana* plant growing.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22741

Comments

Comments

There are currently no comments.

Europe’s Joint Research Centre, although improving, must think bigger

External report criticizes lack of exploratory research.

03 October 2017

Sean Gallup/Getty

Europe’s Joint Research Centre first raised awkward questions about diesel car emissions.

The European Union’s Joint Research Centre (JRC) uses the label EU Science Hub now. Whether the rebranding will increase its profile is one

question. What science gets done inside this hub is another. In response to that query, there is some positive news. It is doing what it should be, and doing it well: collecting scientific and technical evidence in support of EU policies. That's according to the report of an external evaluation released this week. Furthermore, EU research commissioner Carlos Moedas praised the JRC at its annual public meeting on 26 September for contributing to the interminable struggle to counter false information and communicate science effectively to a sceptical public.

The JRC employs more than 2,000 scientists, who generate or collate a constant feed of information for authorities and politicians. In theory, this helps to support evidence-based policies — from the old chestnuts of genetically modified (GM) crops and nuclear safety to the ongoing refugee crisis, for which it holds a repository of relevant information and reliable statistics. Yet most of this work fails to reach public attention. For example, staff in the JRC transport section had worked out and published evidence that car makers were manipulating diesel-emission data years before the public scandal over Volkswagen finally broke in 2015.

The JRC celebrates its 60th anniversary this year. It has become a complex beast, operating at six sites in five EU countries, with a budget this year of €372 million (US$437 million). It was originally set up as a nuclear research organization, but widened its remit over the decades, adding institutes. Twenty years ago, it morphed into a centre with an explicit mission to provide support for a wide range of EU policies. But by that time it had lost its way, and tough reforms were introduced. A 2009 evaluation led by former UK government science adviser David King concluded that it was carrying out its new remit well, but criticized it for doing too little independent research of the type required to attract and keep the best scientists.

The new report, headed by the former Irish government science adviser Patrick Cunningham, echoes this call. It acknowledges how rapidly the centre has broken out of its much-criticized institute-based silos to restructure thematically into cross-site departments, such as energy and health, which more directly mirror policy areas. It also notes that the JRC has significantly increased its presence in the world's top-cited literature. But it says that the centre still does too little exploratory research — such research engages only

3.5% of JRC staff, well below the target of 10% that it set itself in 2015.

Why has it struggled? Although it has established partnerships with European universities and research institutes, and aided the exchange of scientists, many JRC researchers have different motivations from those of colleagues in universities. There is much satisfaction in contributing to policies that influence the lives of people in the EU. But officials and staff must look again at their priorities. As well as keeping the JRC relevant, a wider focus on the cutting edge would allow it to flag up hot topics to policymakers earlier.

But what policymakers do with the information they receive from their science service is another matter entirely. EU policy on GM crops is notoriously weak — scientific evidence for their safety has failed to convince some countries, whose citizens viscerally reject the technology. And sometimes the EU's intrinsic political weakness can block the implementation of its science-based policies. After all, the European Commission and EU member states ignored the findings on diesel emissions, and acted only after regulators in the United States cracked down.

Journal name:
Nature
Volume:
550,
Pages:
8
Date published:
(05 October 2017)
DOI:
doi:10.1038/550008a

Comments

Comments

There are currently no comments.

Bill &
Melinda
Gates
Foundation

Make plans to eliminate cholera outbreaks

Governments must stop denying the occurrence of cholera and unite in long-term prevention strategies, says Anita Zaidi[1].

03 October 2017

As a medical student in Karachi in the 1980s, I saw cholera all the time. We had a dedicated diarrhoea ward in the hospital, and if there was an increase in diarrhoea cases in children aged over 3, we knew we had a cholera outbreak. Over the past decades, the world has become much better equipped to fight cholera, yet the disease continues to spread across sub-Saharan Africa, Asia and the Caribbean.

In Yemen, cholera has killed more than 2,000 people and infected nearly 700,000 in the past 5 months alone, eclipsing the post-earthquake outbreak in Haiti. Haiti still battles with the disease 7 years after its reintroduction. Meanwhile, Somalia is experiencing its worst outbreak in five years. South Sudan continues to fight its worst outbreak since it gained independence in

2011. If nothing changes, cholera will continue to claim some 100,000 lives a year and afflict around 3 million people, many of them children.

This week, the World Health Organization (WHO) launches a campaign to eliminate cholera outbreaks by 2030. The plan could move countries beyond ad hoc reactions, to sustainable prevention.

The disease is caused by the bacterium *Vibrio cholerae* and spreads mainly through contaminated water. Infection usually causes no or mild symptoms, but in approximately one-tenth of cases it swiftly leads to watery diarrhoea, vomiting and cramps. Rapid loss of fluid can result in dehydration and death within hours. An oral rehydration solution that costs cents can reduce fatality from a high of 50% to under 1%. Every year, it still fails to reach tens of thousands of victims in time.

Clean water, improved sanitation and better access to treatment have been game-changing for much of the world, but cholera is still thought to be endemic in 69 countries, including most of sub-Saharan Africa.

In the twenty-first century, no one should die from this disease. We have treatments and prevention strategies that work, including sufficient cholera-vaccine stocks. We know where outbreaks are most likely to start. To spread, cholera needs estuaries, rivers or coastal waters that are contaminated with faeces, and susceptible people living nearby; it has clear patterns of recurrence. What we need to do is get there first.

What's stopping us? One barrier is stigma. Many national and regional governments don't want to admit that their territory harbours cholera. Rather than controlling it, they hide it. The stigma goes back hundreds of years, to when ships with sick passengers were not allowed to dock and people feared being put in quarantine. Now the fears are public anger and loss of economic opportunities. Many countries with known endemic cholera in Asia and Africa report to the WHO that they have no cases, and in the face of an outbreak do not request cholera vaccines. In 2010, during the massive floods in Pakistan, my colleagues and I saw hundreds of cases of acute watery diarrhoea in Sindh that we confirmed to be cholera in our laboratory, but national health officials told us to keep it quiet.

Too many countries act only after a crisis has emerged: then they request vaccine campaigns, set up makeshift cholera clinics and urgently mobilize supplies.

These tactics can quell an outbreak and dampen transmission in the short term, but they don't stop outbreaks from happening again. For that, governments must intervene preemptively to control cholera in places where it recurs frequently. Since the WHO cholera-vaccine stockpile was established in 2013, almost 13 million doses have been delivered. Millions more doses should have been requested.

To truly stop cholera outbreaks, countries must do two things: deploy vaccines where cholera is endemic and strengthen the infrastructure that provides clean water and good sanitation.

Events in Malawi give reason for optimism. In April this year, the country adopted a national plan to control and prevent cholera that directs vaccines to affected communities identified by geo-spatial mapping. More than 2 million citizens have been vaccinated ad hoc since 2015. The new plan, made possible by strong political commitment at the Ministry of Health, collates two decades' worth of information to better estimate cholera burden, identify hotspots and support early intervention. At the same time, Malawi is planning to strengthen water and sanitation infrastructure. Experts are hopeful that this will reduce the country's cholera burden to its lowest level in years.

Similarly, the WHO Global Task Force on Cholera Control is launching a renewed strategy to eliminate cholera outbreaks worldwide. Unlike past efforts, this plan goes beyond responding to cholera flare-ups: it encourages countries to invest in protecting people from cholera over the short and long term.

The success of the WHO's plan ultimately depends on the commitment of governments worldwide. All governments, whether or not they are directly affected by cholera, must unite and increase their political and financial investment in cholera prevention and control.

The first cholera pandemic, in 1817, swept across South Asia, East Africa, the Middle East and Europe, claiming hundreds of thousands of lives. Back

then, we had no vaccine and a limited understanding of transmission. It is unacceptable that, now, in that pandemic's 200th anniversary year, a disease we know how to fight remains out of control.

Journal name:
Nature
Volume:
550,
Pages:
9
Date published:
(05 October 2017)
DOI:
doi:10.1038/550009a

Comments

Comments

There are currently no comments.

Ethics of Internet research trigger scrutiny

Concern over the use of public data spurs guideline update.

03 October 2017

Matt Cardy/Getty

A Banksy artwork in Cheltenham, UK. Scientists tried to find the artist’s true identity using public data.

British graffiti artist Banksy is renowned for his anonymity. But that status was dented last year when researchers published a paper that cross-referenced the locations of Banksy’s street art with public information about people’s

addresses and likely movements ([M. V. Hauge *et al. J. Spatial Sci.* **61,** 185–190; 2016](#)). The team, led by academics at Queen Mary University of London, concluded that someone previously suspected to be Banksy probably was the secretive artist.

Because the study used public data, a university ethics committee said that the work was exempt from formal review — and informally advised academics that it would do no harm because a UK national newspaper had already identified the person in question as Banksy. But for some ethicists, the paper highlights growing concerns about the potential hazards of research that uses public data. "I think this study should never have been done," says Jake Metcalf, a technology ethicist at the think tank Data & Society in New York City.

Metcalf is one of several academics calling for new guidelines to steer scientists through ethical quandaries in Internet research. The unprecedented availability of online data — together with tools to draw patterns from it, such as machine learning — is opening up research possibilities that outpace existing ethics frameworks around privacy, consent and harm, says Charles Ess, a research ethicist at the University of Oslo and a member of the Association of Internet Researchers. The association will discuss how to update its guidelines at its annual meeting on 19 October in Tartu, Estonia.

A flurry of similar initiatives is under way. Earlier this year, the SATORI project, funded by the European Commission, published recommendations on Internet research as part of an effort to standardize and update research-ethics guidelines. In September, the US National Science Foundation funded a US$3-million, 4-year study called PERVADE — of which Metcalf is a part — that aims to chart attitudes to data-research ethics, produce best-practice guidelines and create tools to assess the potential harms of such work. And some British universities are preparing their first guidelines on the ethics of Internet research, after the UK Research Integrity Office, a national advisory body, published non-binding recommendations about it last December.

Common themes among these efforts include rethinking what counts as 'public' data, the ethical use of social media and the need to consider a study's potential harm to wider society, as well as to individuals. Many

countries have long-standing ethical checks for research that intervenes in human lives. But those principles, set up for medical and psychological studies, apply to research on human subjects, the definition of which often excludes Internet research, says Metcalf.

In the United States, for instance, studies using public data (which includes that purchased from a third party) generally do not count as human-subjects research because they don't access private, identifiable information about people. They don't need to be checked by an institutional review board (IRB) or require informed consent. Guidelines issued in 2013 add that researchers should sometimes consider seeking review — if a person incorrectly assumed that access to his or her public information was restricted, for example. But IRBs have no obligation to adopt these proposals, and different committees may come to different verdicts, says Metcalf.

Peter Hedges, head of the research-operations office at the University of Cambridge, UK, argues that even researchers who use information that is undeniably public, such as Twitter data, should review the ethics of their work. The SATORI guidelines advise that regulators and researchers should carefully consider whether publicly available information is actually private, and not fall back on simple classifications.

If someone's data are considered private and identifiable, that would usually mean obtaining their informed consent. But, in practice, such consent is often impossible to acquire for large-scale data studies, says Ess. And anonymizing data is difficult, because search engines can easily identify individuals from even small snippets of anonymized text or by cross-referencing them in multiple data sources. The SATORI guidelines recommend that researchers take precautions to ensure the anonymity of study participants, and Ess suggests that scientists can still, without too much effort, seek consent from anyone they explicitly quote in research papers.

When ethics committees do assess data studies, their viewpoint might be too narrow, says Ansgar Koene, an engineer and ethicist at the University of Nottingham, UK. They tend to consider the direct damage to an individual involved in research, rather than a project's potential to do widespread harm to society. That debate flared up in September when artificial-intelligence researchers at Stanford University in California posted a preprint of research

that predicted whether someone is gay from their photo; it used pictures sourced from an online dating site (see https://osf.io/zn79k). The study was approved by Stanford's IRB, but provoked condemnation from some advocacy groups for lesbian, gay, bisexual, transgender and queer (LGBTQ) people, which branded it dangerous. The study's lead author, Michal Kosinski, said the work aimed to protect people by exposing an existing threat from widely used technology. Kosinski and his colleague, Yilun Wang, discussed their results afterwards with representatives of the LGBTQ community, but Koene says that the discussion should have happened beforehand and the paper should have addressed their comments.

Computer science is a flashpoint for Internet-research ethics. Researchers in this field are not used to working with human study participants and often don't consider the ethical impact of their work, says Koene, who has surveyed approaches to ethics in different disciplines. A major concern, academics agree, is how companies use online data for research — much of which they have proprietary access to. In 2014, for example, Facebook altered users' newsfeeds without telling them, to study how this affected their emotions. A public backlash prompted Facebook to publish some details of its internal review process (M. Jackman and L. Kanerva *Wash. Lee Law Rev. Online* **72,** 442; 2016) — but there is little transparency overall about how this works, says Koene.

Researchers may not want to see their science slowed by formal ethical review, which can be time-consuming and opaque. Better ethics training is one solution, says Koene. But a failure to align data science with public perceptions of what is acceptable could generate a severe reaction, he warns. "The public will see us as no different from corporate or other special-interest groups pursuing a hidden agenda," he says.

Journal name:
Nature
Volume:
550,
Pages:
16–17
Date published:

(05 October 2017)
DOI:
doi:10.1038/550016a

Comments

Comments

There are currently no comments.

Gravitational wave detection wins physics Nobel

Rainer Weiss, Barry Barish and Kip Thorne share the 2017 prize for their work at LIGO to detect ripples in space-time.

03 October 2017

Left: Bryce Vickmark/MIT. Centre: Caltech. Right: Caltech Alumni Assoc.

Rainer Weiss (left), Barry Barish (centre), and Kip Thorne (right), who led work to detect gravitational waves.

Three physicists who had leading roles in the first direct detection of gravitational waves have won the 2017 Nobel Prize in Physics.

Rainer Weiss, at the Massachusetts Institute of Technology (MIT) in Cambridge and Barry Barish and Kip Thorne, both at the California Institute

of Technology in Pasadena, share the 9 million Swedish krona (US$1.1-million) award for their work at the US-based Laser Interferometer Gravitational-Wave Observatory (LIGO). In September 2015, LIGO picked up the deformations in space-time caused by the collision of two distant black holes.

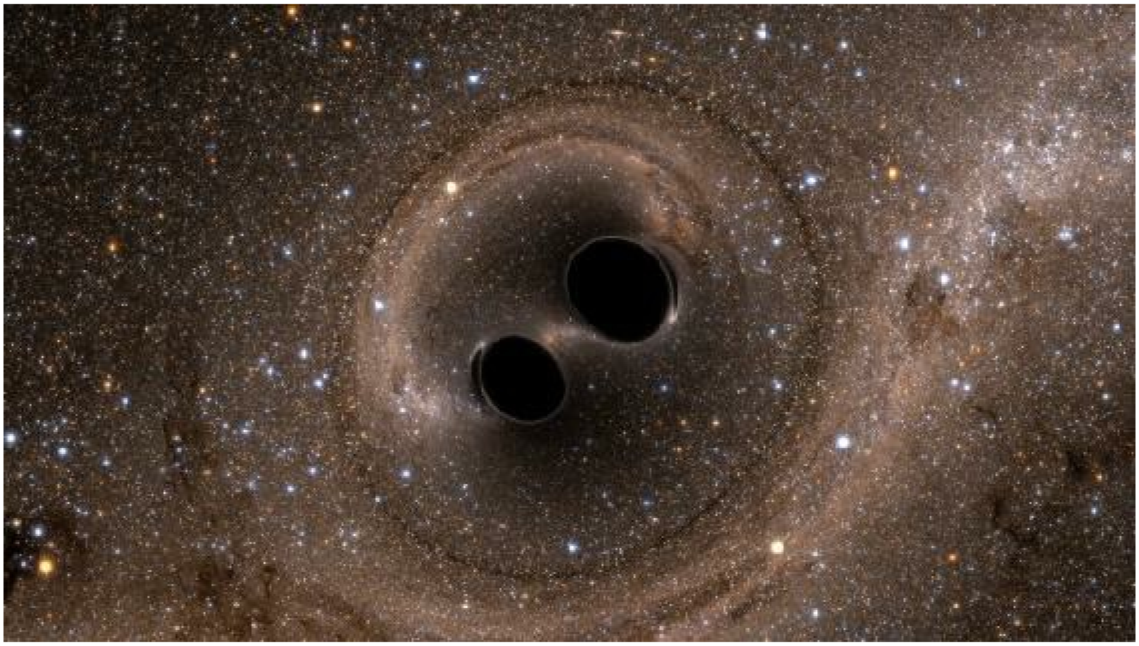
That discovery, which was announced in February 2016, opened up a new field of astronomy, in which scientists listen to the space-time vibrations emitted by some of the Universe's most cataclysmic events. And it confirmed the existence of gravitational waves, which Albert Einstein had predicted a century before.

Weiss and Thorne are two of three physicists known as the Troika — the founders of LIGO's giant twin detectors in Livingston, Louisiana, and in Hanford, Washington. The third troika member, Ronald Drever, died on 7 March this year. And Barish, who was LIGO director from 1997 to 2005, is widely credited with having transformed the collaboration from a chaotic endeavour to a well-oiled machine.

"I view this more as a thing that recognizes the work of about 1,000 people, a really dedicated effort that's been going on for — I hate to tell you — as long as 40 years," said Weiss in an interview with the Nobel Committee just after winning the prize.

"We were all very happy for them to be recognized. They worked on this for decades," says Gabriela Gonzalez, a physicist at Louisiana State University in Baton Rouge, and a LIGO team member and former spokesperson for the collaboration. The Nobel prize can be awarded only to a maximum of three people, but the Nobel Committee noted the huge numbers of people who worked on LIGO in its press release.

Researchers had been widely expecting the committee to reward the team since last year's detection announcement. "I'm very happy that they got the right people," says Charles Misner, a general relativity theorist at the University of Maryland in College Park. Half of the Nobel prize has been awarded to Weiss, with the other half split between Barish and Thorne.



The SXS Project

A computer simulation of two black holes colliding, which generates gravitational waves.

Unimpeded motion

Few physicists doubted the existence of gravitational waves before the LIGO discovery. The distortions in space-time are an inevitable consequence of Einstein’s general theory of relativity, and propagate across the Universe almost unimpeded. In 1974, they were confirmed indirectly when researchers examined the radio flashes emitted by a pair of merging neutron stars; the shifts in the flashes' timing matched predictions of how gravitational waves would carry energy away from the event. That discovery was rewarded with the 1993 Nobel Prize in Physics.

But sensing the waves themselves was a monumental task. Even the most powerful deformations — those produced by collapsing stars or colliding black holes — would typically be tiny by the time they reached Earth. The waves detected in 2015 stretched and squeezed LIGO’s perpendicular 4-kilometre vacuum pipes by a fraction of a proton’s width, but that was

enough to noticeably shift out of sync the laser beams bouncing inside the pipes.

Physicists in the United States and the then-Soviet Union first proposed using laser interferometers to detect gravitational waves in the 1960s. Weiss made the first detailed calculations for how an interferometer would work in 1972. The idea seemed so far-fetched that even he was not sure it would work. “It might come to a junction in a year or so when we will decide it ain’t worth it,” he told science sociologist Harry Collins at the time[1].

Weiss, who was born in Germany in 1932, emigrated with his family to the United States in 1938 to escape from Nazism. He built his first prototype interferometer in the mid-1970s, soon followed by researchers in Europe — among them, Drever and his collaborators at the University of Glasgow, UK, and another group in Munich, Germany.

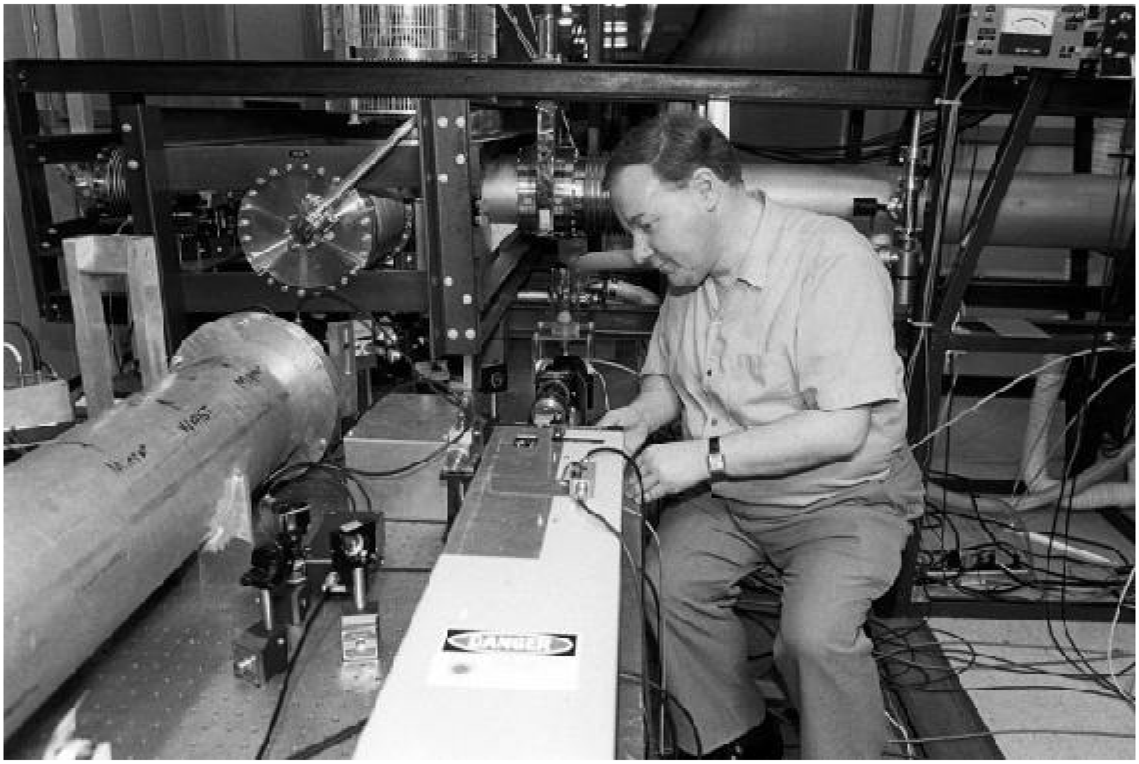
Thorne, born in Utah in 1940 to Mormon parents, specialized in general relativity and had also been developing ideas on the waves. At a conference in Washington DC in 1975, Thorne and Weiss shared a room in an over-booked hotel. During their conversations, Weiss convinced Thorne that interferometers were the right approach. Thorne, Weiss and Drever joined forces in the early 1980s, when it became clear that the US National Science Foundation would not fund two separate efforts, and the LIGO collaboration was born.

Dramatic turn-around

The troika did not always work smoothly and, at their own admission, did not possess the right skills for managing what was quickly becoming a vast operation. Things improved dramatically after Barish, who had been LIGO’s principal investigator since 1994, became director in 1997. Collins, who has closely studied the collaboration for decades, says that Barish turned LIGO into a ‘big science’ organization. “Without Barish turning things around, it would have collapsed,” he says.

LIGO initially struggled to get funded, but ended up being the largest and

most expensive experiment in the history of the US National Science Foundation. Its two nearly identical detectors first opened in 2002, with an admittedly scant chance of detecting anything during their first phase of data collection. The observatory shut down in 2010 for a major overhaul, and restarted in September 2015, three times more sensitive than before.



Bob Paz/Caltech Archives

Ronald Drever was one of the original co-founders of the LIGO project; he died in March 2017.

Researchers were cautiously optimistic of a discovery within a few years. But the Universe was kind to LIGO, providing a dramatic event for it to record on 14 September, while the interferometers were still being calibrated, days before their official science run was due to start. Since then, LIGO has detected at least three other gravitational-wave events — the most recent also spotted by Virgo, a similar interferometer near Pisa, Italy.

The LIGO team benefited from significant research efforts in other countries.

Germany and the United Kingdom have contributed funding and research, and GEO600, a smaller interferometer near Hannover, Germany, is the main test-bed for technologies that are implemented on its larger cousins in the United States.

The three winners have other strings to their bows: as well as working on LIGO, Weiss was a leading scientist in the Cosmic Background Explorer (COBE), a NASA probe that in the 1990s produced the first map of the cosmic microwave background, the 'afterglow' of the Big Bang. (Two other COBE researchers shared the physics Nobel in 2006.)

Thorne, who has spearheaded theoretical studies of gravitational waves, also helped to conceive the original idea for the plot of the 2014 film *Interstellar*, on which he was an executive producer. And before joining LIGO, Barish worked on neutrino experiments at the Fermi National Laboratory in Batavia, Illinois and elsewhere. He has also led the design of a proposed International Linear Collider.

Thorne and Weiss were generally considered shoo-ins for the Nobel. Before Drever's passing last March, the troika raked up almost every prize there was for them to win, including the $3-million Special Breakthrough Prize in Fundamental Physics; the $500,000 Gruber Foundation Cosmology Prize; the $1.2-million Shaw Prize in Astronomy; and the $1-million Kavli Prize in Astrophysics.

Journal name:
Nature
Volume:
550,
Pages:
19
Date published:
(05 October 2017)
DOI:
doi:10.1038/nature.2017.22737

Comments

Commenting is currently unavailable.

| 章节菜单 | 主菜单 |

Risk of human-triggered earthquakes laid out in biggest-ever database

Geologists track hundreds of quakes caused by people and the projects that set them off.

02 October 2017

Chris McGrath/Getty

A 7.8-magnitude earthquake that hit Nepal on April 30, 2015, has been linked by some to groundwater pumping.

From mining projects to oil and gas operations, human activity has set off

earthquakes around the world and in many geological settings. Research now highlights how big these quakes can get — and how little scientists agree on which ones are caused by people.

The Human-Induced Earthquake Database, or HiQuake, contains 728 examples of earthquakes (or sequences of earthquakes) that may have been set off by humans over the past 149 years. Most of them were small, between magnitudes 3 and 4. But the list also includes several large, destructive earthquakes, such as the magnitude-7.8 quake in Nepal in April 2015, which one paper linked to groundwater pumping[1].

Miles Wilson, a hydrogeologist at Durham University, UK, and his colleagues describe the database in a paper set to be published on October 4 in *Seismological Research Letters*[2]. The scientists say that HiQuake is the biggest, most up-to-date public listing of human-caused quakes ever made. By bringing the data together in this way, they hope to highlight how diverse induced quakes can be — and help society to understand and manage the future risk.

Earth-shaking activity

HiQuake began in 2016, when the Dutch Petroleum Society (NAM), an oil and gas company based in Assen, funded a team of researchers at Durham and at Newcastle University, UK, to collect examples of induced earthquakes. NAM drills in the Groningen gas field in the Netherlands, where it has set off many small earthquakes.

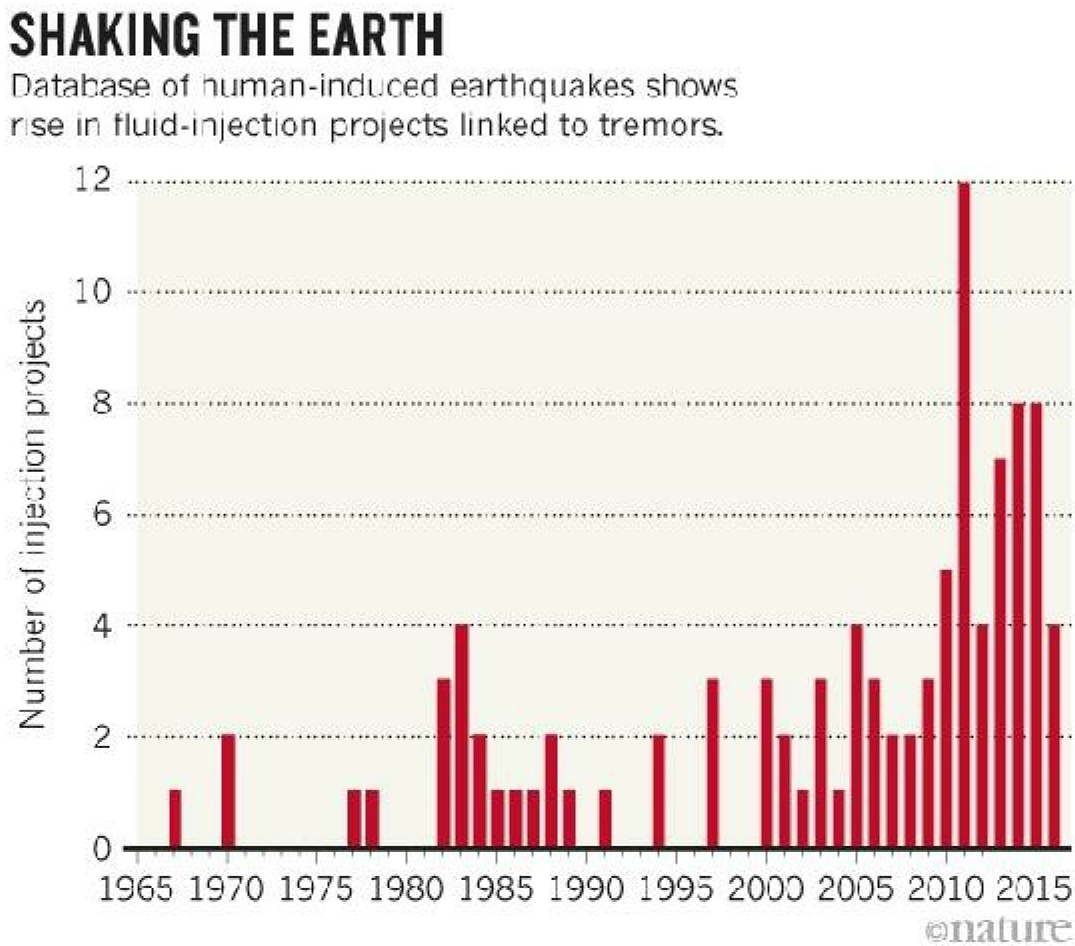
Wilson’s team trawled through sources including scientific papers and media accounts to come up with its 728 events. When a single project, such as a wastewater-injection well, set off more than one quake, the researchers counted those as a single event. Further details appear in *Earth-Science Reviews*[3].

The result is a database in which the earliest entry dates to 1868, with a quake triggered by an Australian coal-mining operation. Of the 728 events, 271 (37%) are linked to mining — often from tunnel collapses. About 23% are

linked to water piling up behind a dam and 15% to conventional oil and gas development. Just 4% are linked to hydraulic fracturing, or fracking, for oil and gas. Some of the more unusual cases involve quakes triggered by the building of heavy skyscrapers or by an underground nuclear-bomb test.

Mass movement

In HiQuake, the fastest-growing quake-inducing activity in the database is the injection of wastewater back into the ground by oil and gas operations (see 'Shaking the earth'). The process that can increase stress on buried geological faults and cause them to generate small earthquakes. The number of these projects spiked in the early 2010s, at the height of wastewater-injection in Oklahoma and other parts of the central United States.



The largest event in the database is the magnitude-7.9 earthquake that struck in Sichuan, China, in 2008, which some have linked with the filling of a nearby reservoir[4]. Wilson says his team was initially startled to see quakes that large proposed as human-induced. But in retrospect, he says, “we probably shouldn’t be surprised by any anthropogenic cause”. All the projects linked to earthquakes — whether blasting a mining tunnel, injecting wastewater or pumping groundwater — involve moving mass around on Earth’s surface in ways that can nudge already-stressed faults.

The scientists found a relationship between the volume of material moved — such as the size of the reservoir filled before the Chinese quake — and the magnitude of the largest linked earthquake that followed. No such relationship was seen with factors such as dam height or reservoir area. The researchers suggest that limiting the amount of material moved in a construction project could help to minimize any quakes triggered.

Judgement calls

All possible instances of induced quakes were included “without regard to plausibility”, writes the team, because of the difficulty involved in deciding what constitutes absolute proof that an earthquake was caused by human activity. But that could mislead people about the real hazard from induced quakes, says Raphaël Grandin, a geophysicist at the Institute of Earth Physics in Paris. “When you put a dot in the database, and a scientific reference behind it, then you may lead the non-expert to think that the earthquake was caused by humans,” he says. Such a listing might hide scientific uncertainty, as with the Chinese quake: despite the paper linking it to reservoir filling, many seismologists do not believe it was triggered by human activity[5].

Susan Hough, a seismologist at the US Geological Survey in Pasadena, California, says she understands why the HiQuake team included all possible instances of induced quakes. “I suspect the authors were unwilling to pass judgement on published studies, which I consider a reasonable decision,” she says. “If you start down the road, where do you stop?”

Wilson agrees. “Any judgement calls we leave to users,” he says.

Over time, HiQuake should become more useful as researchers add examples and references to its entries, says Gail Atkinson, a seismologist at the University of Western Ontario in London, Canada, who leads a Canadian collaboration to study induced seismicity.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22693

Comments

Comments

There are currently no comments.

Discoveries have awkward first dates

Fuzzy timings over a plate-tectonics anniversary highlight the rolling nature of scientific discovery.

02 October 2017

Archive of Alfred Wegener Institute

Alfred Wegener first suggested the idea of continental drift which led to the theory of plate tectonics.

This week, the Geological Society in London will mark the 50th anniversary

of plate tectonics — the theory that describes the workings of Earth, how earthquakes strike, and why volcanoes happen. Or will it?

The timing of the anniversary is disputed. After all, this journal published its own 50th anniversary commemoration of plate tectonics 4 years ago (*Nature* **501,** 27–29; 2013). Columbia University's Lamont–Doherty Earth Observatory in New York celebrated last May. Confused? Blame the rolling nature of scientific discovery. Plate tectonics did not spring into existence fully formed, Athena-like, on a particular day in a particular year.

No doubt aware of this, the London conference, although billing itself as "Plate Tectonics at 50", pins next week more cautiously: as a commemoration of the "advent of the paradigm" — the arrival of the model of the theory.

Coming up with the modern theory of Earth involved sparks of insight from many different researchers, working in different laboratories on different continents. Most of the resulting papers were published in the 1960s, many of them in *Nature*.

In September 1963, Frederick Vine and Drummond Matthews described how stripes of changing magnetism on the sea floor represented the spreading of new oceanic crust away from the ridge where it was born (F. J. Vine and D. H. Matthews *Nature* **199,** 947–949; 1963). This was the crucial insight that nailed the concept of sea-floor spreading, which had been hinted at in the 1950s, when oceanic mapping by Marie Tharp and Bruce Heezen revealed a mountainous rift, and so this is the paper that *Nature* editors choose to commemorate in plate-tectonics anniversaries. Fast-forward four years, and Dan McKenzie and Robert Parker publish the first complete description of how crustal plates move around on the surface of the sphere (D. McKenzie and R. L. Parker *Nature* **216,** 1276–1280; 1967), the paper that the Geological Society is now celebrating.

Of course, Vine, Matthews, McKenzie and Parker were far from alone. In the 1960s, plate tectonics was such a fecund, fast-moving field that it involved several instances of simultaneous discovery. In early 1967, as McKenzie was developing his ideas of rigid-plate motions, he looked at a conference abstract by colleague Jason Morgan and decided not to attend the talk. As it

turns out, Morgan veered from the text of his abstract and instead described ideas of plate motions that were eerily like McKenzie's. Later that year, McKenzie sent off his manuscript to *Nature* — and, when he realized that Morgan was about to publish similar ideas, he asked the journal to delay his own paper in order to give Morgan the credit. *Nature*'s editor, John Maddox, sent a telegram back saying that the issue had already been typeset, so there would be no delay. Who has not skipped an event, only to have that affect their careers for years to come?

But back to the question of anniversaries. Popular interpretations of scientific history are biased towards the single great discovery by a single great person — and they are more easily commemorated in an anniversary. But most discoveries are much more nuanced and communal. Charles Darwin would not have published his ideas of evolution by natural selection when he did, had he not been prompted into it by the similar thoughts of Alfred Russel Wallace. Albert Einstein relied on the work of friends and colleagues to develop his general theory of relativity.

Similar broad revolutions are unfolding today. Despite all the bitterness and infighting over who invented the CRISPR–Cas9 gene-editing technique, the fact remains that a large number of very bright scientists made enormous advances quickly by playing off one another. Just as in the heyday of plate tectonics, one gene-editing breakthrough inspired the next, until biologists were brimming with publications. Historians may one day bicker about which CRISPR paper to celebrate on the 50th anniversary of the technique, but science as a whole is much better off than it was before.

And so, we could celebrate a 1963 publication on the magnetism of the sea floor, or a 1967 paper on the geometry of spherical rotations, or even the entirety of the dawning of plate tectonics. But when was that? Was it in 1912, when Alfred Wegener came up with the idea of continental drift? Or was it decades later, when his ideas were finally transformed into the concept we now know as tectonics? Much of that delay might trace to US researchers viciously opposing his ideas, as historian Naomi Oreskes described in *Plate Tectonics* (Westview Press, 2001). But after the slow start, Earth scientists in the 1960s were quick to embrace the data and theories that redrew almost every aspect of their field.

Such is the nature of discovery — incremental at times, fast-paced at others, occasionally derailing into pettiness. But it does nearly always move in the right direction. In these times of political uncertainty and global unrest, that is an accomplishment worth noting.

Journal name:
Nature
Volume:
550,
Pages:
7
Date published:
(05 October 2017)
DOI:
doi:10.1038/550007a

Comments

Commenting is currently unavailable.

Chinese scientists fix genetic disorder in cloned human embryos

A method for precisely editing genes in human embryos hints at a cure for a blood disease.

02 October 2017

Mauro Fermariello/SPL

Fixing the genetic mutation linked to β-thalassaemia would save affected individuals from having to get life-sustaining blood transfusions.

A team in China has taken a new approach to fixing disease genes in human embryos. The researchers created cloned embryos with a genetic mutation for a potentially fatal blood disorder, and then precisely corrected the DNA to

show how the condition might be prevented at the earliest stages of development.

The report, published on 23 September in *Protein & Cell*[1], is the latest in a series of experiments to edit genes in human embryos. And it employs an impressive series of innovations, scientists say. Rather than replacing entire sections of genes, the team, led by Junjiu Huang at Sun Yat-sen University in Guangzhou, China, tweaked individual DNA letters, or bases, using a precision gene-editing technology developed in the United States[2].

Huang's team is also the first to edit out the mutation responsible for a 'recessive' disease: one caused by having two faulty copies of a gene. Because it would be difficult for researchers to find dozens of embryos that all have this rare double mutation, the team worked around this roadblock by developing embryonic clones from their patient's skin cells.

"I thought, 'Why would they do cloning?' Then I read the paper, and thought, 'Wow, that's fascinating,'" says Shoukhrat Mitalipov, a reproductive-biology specialist at the Oregon Health and Science University in Portland who pioneered human cloning and also works on gene editing in embryos. "I would not have thought to do this."

Scientists around the world have now published eight studies reporting gene editing in human embryos, five in the past two months. None have permitted the embryos to grow beyond 14 days, and the research has had different purposes: some to test gene-editing technologies; others to edit various disease-related genes; and some to unravel the mechanisms behind early embryonic development. Huang's team led the first report, published in April 2015, in which they used the CRISPR–Cas9 enzyme complex to snip chromosomes at specific locations, excise DNA and replace it with other genetic material[3].

Precision editing

In the latest study[1], Huang's team used 'base editing', a modification of CRISPR–Cas9. It guides an enzyme to specific gene sequences, but does not

cut the DNA. Instead, the Cas9 enzyme is disabled and tethered to another enzyme that can swap out individual DNA base pairs. So far, this technique can convert guanine (‘G’) to adenine (‘A’), and cytosine (‘C’) to thymine (‘T’). Hundreds of genetic diseases are caused by single-base changes, or ‘point mutations’, and so editing of this sort at the embryonic stage could potentially stave off such conditions.

Huang’s team chose one mutation common in the Chinese population: a switch from an A to a G at a certain spot in the *HBB* gene, which can lead to β-thalassaemia, a recessive blood disorder associated with severe or fatal anaemia. Researchers generally source embryos from *in vitro* fertilization (IVF) clinics, but it’s rare for these facilities to have embryos with two copies of the same rare mutation. So Huang’s team found a person with the blood disorder, extracted their skin cells and used cloning techniques to develop embryos with the same genetic makeup.

The researchers reported that in 8 of 20 cloned embryos, they were able to convert the errant G back into an A in one or both copies of the gene. (Repairing only one copy might be enough to cure a recessive disease.) That rate is too low for the technique to be considered for clinical use, but the efficiency was high relative to that achieved in other gene-editing studies. “The repair rate is pretty good, and certainly promising,” says Gaetan Burgio, a geneticist at the Australian National University in Canberra. “Our study opens new avenues for therapy of β-thalassaemia and other inherited diseases,” says Huang.

But scientists caution that not all cells in the eight embryos were fixed. Such embryos are ‘mosaic’, meaning that they have a patchwork of cells with different genetic make-ups, which is potentially dangerous. “It looks like solid work, but highlights that the problem of mosaicism remains a challenge for any form of gene editing in the human embryo,” says Dieter Egli, a stem-cell biologist at Columbia University in New York City.

Unintended consequences

Some scientists also question whether Huang’s team looked thoroughly

enough for unintended genetic changes, called off-target effects, that might have been caused by the base-editing procedure, although the authors reported that none were found.

Huang says future experiments will be more comprehensive, but that this first study was a successful proof of principle that the base-editing technique can be used to correct a disease mutation in a human embryo. It may be that conventional CRISPR–Cas9 cannot fix embryos when both copies are faulty, although this isn't yet clear. In August, for instance, Mitalipov's team reported using CRISPR–Cas9 to repair a mutation in a gene that can cause a potentially deadly heart disorder, by using the other, healthy copy of the gene as a template[4].

In the future, Huang says, he plans to ask for oocytes and sperm from donors who have one mutated copy of the gene — and so are unaffected by the condition, but are carriers of the disease — and use these to produce embryos. Some of those embryos would have two mutated copies, and some one, but Huang wants to edit both types. That raises the contentious idea that gene editing might be used not only to prevent severe disease, but also to eliminate the chance of people becoming carriers of the disorder. "Base editing can repair the mutant site and block it from being passed on to the next generation," he says.

Journal name:
Nature
Volume:
550,
Pages:
15–16
Date published:
(05 October 2017)
DOI:
doi:10.1038/nature.2017.22694

Comments

Comments

There are currently no comments.

Medicine Nobel awarded for work on circadian clocks

Jeffrey Hall, Michael Rosbash and Michael Young unpicked molecular workings of cells' daily rhythms.

02 October 2017

Nora Tam/SCMP

Michael Rosbash (left), Jeffrey Hall (centre) and Michael Young (right) have been recognized for their work on circadian clocks.

Three scientists who studied the workings of organisms’ inner circadian clocks have won the 2017 Nobel Prize in Physiology or Medicine. Jeffrey Hall and Michael Rosbash, both at Brandeis University in Waltham, Massachusetts, will split the award of 9 million Swedish kronor (US$1.1

million) with Michael Young at Rockefeller University in New York City.

Beginning in the 1980s, the three researchers isolated and characterized a gene in fruit flies, *period*, that encodes a protein that builds up each night, only to be broken down the following day. In subsequent work, the trio, as well as other scientists, unpicked the molecular regulation of the *period* gene (and the protein that it encodes, called PER) and identified additional components of the circadian clock.

All multicellular organisms possess circadian clocks, and human versions of the genes that comprise their clocks have been implicated in sleeping disorders and other medical conditions.

Rosbash, Hall and Young have been collecting awards together for the past five years. In 2013, for example, they shared the Shaw Prize in life science and medicine, then worth US$1 million. That has set the expectation that a Nobel might be around the corner, says Herman Wijnen, who studies circadian clocks at the University of Southampton, UK and was a postdoc in Young's lab. "This has been one that people have been looking out for," he says. "It's been settled in the scientific community that this is the trio."

But Young says he was so stunned by the news that he could barely get his shoes on the morning he found out. "I'd go and I'd pick up the shoes, and then I'd realize I need the socks," he said during a press conference. "And then I realized I needed to put my pants on first." The award took Rosbash by surprise too, says Thomas Perlmann, secretary of the Nobel Assembly, which selects the prizewinners. "I first got hold of Michael Rosbash, and he was silent," says Perlmann. "And then he said, 'you are kidding me'."

The work has its roots in genetic screens performed by physicist and molecular biologist Seymour Benzer and geneticist Ronald Konopka, who together found fruit-fly mutants with abnormal hatching rhythms. (Benzer died in 2007; Konopka in 2015.) At the time, the idea that behaviour could have a genetic basis was controversial, says Wijnen. Years later, two teams — Young leading one, Hall and Rosbash working together to lead another — would clone the genes responsible. "That really changed the situation," says Wijnen. "Since then, it has become clear how conserved this system is and how conceptually it could work."

The competition between the two teams — each with ambitions to be first to identify the gene — was initially intense, says Charalambos Kyriacou, a behavioural geneticist at the University of Leicester, UK, who worked with Hall in the late 1970s. “As they got older they mellowed,” he says. “They’re all good buddies now.”

Subsequent work detailed how abundance of the PER protein peaks at night and then declines during the day. Researchers gradually pieced together a model in which the accumulation of PER serves as a signal that represses expression of the gene that encodes it. This type of negative feedback loop would become a prevailing theme in the study of circadian rhythms, as researchers identified additional loops and clock proteins over the years.

Joseph Takahashi at the University of Texas Southwestern Medical Center in Dallas and others extended the work from fruit flies to mammals, and showed that the system is remarkably conserved across species. Researchers have since tied the circadian clock to many aspects of mental and physical well-being. “We expose ourselves to inappropriate light, we travel across time zones, we do shift work,” says Wijnen. “And all of that is negatively impacting our health.”

The links between the circadian clock and human health are so pervasive that medical schools should increase their focus on chronobiology, says Martha Merrow, chair of medical psychology at Ludwig Maximilian University of Munich in Germany. This could be either as a speciality in its own right, or incorporated into medical training in other specialities such as endocrinology or rheumatology, she adds. A Nobel prize may give Merrow and her colleagues added force to make that case. Merrow learnt of the news before heading into an administrative meeting. “I was so breathless, I could hardly go into my meeting,” she says. “It’s just a fantastic choice. It will be great for our field.”

Journal name:
Nature
Volume:
550,
Pages:
18

Date published:
(05 October 2017)
DOI:
doi:10.1038/nature.2017.22736

Comments

Commenting is currently unavailable.

Parakeet invasion of Mexico driven by Europe’s ban on bird imports

Attempts to stop the spread of bird flu and protect wildlife had unintended consequences.

29 September 2017

Joel Sartore/NGC

The monk parakeet is popular in the pet trade, but is also considered an invasive species when it escapes into the wild.

Small, emerald-coloured birds called monk parakeets (*Myiopsitta monachus*) invaded Mexico in the span of a decade because of trade policies thousands of kilometres away in Europe, according to a study released this month. The research highlights how fears over avian flu, which prompted a ban on bird imports in Europe, had wide ranging effects in other countries.

Monk parakeets, a type of parrot native to South America, popped up in countries such as the United States in the 1960s and have established themselves from Brooklyn to Brussels. There were only a handful of reported sightings of the bird in Mexico City in 2005. But by 2015, feral monk parakeets were documented in 97 cities throughout the country, say researchers in a study[1] published on 19 September in *PLoS ONE*. Monk parakeets are considered agricultural pests, and their enormous communal nests can cause blackouts when built on electrical equipment[2]. But they are popular as pets, and so have been part of the international parrot trade.

“It’s been a really, really fast invasion,” says Elizabeth Hobson, a behavioural ecologist at the Santa Fe Institute in New Mexico and lead author on the study, both in terms of the geographic scope and the shifts in the trade policies that contributed to it. Usually, it’s hard to work out when a non-native species first appeared in an area, says Hobson. But the arrival of monk parakeets in Mexico has a sharply defined start and end point, thanks to shipping documentation and bird sightings recorded by citizen scientists using apps such as iNaturalist and eBird, Hobson says.

Unintended consequences

She and her colleagues contend that two pieces of legislation shifted the global demand for monk parakeets from Europe to Mexico. In 2004, concerns about the spread of avian influenza in Europe led to an import ban on birds from southeast Asia. By 2007, the European Union had banned the importation of all wild-caught birds, regardless of their origin.

As EU demand for monk parakeets crashed, the international market for the birds shifted to Mexico, where regulatory changes in 2008 had made it illegal to purchase native Mexican parrots as pets, in an effort to preserve wild population numbers. The monk parakeet was one of the few options left for people who wanted to lawfully purchase a parrot.

More than half a million monk parakeets were imported into Mexico as part of the pet trade between 2000 and 2015. Hobson and her colleagues used international trade data to determine that 90% of those birds entered Mexico starting in 2008 and ending in 2014, mostly from Uruguay. The increase in wild monk-parakeet sightings throughout Mexico roughly coincided with the changes in regulations and commercial imports.

“This whole invasion seems like it was just a fascinating series of unforeseen consequences of regulation changes,” says Hobson. It’s important to think about how policy changes can both protect human populations and have unexpected negative results — such as the introduction of an invasive species, she says.

Setting a baseline

Mexico stopped its commercial imports of monk parakeets in 2014 over concerns about the possible spread of avian influenza. The country declared the monk parakeet an invasive species in late 2016, and is required by law to devise a species management plan. This doesn’t necessarily mean the invasion is over, Hobson says, because there are a lot of monk parakeets in Mexico that can escape their owners and reproduce in the wild. It’s also still unclear what effect the animals are having on the country’s native wildlife, urban infrastructure and local economy.

The study’s findings punctuate the importance of banning the international trade in parrots, as well as the need for evaluating the unintended consequences of legislative and management action, says Michael Russello, an evolutionary biologist at the University of British Columbia in Kelowna, Canada.

The baseline data provided by the study “will be invaluable for tracking the spread and potential establishment of self-sustaining monk-parakeet populations in Mexico moving forward, and monitoring the performance of any management action”, Russello says.

Journal name:

Nature
DOI:
doi:10.1038/nature.2017.22653

Comments

Commenting is currently unavailable.

Time capsule buried to preserve science for the ages

Message in a bottle sums up state of research in 2017.

29 September 2017

Marek Lewandowski

The science time capsule buried in Svalbard.

On an Arctic island, researchers have buried a stainless-steel tube stuffed with artefacts that they say sum up science and technology in 2017. The capsule, buried on 17 September, could remain in the ground for more than half a million years before it resurfaces as a result of geological uplift, sea-level rise and erosion.

Placed five metres deep in an out-of-use borehole near the Polish Polar Station in Hornsund, Svalbard, the 60-centimetre-long tube holds smaller containers with samples that include a fragment of a 4.5-billion-year-old meteorite, basaltic lava from an Icelandic volcano eruption and Namibian sand hiding particles of kimberlite and diamonds — all geared at informing a future discoverer of our present understanding of Earth's geology.

To summarize biology, it includes dried DNA samples from humans, rats, salmon and potato, a bee in resin, seeds and around 300 tardigrades, the minuscule aquatic 'water bears' that can survive extreme radiation, drought and heat.

And to communicate to future historians the state of today's technology, scientists packed into the tube silicon-based electronic devices, including accelerometers, a radiation detector and a mobile phone. They added a credit card, a wristwatch and a photograph, etched into porcelain for longevity, of Earth taken from space. Researchers also left their fingerprints on the inside of some of the container caps.

Polar anniversary

The message in a bottle was created to celebrate the sixtieth anniversary of Poland's polar station, which was set up during the International Geophysical Year 1957-58, a research project that included a series of global geophysical activities.

"I wanted to create a memorial for the ages," says Marek Lewandowski, a permafrost specialist with the Polish Academy of Sciences Institute of Geophysics in Warsaw, who selected the objects for the time capsule. Lewandowski, who thought up the idea in May, says that he consulted dozens of experts at Polish and foreign research institutes about the capsule's inventory. The capsule is described in a manuscript published in the journal *Gondwana Research*[1] on 28 September.

Image Slideshow

1. 

Seeds, including oats, pumpkin seeds, maize, beans, peas and a sunflower, were buried in the capsule.

Adam Nawrot

2. 

Also in the capsule: DNA from a woman, a man, a rat, a salmon and a potato.

Ewa Gojska-Sledzewska

3. 

A medical injector, coal for a grill, and a model car were among the items buried to represent everyday life.

Marek Lewandowski

4. 

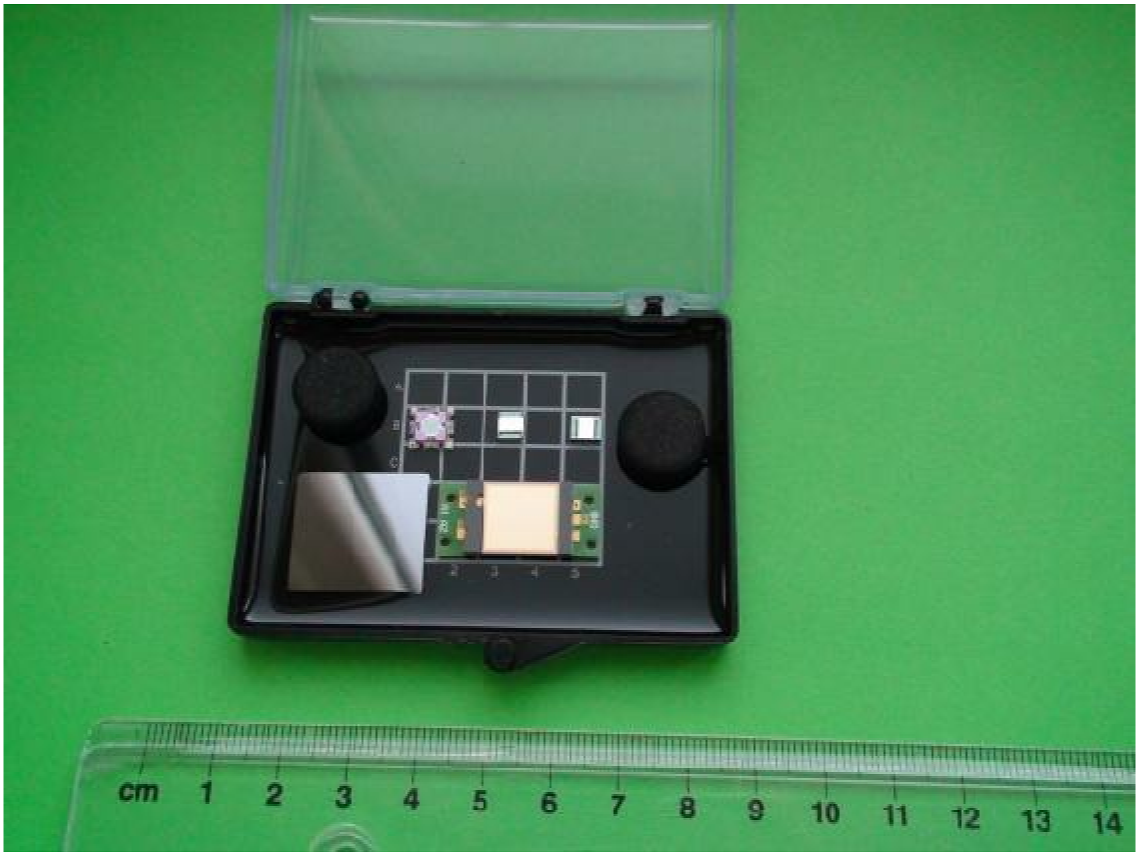
The Moon and Earth printed on porcelain.

Marek Lewandowski

5. 

A mesozoic ammonite, one of a host of fossils and rocks in the capsule.

Marek Lewandowski

6. 

Silica-based electronics were also buried in Svalbard.

Dariusz Szmigiel

It’s a bit of a balancing act between jocular and serious science,” Lewandowski says. “But I do think it’s a good way to capture what we know today about the natural history of our planet and the evolution of life on it.”

The objects are nicely, if quirkily, chosen, says Jan Zalasiewicz, a geologist at the University of Leicester, UK. “They have put together a thoughtful and ingenious message for the far future,” he says, “But the few things in the capsule will be a drop in the ocean among the huge diversity of ‘techno-fossils’ that humans will leave behind as geology.”

Zalasiewicz adds that he thinks the capsule might resurface well before the half-a-million year estimate, because the chosen burial place is just a few metres above sea level, and marine erosion from sea-level changes are difficult to predict.

It’s not the first time that humans have designed a time capsule for distant civilizations to unwrap and decode. The Voyager Golden Record — phonograph records (together with a cartridge and a needle) on board the two Voyager spacecrafts launched in 1977 — contains 115 images, musical selections, natural soundscapes and spoken greetings to any extraterrestrials that might pick up the messages.

But chances are slim that Voyager’s snapshot of twentieth-century human culture, selected by a NASA committee, will ever be delivered and understood, says Lewandowski.

“Our own time capsule is sure to be found one distant day, and its discoverers will be able to grasp the message,” he says. “If they look carefully inside — like we did into the Cheops pyramid and the tombs and artefacts inside it — they will understand who we were.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22657

Comments

Commenting is currently unavailable.

Tsunami wreckage serves as liferafts for invasive species

Hundreds of species can subsist for years on tsunami debris.

29 September 2017

Oregon Parks Department/ Handout/Corbis via Getty

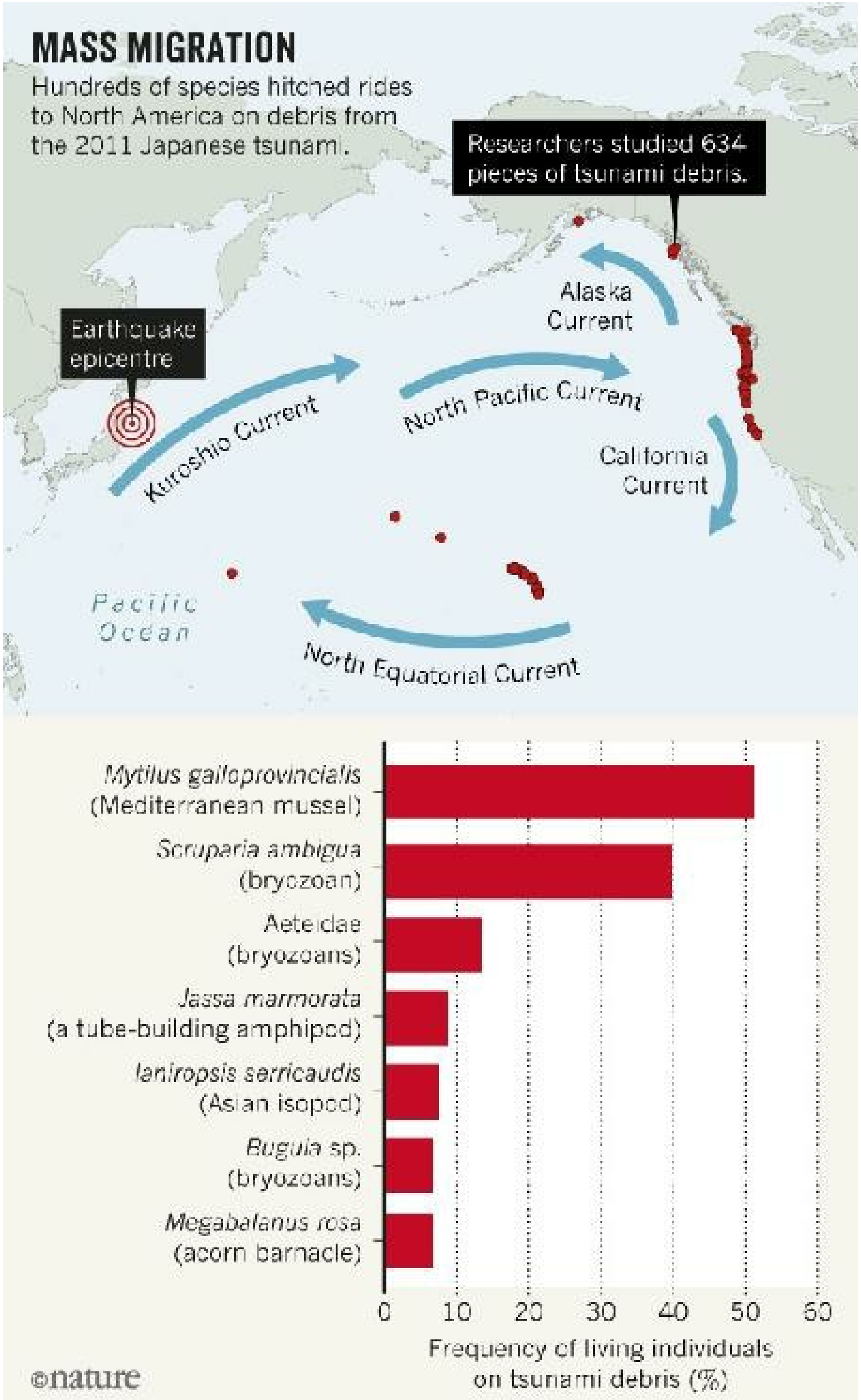
Tsunami debris included this Japanese dock, which washed up on the shores of Oregon.

Two years after a tsunami devastated parts of Japan, a small black-and-white-striped fish washed ashore in Long Beach Peninsula, Washington. The barred knifejaw (*Oplegnathus fasciatus*), which is native to Asian waters, had made the 7,000-kilometre trip in the stern well of a deserted fishing vessel set adrift by the giant wave.

The knifejaw found in 2013 is just one of hundreds of species carried across the Pacific Ocean to North America by debris — estimated to weigh a total of nearly 1.5 million tonnes — that was swept out to sea after the Tohoku earthquake in March 2011. As extreme coastal weather events such as hurricanes, typhoons and tsunamis become more intense and frequent as a result of climate change, researchers warn that such mass-migration events could also become more common.

James Carlton, a marine ecologist at the Maritime Studies Program of Williams College and Mystic Seaport in Mystic, Connecticut, and his colleagues worked with more than 100 volunteers to look for tsunami debris along North American shores, including the west coast of the United States and Canada, as well as Hawaii. Over almost 5 years starting in 2012, they intercepted 634 objects that could be traced back to the tsunami, ranging in size from small fragments of plastic to fishing vessels and mooring docks (see ‘Mass migration’). Between them, they carried from Japan 289 species of living invertebrates and fish, the researchers report in *Science*[1]. Some of the creatures had survived adrift for several years.

That’s just a fraction of the “thousands or tens of thousands” of objects estimated to have landed in North America, says Carlton. And he suspects there are more to come. “Many of these can subsist in the ocean for longer than we could imagine,” he says. “We had no idea this would last into 2017.”



Source: Ref. 1

The team began its search when a 165-tonne dock — made of concrete, steel and polystyrene foam — washed up on the coast of Oregon, 15 months after the disaster. This ‘megaraft’ was coated with almost 100 different species. It was a harbinger, Carlton says, of the need to monitor what else might be coming. More-recent debris has not been so species-rich; only one object hosting more than 20 species has been found since summer 2015.

The team’s finds included gooseneck barnacles (*Lepas* sp.) that blanketed the bottom of a wrecked fishing boat and a Japanese limpet (*Siphonuria sirius*) that had hitched a ride on a buoy. Most of the creatures arriving were invertebrates: molluscs, annelid worms, cnidarians (jellyfish and their relations), crustaceans and moss-like marine invertebrates called bryozoans. It is unusual for vertebrates such as the knifejaw fish to be carried so far, says Gail Ashton, a marine ecologist at the Smithsonian Environmental Research Center in Tiburon, California.

The mass migration raises the concern that some of these trans-Pacific passengers might establish invasive populations on the North American coast. None of the species has been spotted doing so yet. But “the fact that they’ve lasted in the ocean for four or five years shows they’re pretty hardy”, says Ashton. And by the time any species do settle, says Carlton, it could be too late to do anything about it. Once a population is common enough to see, he says, “it becomes harder to manage eradication”.

Such a huge rafting event is unprecedented, say the researchers. Japan has seen only two other earthquakes with magnitudes comparable to Tohoku in the last few centuries; they occurred in 1896 and in 1933. “If you look at photos of the same coasts in those years, there are small villages with wood houses,” says Carlton. “Back then, a tsunami could not generate this sea of plastic we saw in 2011.”

Biodegradable objects such as wood would rarely survive such a long trip. The study underscores the far-reaching consequences of plastic in the environment, says Jenna Jambeck, an environmental engineer at the University of Georgia in Athens. “Once something enters the ocean, it becomes a global problem.”

Journal name:
Nature

DOI:
doi:10.1038/nature.2017.22691

Comments

Comments

There are currently no comments.

Tropical forests may be carbon sources, not sinks

Combination of satellite images and on-the-ground data enables more complete tracking of forest carbon flows.

29 September 2017

Tim Laman/NGC

Tropical forests may emit more carbon than they absorb.

Every moment, the world's roughly 3 trillion trees either suck up carbon dioxide from the air or release it into the atmosphere. Accurately quantifying these carbon flows is a long-standing challenge that has hindered scientists' understanding of how forests help to regulate Earth's climate. Now, researchers have combined ground and satellite measurements to conclude that tropical forests seem to be a net source of heat-trapping carbon emissions, rather than a carbon sink.

The team's paper, published on 28 September in *Science*[1], bolsters a growing consensus: that tropical forests are drying out or being cleared, burned and logged so fast that they now spew out a lot more carbon than they squirrel away.

Whereas earlier estimates based on measurements of atmospheric carbon flows suggested that tropical forests might be carbon neutral or even a net sink, more-recent studies — including ones based on data from NASA's Orbiting Carbon Observatory-2 satellite — agree broadly with this recent paper, says David Schimel, an ecologist at NASA's Jet Propulsion Laboratory (JPL) in Pasadena, California. He suspects that human activities such as starting fires and natural factors including droughts have dealt a severe blow to forests' ability to store carbon.

Tracking carbon

The study authors estimate that the world's tropical forests release approximately 425 million tonnes of carbon annually, equivalent to roughly 5% of the globe's annual fossil-fuel emissions, and about five times more than an estimate in a highly cited 2011 paper[2] that relied on ground-based forest inventories. Their work captures nuances in how droughts and other natural or human-caused disturbances could affect the amount of carbon that tropical forests exchange with the atmosphere.

The research team first travelled to forests throughout the tropics to measure tree diameters and heights. The scientists then fed those measurements into species-specific equations to estimate how much carbon the trees stored. Next, they used those estimates to ground-truth data collected by NASA's Ice, Cloud, and Land Elevation Satellite (ICESat), a laser-equipped satellite that from 2003 to 2010 gathered data on forest height and vegetation layers around the globe.

Finally, the researchers used a machine-learning algorithm to translate measurements from the Moderate-Resolution Imaging Spectrometer (MODIS) instruments — part of NASA's Terra and Aqua satellites that image Earth's entire surface every one to two days — into data they could compare to the ICESat numbers. By extrapolating this comparison to MODIS images for the entire tropics, the team tracked how much carbon tropical forests gained and lost between 2003 and 2014.

The scientists quantified losses due to deforestation, degradation — including logging, firewood gathering and other human activities — and natural disturbances such as droughts. Because degradation and natural disturbances often leave forest canopies mostly intact, most previous satellite studies have failed to account for their impact on carbon emissions, says Alessandro Baccini, a remote-sensing scientist at the Woods Hole Research Center in Falmouth, Massachusetts, who led the work. Yet the researchers calculated that these processes accounted for more than two-thirds of forests' carbon emissions. "We were surprised how much of the emissions were a result of degradation," he says.

On the map

The study also tracks carbon captured by growing forests, which had been missing in previous analyses of satellite data, says Nancy Harris, a carbon scientist at the World Resources Institute in Washington DC. "This paper really helps to put carbon gains on the map." In doing so, it moves scientists closer to being able to monitor countries' progress toward forest-protection goals set under the 2015 Paris climate agreement, which requires accurate tracking of both carbon losses and carbon gains due to forest growth, she says.

Carbon estimates from satellite imagery should be viewed with caution, however, says Matthew Hansen, a geographer at the University of Maryland in College Park who produces satellite-based maps of changes in tree cover. MODIS and other optical sensors can be compromised by atmospheric interference, he says. And Hansen is concerned that the Woods Hole team reports large carbon losses in areas where forests have not disappeared, such as northern Brazil. “Geographically, there are some places that look suspect” in the team’s analysis, he says.

Moreover, MODIS cannot easily detect how much older forests are growing, potentially causing Baccini’s team to underestimate the carbon that these areas absorb, says Sassan Saatchi, a remote-sensing scientist at JPL. That could change when NASA’s Global Ecosystem Dynamics Investigation instrument launches to the International Space Station in 2018, Saatchi says. The instrument will measure forest height and vegetation layers using lasers that will capture far more data than those of ICESat, and should provide a more direct way to estimate tropical-forest carbon.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22692

Comments

Commenting is currently unavailable.

French government proposes big science-spending boost

President Emmanuel Macron’s 2018 draft budget would raise research funds by 6%.

29 September 2017

Ludovic Marin/AFP/Getty Images

Frédérique Vidal, France's higher education, research and innovation minister, said the budget would give 'fresh oxygen' to the country's research.

French research funding is set for a heartening increase in the country’s first budget under President Emmanuel Macron, if draft 2018 plans released on 27 September are voted into law.

The research portfolio of France's ministry of higher education, research and innovation would rise by more than 6%, to €8.4 billion (US$9.9 billion) in 2018. And on top of that, a giant economic-recovery plan unveiled on 25 September by Prime Minister Edouard Philippe should divert an extra €2.4 billion to research over the next five years.

The cash injection will lead to a "small revolution", said Frédérique Vidal, the country's minister for higher education, research and innovation at a press conference the day after the budget release. In particular, Vidal said that France's public laboratories stand to gain money after years of cuts. "We all know we have come to the end of a movement where laboratories' allocations have been trimmed, year after year. With the 2018 budget, we are reversing the trend and are starting to give fresh oxygen to our research," she said.

Scientists who have long campaigned for more funding praised the proposals. "It is a signal that President Macron and the government have understood the long-term consequences of the funding crisis that has hit universities and research agencies for years," says Patrick Lemaire, a biologist at the University of Montpellier and founder of the researcher-led campaign group Sciences en Marche.

For Bernard Meunier, a chemist and a past president of the French Academy of Sciences, the most positive point of the budget was that Vidal seemed to recognize the poor state of French labs' finances. "There couldn't be any further cut in their funding, because there is practically nothing left. The minister is aware there is a problem, whereas her predecessors said there wasn't," he says.

In the draft proposal, the French National Research Agency (ANR), which funds individual projects on a competitive basis, would see its budget rise by 5%, to €706 million — although its funding levels are still slightly lower than they were in 2012, and it still has no head after former president and chief executive Michael Matlosz resigned in July. Competition for grant funding remains fierce at the ANR, where only around 12% of grant applications are successful, and Lemaire doubts that the extra money will do much to improve that.

The funding boost is welcome, but not sufficient on its own to transform the agency, says Meunier. “We need the ANR to be restructured to permit more blue-skies funding and simpler grant-application procedures,” he says.

There would be a smaller increase for the country’s public-research bodies — including the basic-research agency CNRS and the biomedical agency INSERM — which give out grants and run their own laboratories, many of them jointly with universities. These agencies see their collective spending rise by just over 1%, to €5.94 billion. Some of the money will be used for Macron’s Make Our Planet Great Again campaign, which aims to attract foreign climate scientists to France.

This year’s budget is the first since Vidal, a biochemist who was president of the University of Nice Sophia Antipolis from 2012 to 2017, was appointed to the research ministry. In a sign that France’s government is taking the post more seriously, Vidal's role was also made more senior: she reports directly to the prime minister, whereas her predecessor, Thierry Mandon, reported to a minister for education.

The proposed increases are all the more welcome because the European Commission is pressuring France to rein in its deficit. This July, around €184 million was trimmed from the ministry’s 2017 budget for research, as part of a series of public-spending cuts.

France’s controversial system of tax credits for companies that conduct research will remain in place, economy and finance minister Bruno Le Maire told reporters. The system, which costs the state up to €6 billion a year in tax revenues, has come under fire for alleged abuses: critics say companies use it to reduce their tax bill, rather than to increase their research spending. But Le Maire said he would simplify the system to make it easier for smaller companies to apply for credits, although he did not give details.

Macron, meanwhile, has urged the European Union to pay more attention to research. In a 26 September speech, he argued that the EU should create an agency to accelerate the commercial applications of basic science, with the idea of spurring innovation in fields such as artificial intelligence.

Journal name:

Nature
DOI:
doi:10.1038/nature.2017.22733

Comments

Comments

There are currently no comments.

Toad tadpoles turn homegrown poisons on each other

Young amphibians are the first animals thought to use toxins against rivals of their own species.

29 September 2017

Bert Willaert/NPL

These common-toad tadpoles produce a potent toxin that affects the heart.

Many tadpoles ward off predators with potent poisons — but those toxins also seem to help win battles with their own kind, a new study finds.

Tadpoles of common toads (*Bufo bufo*) are more poisonous when raised in crowded conditions, which may give them a competitive edge, according to the work published on 23 September in *Functional Ecology*[1].

Many noxious plant species are known to modulate their defences to fend off different threats[2], but it is less clear whether animals possess similar toxin-tuning abilities. Although predation pressure is known to induce tadpole chemical defences[3], the new findings are the first unequivocal evidence of toxin synthesis spurred by competition in vertebrate animals.

Being poisonous can make a species essentially inedible to predators, but making potent toxins comes at a metabolic cost — so it’s best to make that investment count. “It would be very profitable for such animals to kill two birds with one stone by using their anti-predatory toxins as chemical weapons against their competitors, too,” says the study’s lead author, Veronika Bókony, an ecologist with the Hungarian Academy of Sciences in Budapest.

Common toads are equipped with bufadienolides, potent toxins that cause harm by accelerating and disrupting the heart’s rhythms[4]. Field studies have found that common toad toxicity varies geographically, with the intensity of competition being the most reliable predictor[5]. But it has been unclear whether such patterns occur because populations are genetically isolated from one another in different ponds, or whether they reflect defences induced by environmental factors.

Bókony and her colleagues took this question to the laboratory, rearing toads in artificial ponds with varying numbers of individuals — a proxy for the strength of competition. The species composition of the ponds also varied; some contained common toads, others contained agile frogs (*Rana dalmatina*) and some contained a mix. Agile frogs hatch earlier and grow to larger sizes than common toads, so they were considered to represent tougher competition. Because the frogs are non-toxic, the researchers wanted to see whether the toads’ toxins are especially aimed at these intense rivals (a phenomenon called allelopathy).

Toxic relationships

The more competitors the toads were raised with — of either species — the smaller and more toxic they were, echoing the field results. But surprisingly, toad tadpoles defended themselves against their own kind more fiercely, by producing more toxins than they did against the frogs. Meanwhile, the frogs didn't seem to be bothered by their toxic tankmates.

The study is "very well designed", says Thomas Hossie, an ecologist at Trent University in Peterborough, Canada. The plasticity of other tadpole traits, including morphology and behaviour, is well documented, he notes, but most studies examine the response to predation risk. "This paper is another great example of how amazingly plastic larval amphibian traits really are."

Gary Bucciarelli, an ecologist at the University of California, Los Angeles, also praises the work: "I think the researchers present a very compelling study that questions the evolution and ecological role of amphibian chemical defences." His own research has shown that newts become more toxic in response to stressful conditions[6]. Such findings "really begin to scrutinize the idea that predation alone drives variation in animal chemical defences", he adds.

Toxicity that varies by the density of an organism's population has also been observed in insects[7], notes Hossie: "This experiment indicates that it may be more widespread than we anticipated."

Bókony and her colleagues aren't done with the toads yet, as the unexpected lack of harm to the competitor frogs "begs the question what exactly [the toads] are defending themselves from". Cannibalism is certainly a possibility, as tadpoles of many species are known to turn on their own when times are tough.

But Bókony wonders whether the toxins might serve a different function altogether. She hypothesizes they may "provide a sort of immune defence against contagious diseases they could catch from [fellow tadpoles], especially when crowded". She and her colleagues hope to explore this possibility next.

Journal name:
Nature

DOI:
doi:10.1038/nature.2017.22734

Comments

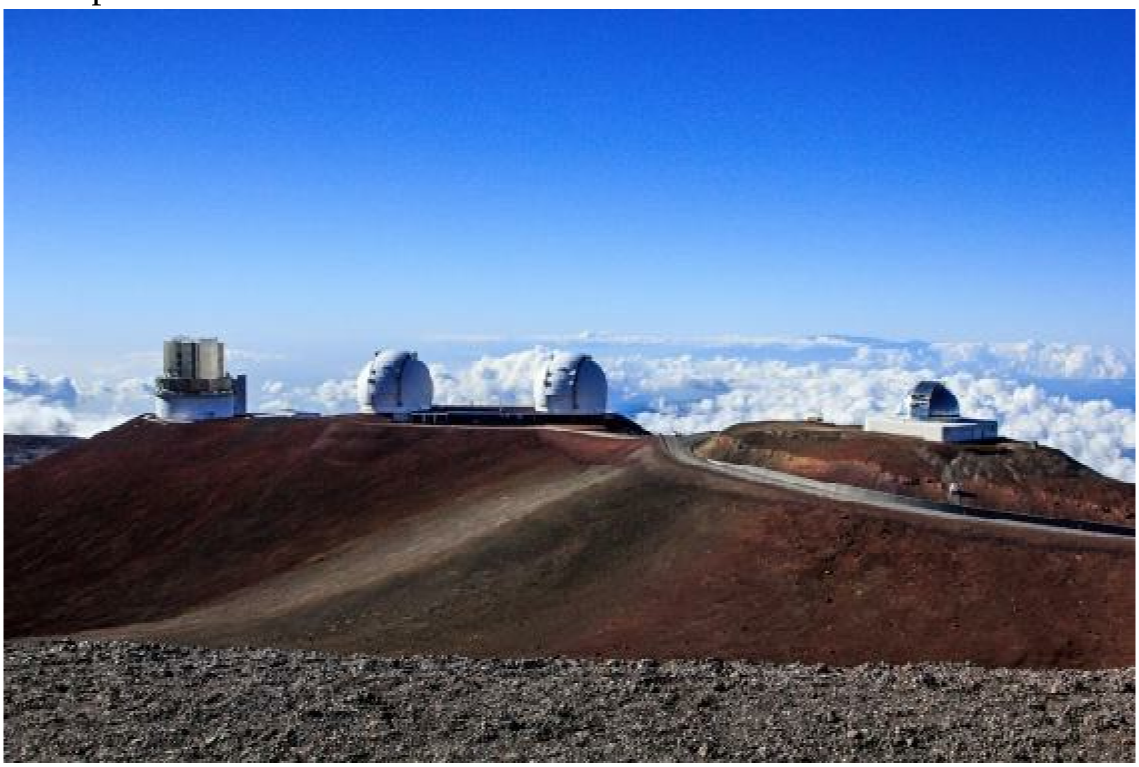
Comments

There are currently no comments.

Controversial Thirty Meter Telescope gets go-ahead to build in Hawaii

State board issues construction permit for project, but legal fight over telescope continues.

29 September 2017



Moment Editorial/Getty

The Thirty Meter Telescope would join other large telescopes atop Mauna Kea in Hawaii.

Hawaii’s board of land and natural resources granted a fresh construction permit to the Thirty Meter Telescope (TMT) on 28 September, reviving the fortunes of the US$1.4-billion observatory — at least temporarily.

The permit moves the international project closer towards restarting construction near the summit of the Hawaiian mountain of Mauna Kea. Some Native Hawaiians oppose the TMT, saying that its construction would further violate a sacred mountain that is already home to multiple telescopes.

The board's decision effectively puts the TMT project back where it was before protestors halted the telescope's construction in April 2015, just days after it had begun, by blocking the road up Mauna Kea. That December, following months of challenges, Hawaii's supreme court invalidated the telescope's first construction permit. The court ruled that the state land board had not followed appropriate procedures because it had approved the first permit, in 2011, before it held a set of public hearings on the case.

The board's latest decision follows a July recommendation to issue the permit from retired judge Riki May Amano, who oversaw more than 40 days of additional hearings earlier this year for the board. Another set of public hearings took place this month, after which the seven-member board voted five to two to issue the permit. "This was one of the most difficult decisions the board has ever made," said chairperson Suzanne Case.

The new permit adds requirements to construction plans for the telescope, including a zero-discharge wastewater system and cultural and natural-resources training for workers.

"We are greatly encouraged," said TMT board chair Henry Yang in a statement. "In moving forward, we will listen respectfully to the community in order to realize the shared vision of Maunakea as a world center for Hawaiian culture, education and science."

Telescope opponents have filed motions that would effectively put the permit on hold until the state supreme court can hear an appeal. "Construction should not begin before all legal processes have run their course," said KAHEA: The Hawaiian–Environmental Alliance, a group in Honolulu that opposes the TMT, in a statement. Mauna Kea "is being stripped and disrespected".

But TMT supporters say the telescope would bring educational and employment opportunities to a state with a long history of astronomy. TMT organizers have been exploring the possibility of building the telescope on the island of La Palma, in Spain’s Canary Islands, if they cannot begin construction on Mauna Kea by a self-imposed deadline of April 2018. Project partners include the University of California system, the California Institute of Technology in Pasadena and the governments of India, China, Japan and Canada.

Journal name:
Nature
Volume:
550,
Pages:
20
Date published:
(05 October 2017)
DOI:
doi:10.1038/nature.2017.22731

Comments

Comments

There are currently no comments.

Nature News

周四, 12 10月 2017

Nature News

[周四, 12 10月 2017]

- **Nature News**

Nature News

Nature is a weekly international journal publishing the finest peer-reviewed research in all fields of science and technology on the basis of its originality, importance, interdisciplinary interest, timeliness, accessibility, elegance and surprising conclusions. Nature also provides rapid, authoritative, insightful and arresting news and interpretation of topical and coming trends affecting science, scientists and the wider public.

- **South African researchers bemoan slashed funds** [周三, 11 10月 08:00]
  Plans to cut funding to a programme that recognizes and rewards excellence in research have met with criticism.
- **A more personal view of human-gene regulation** [周三, 11 10月 08:00]
  A long-planned effort to examine gene expression and gene regulation in all the major tissues in the human body across many people comes to fruition.
- **Marine snow falls heaviest at the Equator** [周三, 11 10月 08:00]
  Organic matter drifts down to the equatorial ocean floor in distinct patterns.
- **ResearchGate lawsuit, walrus spat and a Second World War shipwreck** [周三, 11 10月 08:00]
  The week in science: 6–12 October 2017.
- **The ambitious effort to document California's changing deserts** [周三, 11 10月 08:00]
  Ecologists catalogue bird and mammal populations as warming transforms Death Valley.
- **Gene-expression study raises thorny ethical issues** [周三, 11 10月 08:00]
  Project obtains tissues from recently deceased individuals to look for the origins of disease.
- **The rise and fall and rise again of 23andMe** [周三, 11 10月 08:00]
  How Anne Wojcicki led her company from the brink of failure to scientific pre-eminence.
- **The future of DNA sequencing** [周三, 11 10月 08:00]
  Eric D. Green, Edward M. Rubin and Maynard V. Olson speculate on the next forty years of the applications, from policing to data storage.
- **Physics: A classical toolkit** [周三, 11 10月 08:00]
  Malcolm Longair extols a long-heralded tome by Roger Blandford and 2017 Nobel laureate Kip Thorne.
- **Chemistry: Explosive moments in the laboratory** [周三, 11 10月 08:00]
  Mark Peplow surveys a gorgeous gala of reactions in Theodore Gray's new book.
- **Books in brief** [周三, 11 10月 08:00]
  Barbara Kiser reviews five of the week's best science picks.

- **Cancer care: Tap latent source of frugal cancer ideas** [周三, 11 10月 08:00]
- **Natural hazards: Risk assessments face legal scrutiny** [周三, 11 10月 08:00]
- **Countries: Avoid glib terms of development status** [周三, 11 10月 08:00]
- **Brain modelling: Does the brain control foraging?** [周三, 11 10月 08:00]
- **Predatory journals: Research that isn't read doesn't exist** [周三, 11 10月 08:00]
- **Runes transcribed from Dig Site 401A in Ladysmith, Wisconsin** [周三, 11 10月 08:00]
  Postcards from the past.
- **Publishers threaten to remove millions of papers from ResearchGate** [周二, 10 10月 08:00]
  Take-down notices “imminent” as lawsuit is filed alleging widespread copyright infringement.
- **Trump EPA begins push to overturn Obama-era climate regulation** [周二, 10 10月 08:00]
  The agency's plan to reverse limits on greenhouse-gas emissions is likely to draw legal challenges.
- **Climate meetings pose serious test in the Trump era** [周二, 10 10月 08:00]
  Annual jamborees fail to ignite public passion but are crucial to progress on global-warming.
- **Developing nations need more than just money** [周二, 10 10月 08:00]
  Grants from big science funders can be hard to use without better administration and mutual understanding, says Rana Dajani.
- **How the United States plans to trap its biggest stash of nuclear-weapons waste in glass** [周二, 10 10月 08:00]
  After decades of delays, a challenging clean-up project is gaining ground.
- **Cancer-genome study challenges mouse 'avatars'** [周一, 09 10月 08:00]
  Grafting human cancer cells into mice alters tumour evolution.
- **LIGO's unsung heroes** [周一, 09 10月 08:00]
  Nature highlights just a few of the people who played a crucial part in the discovery of gravitational waves — but didn’t win the Nobel Prize.
- **Water-repellent coatings could make de-icing a breeze** [周一, 09 10月 08:00]
  Coatings that force ice to grow upwards from the surface could make it easier to remove.
- **Build on the outer space treaty** [周一, 09 10月 08:00]
  Fifty years on, the agreement is being pushed to its limits by changing geopolitics, technology

and commercial interests, warns Joan Johnson-Freese.

- **The scientist who spots fake videos** [周五, 06 10月 08:00]
  Hany Farid discusses how to detect image manipulations — and the increasing sophistication of forgers.
- **Navajo Nation reconsiders ban on genetic research** [周五, 06 10月 08:00]
  Tribal leaders are developing a policy for genetic research and data sharing, potentially ending a 15-year moratorium.
- **Proton-size puzzle deepens** [周四, 05 10月 08:00]
  Measurement in ordinary hydrogen agrees with a surprising 2010 result on the element's exotic cousin — but gives a smaller value than virtually every other experiment.
- **Controversial pesticides found in honey samples from six continents** [周四, 05 10月 08:00]
  Neonicotinoids are at the centre of a long-running debate about whether they harm bees.
- **Antikythera shipwreck yields statue pieces and mystery bronze disc** [周三, 04 10月 08:00]
  Archaeologists think that at least seven life-sized sculptures are hidden nearby.
- **Crash in sea-turtle births stumps ecologists** [周三, 04 10月 08:00]
  Leading suspect — climate change — doesn’t fully explain what is happening to leatherback turtles in the US Virgin Islands.
- **Supercomputer redesign of aeroplane wing mirrors bird anatomy** [周三, 04 10月 08:00]
  Bird-bone structures emerge from an evolution-like algorithm.
- **Elite Hungarian university may be saved** [周三, 04 10月 08:00]
  Hungary-New York agreement could allow Central European University to sidestep law change.
- **Science without walls is good for all** [周三, 04 10月 08:00]
  International mobility and collaboration are linked to stronger research.
- **Nobel prizes, giant telescope and buried treasure** [周三, 04 10月 08:00]
  The week in science: 29 September–5 October 2017.
- **Why fake islands might be a real boon for science** [周三, 04 10月 08:00]
  The seasteading movement is getting close to building its first prototype, an artificial archipelago where people will live, play and do research.
- **How fracking is upending the chemical industry** [周三, 04 10月 08:00]
  As shale-gas compounds flood the market, chemists are working out the best ways to convert them into the ingredients of modern life.
- **Scientists have most impact when they're free to move** [周三, 04 10月 08:00]
  An analysis of researchers' global mobility reveals that limiting the circulation of scholars will

damage the scientific system, say Cassidy R. Sugimoto and colleagues.

- **Open countries have strong science** [周三, 04 10月 08:00]
  Caroline S. Wagner and Koen Jonkers find a clear correlation between a nation's scientific influence and the links it fosters with foreign researchers.
- **Neuroscience: The mother lode of invention** [周三, 04 10月 08:00]
  Dan Jones compares three studies on the origins and fruits of human creativity.
- **Health: The war on germs** [周三, 04 10月 08:00]
  Tilli Tansey hails a history of Joseph Lister's drive to vanquish post-operative infection and putrefaction.
- **New in paperback** [周三, 04 10月 08:00]
  Highlights of this season's releases
- **Sustainability: China's path to ecotopia** [周三, 04 10月 08:00]
  Xuemei Bai critiques a critique of the country's eco-city initiative.
- **Ornithology: All eyes on the 10,000 species** [周三, 04 10月 08:00]
  Stuart Pimm considers the obsessive, sometimes dark side to the joyous pursuit of watching birds.
- **Theoretical physics: When the doer met the dreamer** [周三, 04 10月 08:00]
  Graham Farmelo applauds a study on the productive friendship of two very different physicists.
- **Technology: Into cyberia** [周三, 04 10月 08:00]
  Li Gong weighs up three tomes on Silicon Valley's vast influence, for good or ill.
- **Fossil fuels: Heed local impact of coal mining** [周三, 04 10月 08:00]
- **Hurricanes: rescue natural defences** [周三, 04 10月 08:00]
- **Hurricanes: enlist nature's protection** [周三, 04 10月 08:00]

South African researchers bemoan slashed funds

Plans to cut funding to a programme that recognizes and rewards excellence in research have met with criticism.

11 October 2017

Academics in South Africa are in uproar after a government research agency announced plans to cut the budget of a prestigious grant programme that rewards the country’s best researchers.

The initiative aims to foster academic excellence by awarding grants to individual researchers who volunteer to be rated, with higher-rated academics attracting more money than lower-rated ones. But the National Research Foundation (NRF) said last week that, in an effort to contain costs, it would cut funds to the programme. Some rated researchers will lose up to 90% of their cash.

The move is “catastrophic”, according to George Ellis, a top-rated mathematician at the University of Cape Town who receives funding from the programme. He said it would “leave many of the best researchers in the country high and dry”.

South Africa’s research and higher education system has long struggled with chronic underfunding, exacerbated in recent years by economic and political turmoil. The budget of the government’s science and technology department, the NRF’s parent body, has increased slightly over the past few years but decreased in real terms owing to rising inflation. And in August 2016, academics wrote an open letter to the government, warning that the system was on the brink of collapse because of systemic underfunding.

The rating system, introduced in 2008, aims to benchmark South Africa’s researchers against those in the rest of the world and improve the country's competitiveness. The number of researchers who have been rated has since more than doubled to 3,689.

South Africa's research system is "subject to the availability of resources, and we are being asked to do more with less", says Gansen Pillay, deputy chief executive of the NRF. "The question was sustainability into the future. It hasn't been terminated, but the funding model has been revised."

The system, known as the Incentive Funding for Rated Researchers programme, has five ratings: A (for international leaders in their field), B (for researchers who are internationally acclaimed), C (for established researchers), P (for those who have received prestigious awards), and Y (for emerging young researcher). Ratings were awarded for a period of five years, and came with cash rewards that researchers were free to spend on research of their choice.

The NRF's plans will cut funding across all rating categories, but top-rated researchers will be hit hardest; Y- and C-rated researchers will see comparatively moderate declines. In 2018, newly A-rated researchers will see their funding decline from up to 100,000 South African rands (£5,500) a year over five years to a one-off payment of 50,000 rands in the first year of their rating. Newly Y-rated emerging researchers will receive 100,000 rands from the NRF over two years, instead of 40,000 rands a year over five years.

From 2019, only P-rated researchers will get an annual sum of 50,000 rands. Those in other categories will receive a one-off payment of 30,000 rands if they retain their rating. If they are newly rated or improve their rating, they will receive a one-off payment of 50,000 rands.

"When you are an A-rated researcher, which means you're world renowned, you should be able to access funding from other sources," says Pillay. However, many of the NRF's largest grants programmes are available only to experienced researchers, he says. "It is incentive funding, not a grant. It was just to acknowledge and affirm excellence."

Ellis says that, in practice, many researchers use the incentive funding to supplement their main research grants, to support students or visitors and to travel for conferences. “In practice, it is a termination of this excellent programme and a huge slap in the face for South Africa’s top level scientific researchers.”

“The incentive grants funding was good: it encouraged researchers to get themselves rated,” says Michael Davies-Coleman, dean of science at the University of the Western Cape. “It will become increasingly difficult to convince colleagues to apply for rating in the future, despite the important contribution which increasing numbers of rated researchers make to a university’s national research profile.” Cutting incentive cash would also have a major effect on the student pipeline, he says.

An A-rated researcher who spoke on condition of anonymity says that the NRF “were victims of their own success” because of the growth in the number of rated researchers. “In an environment where the budgets are being reduced in real terms, they’re desperate to save a bit of money. But from an academic point of view, it’s a bit of a disaster.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22816

Comments

Comments

There are currently no comments.

A more personal view of human-gene regulation

A long-planned effort to examine gene expression and gene regulation in all the major tissues in the human body across many people comes to fruition.

11 October 2017

Dung Vo Trung/Eurelios/Look at Sciences/SPL

Hundreds of post-mortem tissue samples have been analysed for gene expression.

“The observation of and the search for similarities and differences are the basis of all human knowledge,” Alfred Nobel once said. From external events to spiritual influence, each culture and time has found its own way to explain

how we differ from each other and what we have in common. Today, much biological effort focuses on the similarities and differences between people’s DNA, and probing the myriad ways that these can combine, for good or ill, is at the cutting edge of genetics.

This week, geneticists announce the results of one such project. The researchers describe how they have analysed the regulatory code in our genomes. This should help scientists to unpick how genetic variants associated with disease function in different tissues of the body.

The project is called GTEx (genotype-tissue expression) and it catalogues genetic variation and its influence on gene expression in 44 tissues across the human body. The results — published in four papers (see pages 204, 239, 244 and 249) and discussed in an accompanying News and Views article — show how most of these critical regulatory regions are located close to the gene they affect. And they report important differences in gene regulation between tissues and between individuals. These results build on the findings of a pilot study that were announced in 2015.

The project results were a long time coming and were widely anticipated. The GTEx study was first proposed back in 2008. Its goal was to establish a resource database and an associated biobank (holding all major human tissues from 1,000 deceased individuals) that could be used by scientists to study the relationship between genetic variation and gene expression.

That seemed so far beyond technical capabilities at the time that many dismissed the idea as unrealistic. How could that many tissues be sampled from a single donor? How could so many individuals be recruited and be appropriately consented? How could high-quality samples be taken within the required post-mortem interval (different for various tissues)? And would the data even reflect living biology and replicate known findings on gene regulation?

LISTEN

Reporter Shamini Bundell learns about the grieving families contributing to a

huge genetics project.

You may need a more recent browser or to install the latest version of the Adobe Flash Plugin.
Go to full podcast

What was not questioned was the scientific need to reach for those goals. Following the Human Genome Project in the early 2000s, the genomics community had continued to establish reference catalogues for human genomes. These characterized genetic variation within and between individuals in populations worldwide, and made it possible to begin to identify functional elements in different cell and tissue types. Geneticists also identified genetic variation associated with a wide range of human diseases, a large proportion of which is found in non-coding regions, suggesting a role for gene regulation.

The GTEx Consortium investigates this link. To do so, project scientists needed a framework to consider ethical, legal and social issues that surround post-mortem donation (as discussed in a News story on page 169). Research on samples from deceased donors is not covered by rules on using humans as experimental subjects, and so does not need consent in the United States, where the project was based. But the GTEx scientists decided to include only samples from people for whom consent had been obtained from next of kin. This is commendable. Presumed consent — a sensible policy for organ donation for transplantation — seems less appropriate for basic research, where the benefits are not as immediate and clear-cut. It is good, too, that some researchers kept in touch with donor families, many of whom have attended project meetings to hear about the ongoing contribution of their loved one to science.

Nearly all donor families have said that they would like some genetic results returned, especially information relevant to treatable diseases. The GTEx study was not designed to do this. Nevertheless, project organizers and other researchers should consider in future studies whether and how they could return results to tissue donors' families.

Why rely on deceased donors? Previous studies were largely limited to cell lines or blood, but the GTEx project wanted to assess other tissues relevant to

disease, for example the heart and kidneys. Combined with the desire to study materials that are not available from living donors, such as the brain, and the need to sample multiple tissues from the same individual, it was clear that the project would have to find a way to source and quickly sample tissue post-mortem. To identify potential donors, the project made use of a network of existing programmes, such as autopsies carried out soon after death, and organ- and tissue-transplantation registers.

In reaching this point, and by providing an open-access database and tissue biobank that is already being widely used in biomedical research, the GTEx project has provided clear guidelines and procedures that are already informing, and providing the groundwork for, a next generation of studies.

These should include, for example, continued expansion of projects such as GTEx to include larger numbers of donors and sampling across different populations to further our understanding of the impact of genetic variation and regulatory differences. Complementary to these studies are projects such as the proposed Human Cell Atlas, which aims to use single-cell sequencing to better resolve cell types and their relationships.

For now, all biomedical researchers should welcome the wealth of data that continues to be released by the GTEx project, and the insights it provides into the regulatory code of our genomes. It is an important step towards the ultimate and ambitious goal of being able to characterize genetic variation and gene regulation in all cells of the human body.

Journal name:
Nature
Volume:
550,
Pages:
157
Date published:
(12 October 2017)
DOI:
doi:10.1038/550157a

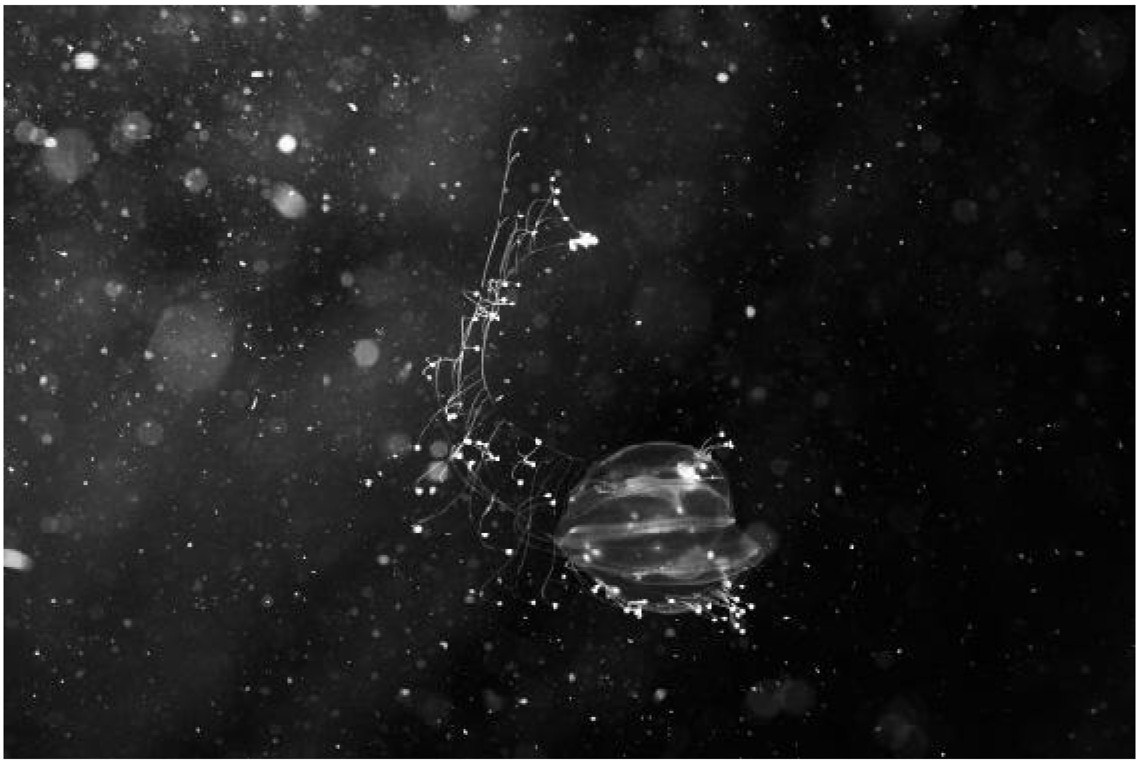
Comments

Commenting is currently unavailable.

Marine snow falls heaviest at the Equator

Organic matter drifts down to the equatorial ocean floor in distinct patterns.

11 October 2017



Flip Nicklin/Minden Pictures/Getty

Scientists have mapped heavy marine snow fall in the equatorial ocean.

According to the Renaissance mathematician Evangelista Torricelli, who discovered atmospheric pressure, “We live submerged at the bottom of an ocean of air.” If the atmosphere is an ocean, then the ocean is also an atmosphere, with its own turbulence and microclimates. And the parallels between these two great fluid environments of our planet go further. When

Japanese scientists took a dive into the ocean in a submersible in 1952 and their lamp revealed a flurry of shining white flakes falling towards the depths, they were going to name it only one thing.

This week, scientists report the most in-depth (and at-depth) analysis of this ‘marine snow’ — in the region that experiences the heaviest falls. For it is more than a mesmeric curiosity. The origins and fate of these oceanic snowflakes — in reality various forms of organic matter ranging from dead plankton to plant and animal detritus — help to determine what happens to carbon in the deep ocean. Carbon that makes it all the way to the depths without being released on its journey is effectively sequestered from the atmosphere for hundreds of years.

Writing in *Nature Geoscience* (R. Kiko *et al. Nature Geosci.* http://doi.org/cdz6; 2017), the scientists describe how they scanned the avalanche of marine snow that makes slow and steady progress towards the depths of the equatorial Atlantic and Pacific oceans. They discovered particularly heavy clouds of the material at depths of between 300 and 600 metres. This is where zooplankton (drifters) and nekton (swimmers) head from the surface during the daytime. The snowy scene, the scientists conclude, is largely made up of the faeces released by these organisms.

The study overturned one common assumption that is included in many models of ocean carbon transport. The researchers found that most of the organic matter that reaches the bottom arrives as a veil of relatively slow-moving small particles, rather than the assumed faster-falling and larger aggregates, which seem to disintegrate steadily as they sink.

The scientists also noted another fascinating effect. Strong and deep equatorial currents stop the snow drifting north or south towards the poles. Instead, it falls as a narrow curtain of flakes drifting down the darkness of the marine sky.

Journal name:
Nature
Volume:
550,
Pages:

158
Date published:
(12 October 2017)
DOI:
doi:10.1038/550158b

Comments

Comments

There are currently no comments.

ResearchGate lawsuit, walrus spat and a Second World War shipwreck

The week in science: 6–12 October 2017.

11 October 2017

Policy | Awards | Publishing | Universities | People | Events | Space | Trend watch

POLICY

Walrus left off threatened-species list The US government will not list the Pacific walrus (*Odobenus rosmarus divergens*) as a threatened species, despite the dwindling of its Arctic sea-ice habitat, the Fish and Wildlife Service (FWS) announced on 4 October. The decision reverses a 2011 FWS finding that the walrus should be listed. Now, officials say that the population seems to be adapting to the changing environmental conditions. They say that although the walrus's sea-ice habitat may shift, the animal should still be around in the near future, which the FWS defines as the year 2060. The Center for Biological Diversity, based in Tucson, Arizona, filed the original petition to force a decision. It called the announcement "disgraceful".

Mike Korostelev/Biosphoto/FLPA

Drug applications China is overhauling its drug-registration system in a bid to fast-track new medicines to market. The powerful State Council announced rules on 8 October that will allow data from clinical trials in other countries to be used to support drug-approval applications in China. That will make it faster and cheaper for companies to introduce medicines — a boon for multinational pharmaceutical companies hungry for a piece of the Chinese market. After the announcement, shares in China's drug-makers jumped in anticipation of higher profits. The move is the government's latest attempt to clear the way for innovative drugs, reduce the backlog of applications and crack down on fraudulent or otherwise-faulty drug applications. The rules will also help research institutions to conduct clinical trials.

Endocrine row The European Parliament has vetoed draft criteria proposed by the European Commission to identify chemicals known as endocrine disruptors: substances such as bisphenol A that may interfere with hormone systems and cause health problems. Under a 2012 law, the commission had been asked to come up with scientific criteria for defining the chemicals by

the end of 2013 as a step towards restricting the substances. But it failed to do so. Experts from 28 European Union member states finally agreed on criteria in July, but Parliament members rejected them in a 4 October vote. They said that the commission exceeded its mandate in exempting from its definition some chemicals that are designed to attack pests' endocrine systems. The Commission must now draft fresh proposals.

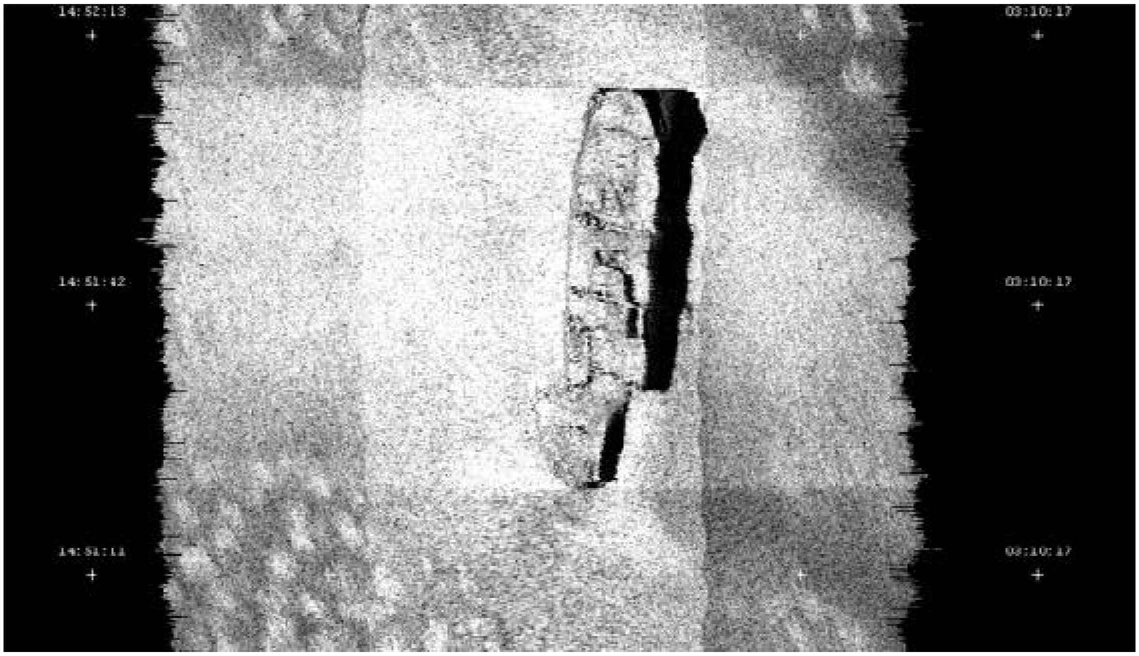
Zika screen On 5 October, the US Food and Drug Administration (FDA) approved a test to detect Zika virus in blood and organ donations. During last year's outbreaks in the US territories of Puerto Rico, the US Virgin Islands and American Samoa, the FDA permitted blood-donation centres to screen blood using the 'cobas' Zika test on an experimental basis, to ensure that people would not be infected through transfusions. The test, manufactured by Roche of Basel, Switzerland, detects Zika virus RNA in blood plasma. The FDA has not yet approved a Zika treatment, vaccine or commercially available diagnostic test.

EVENTS

Climate lawsuit An environmental group is suing the US National Oceanic and Atmospheric Administration (NOAA) to gain access to public records related to the August disbanding of a federal climate-advisory committee. The panel was providing input into the next national climate assessment, a congressionally mandated report on the effects of climate change in the United States, due in 2018. On 18 August, NOAA announced that it would not renew the committee's charter, and on 31 August the Center for Biological Diversity in Tucson, Arizona, asked the agency for documents related to that decision. NOAA failed to respond to that request, and on 3 October the environmental group filed a lawsuit in federal district court, demanding access to the files.

Shipwreck spotted Scientists on board Australia's national deep-water research ship have discovered the wreck of a merchant ship sunk during the Second World War. The wreck of the SS *Macumba* (**pictured**) was found in the Arafura Sea off the coast of the Northern Territory on 4 October during a government-sponsored search by the RV *Investigator*. *Investigator*'s

multibeam sonar located the wreck, which is sitting upright in 40 metres of water. Japanese aircraft sank the *Macumba* on 6 August 1943, killing three crew members.



Marine National Facility, CSIRO

AWARDS

Nobel prizes The 2017 Nobel Prize in Chemistry was awarded on 4 October to Jacques Dubochet, Joachim Frank and Richard Henderson for their development of cryo-electron microscopy, which has transformed the imaging of biomolecules. The Nobel Peace Prize, announced two days later, went to the International Campaign to Abolish Nuclear Weapons in Geneva, Switzerland, for its efforts to achieve a “treaty-based prohibition” of the weapons. The economics prize was awarded on 9 October to Richard Thaler at the University of Chicago, Illinois, in recognition of his work on behavioural economics, which incorporates elements of psychology.

PUBLISHING

Copyright suit Two large scientific publishers, Elsevier and the American Chemical Society, have filed a lawsuit against the scholarly social network ResearchGate to prevent copyrighted material appearing on its site. The publishers are two of five that on 5 October announced they had formed a coalition to start ordering ResearchGate to take down from its site papers that breach copyright. Up to 7 million papers may be affected, the coalition statement said. ResearchGate, based in Berlin, declined to comment on the lawsuit, which was filed in a German court.

UNIVERSITIES

Budapest battle The prestigious Central European University (CEU) in Budapest seems to have dodged a law change that many see as a deliberate attempt to close it down. In April, the Hungarian government sparked mass protests by rushing through a law that requires international universities in the country to also operate as higher-education institutes in their countries of origin. Only the CEU, registered in New York state after being founded in 1991 by Hungarian-born philanthropist George Soros, was seriously affected. The revised law comes into effect on 11 October; the CEU announced on 3 October that it had agreed with Bard College in Annandale-on-Hudson, New York, to provide educational activities in the state.

PEOPLE

WHO leaders Clinical scientist Soumya Swaminathan will be the new deputy director-general for programmes at the World Health Organization (WHO), making the post the most senior in the organization to be held by an Indian national. Swaminathan, a paediatrician and researcher specializing in tuberculosis, is the secretary of India’s department of health research and director-general of the Indian Council of Medical Research. Former UK public-health minister Jane Ellison has been appointed as the WHO’s deputy director-general for corporate operations. Swaminathan and Ellison are two of 13 new WHO leaders announced by director-general Tedros Adhanom Ghebreyesus on 3 October.

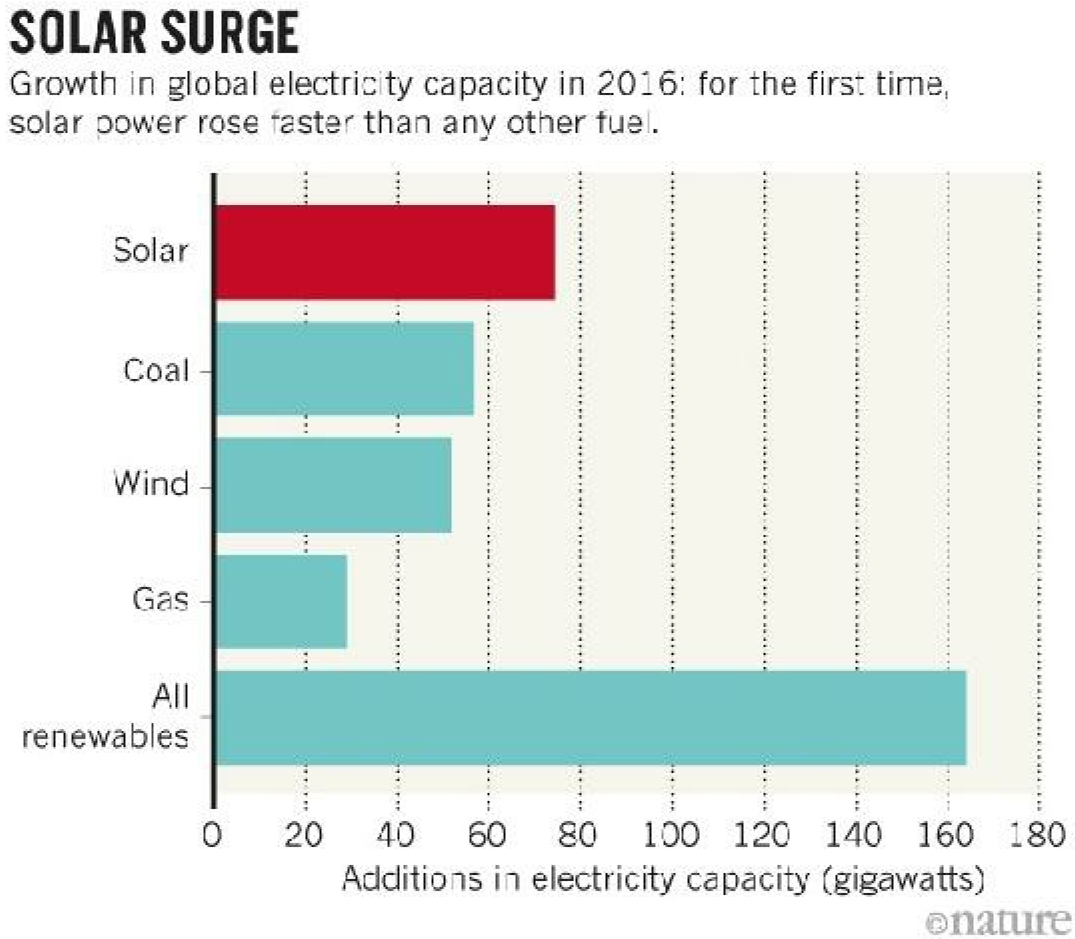
Whistle-blower quits A senior executive who turned whistle-blower at the US Department of the Interior resigned on 4 October, accusing President Donald Trump's administration of advancing fossil-fuel interests ahead of the agency's conservation mission. Joel Clement, who had been at the department for nearly seven years, was director of the office of policy analysis before he was abruptly reassigned to an accounting division in June. Clement has filed a whistle-blower claim against the agency, arguing that his reassignment was in retaliation for speaking out about the threat of climate change to Native Alaskan communities.

SPACE

Plutonium problem NASA's plutonium supply could be threatened if production issues are not addressed soon, according to a report from the US Government Accountability Office (GAO). The space agency uses plutonium-238 to power long-term missions such as some Mars rovers. The review, released on 4 October, found that current stockpiles, along with 100 grams of new ^{238}Pu manufactured by the Department of Energy (DOE), will last NASA until the 2020s. But without fixing one of the two US reactors capable of producing the isotope, the DOE will have trouble producing enough to meet demand. The space agency originally sourced its ^{238}Pu from nuclear-weapons programmes, but the DOE phased them out in the 1980s. NASA began paying the energy agency to manufacture ^{238}Pu in 2011.

TREND WATCH

The solar sector grew faster than any other energy market in 2016, according to the *Renewables 2017* report published on 4 October by the International Energy Agency in Paris. New electricity capacity provided by solar photovoltaics grew by 50% last year — faster than for any other fuel — to more than 74 gigawatts worldwide. China accounted for almost half of this expansion. The surge, driven by government policies and falling costs, opens "a new era for solar power", says the report.



Source: Renewables 2017, IEA

Journal name:
Nature
Volume:
550,
Pages:
162–163
Date published:
(12 October 2017)
DOI:
doi:10.1038/550162a

Comments

Comments

There are currently no comments.

| 章节菜单 | 主菜单 |

The ambitious effort to document California’s changing deserts

Ecologists catalogue bird and mammal populations as warming transforms Death Valley.

11 October 2017

Death Valley, California

Jason Ogulnik for Nature

Jim and Carol Patton hunt for kangaroo rats and other desert rodents in Death Valley, California.

Jim Patton brushes a packrat's furry white belly with a vibrant green marker as his wife, Carol, croons over the animal. "We're making you beautiful — punk mice!"

Patton, a retired mammologist, is trapping and releasing desert wildlife as part of an ambitious project to repeat surveys conducted by renowned ecologist Joseph Grinnell from 1908 to 1939. Known as the 'father of field notes', Grinnell criss-crossed California in his Ford Model T to catalogue its birds and mammals. His descriptions are so complete that researchers today can compare the density and distribution of animal populations then and now.

Grinnell's records provide an unparalleled baseline for researchers to explore how urbanization, farming, mining and climate change are reshaping the state's ecosystems. The Grinnell Resurvey Project, run by the University of California, Berkeley, has sought over the past 14 years to capture current conditions, with an eye to quantifying future ecological shifts. The latest phase of the work, which began last month, is focused on cataloguing small mammals in California's rapidly changing deserts.

"The only way to get a sense of what is happening under climate change, and what to expect in the future, is the kind of work going on in the Grinnell research project," says Josh Tewksbury, a sustainability scientist at Future Earth, an environmental-research group in Boulder, Colorado. "It's hard to see how the water boils when you're in the pot."

When Grinnell began his project in the early twentieth century, he was struck by California's varied geography, from snowy mountains to blazing deserts to rocky coasts. Anticipating the state's inevitable transformation as Americans moved west, he documented the distribution of species in about 700 locations. His team deposited more than 100,000 specimens in natural-history museums, including the skull from one of California's last grizzly bears (*Ursos arctos californicus*), as well as 74,000 pages of field notes and 10,000 images.

"The student of the future will have access to the original record of faunal conditions in California," Grinnell wrote in 1910, two years after he became the first director of Berkeley's Museum of Vertebrate Zoology. "This value

will not, however, be realized until the lapse of many years, maybe a century.”

Image Slideshow

1. 

   Jim and Carol Patton have trapped rodents around the world for more than 40 years. They began a new season of fieldwork in Death Valley in September, as part of the Grinnell Resurvey Project.

   Jason Ogulnik for Nature

2. 

Jim Patton marks a rodent so that he can tell if the same animal shows up again in a trap.

Jason Ogulnik for Nature

3. 

Joseph Grinnell, the first director of the Museum of Vertebrate Zoology at the University of California, Berkeley, documented the state’s flora and fauna in unparalleled detail from 1908 to 1939.

With permission of the Museum of Vertebrate Zoology, UC Berkeley

4. 

Grinnell and a colleague collected these bushy-tailed woodrats (*Neotoma cinere*a) near Death Valley, but the species is rarely found in the same locations there today.

With permission of the Museum of Vertebrate Zoology, UC Berkeley

In 2003, Grinnell's academic descendants [set out to retrace his survey of Yosemite National Park](). Five years later, they reported that 14 of the 28 mammal species monitored in Yosemite had migrated to higher elevations since Grinnell's time, averaging a gain of 500 metres (C. Moritz *et al. Science* **322,** 261–264; 2008). The animals' climb occurred during a period when winters in the park warmed by about 3 °C. Because Yosemite has been a protected area since 1864, the researchers concluded that land-use changes were not a major factor in the species' shifts.

Steve Beissinger, a conservation biologist at Berkeley and the project's leader, says that recent surveys have yielded less-coherent results. "As we look more broadly across sites in California, we find that responses are much more complicated," he says. "Some species [are] moving to lower elevations in areas that have become rainier, and in some places we see stasis."

But a growing number of studies suggest a dim future for desert dwellers in the coming decades, as they face warmer, drier conditions. Temperatures in Death Valley in July were the hottest for any month anywhere in the world in 2017, averaging 41.9 °C.

Many biologists think that desert organisms are living at the limits of survival — and that cooler regions may be out of reach for slow-moving or short-lived species. Preliminary results from the Grinnell Resurvey Project corroborate this idea. Of the 135 bird species surveyed in the Mojave Desert, only the common raven (*Corvus corax*) has significantly expanded its range since the early twentieth century, Beissinger says. The ranges of 38 other species have contracted.

With permission of the Museum of Vertebrate Zoology, UC Berkeley

Photographs of Vogelsang Lake in Yosemite National Park in 1915 (left) and 2004 show how trees have grown larger as the area has warmed.

A changing landscape

Yet on a cool morning in the Lee Flat area of Death Valley, most of the 160 box traps set out by Patton contain small, furry animals. Within 24 hours, he and Carol mark 90 squirrels, mice and rats belonging to nine species — one more than Grinnell listed in the same area in 1917.

Patton rejects the idea that climate change will soon drive many desert mammals to extinction. Like Grinnell, he is awed by the animals' ability to adapt to extreme conditions. Kangaroo rats (*Dipodomys* sp.) extract water from seeds, and lose little of it because their kidneys concentrate urine to a crystal-like consistency. The rodents' oily coats also prevent water loss through sweat.

Still, Patton sees signs of change. He has not yet captured a bushy-tailed woodrat (*Neotoma cinerea*), prominent in Grinnell's Death Valley accounts. But Patton hesitates to speculate on the species' absence, because reliable data on its distribution come only from Grinnell's time and now. The rat's numbers might have dwindled before desert warming intensified in the 1970s.

Others on the resurvey project are exploring how hotter, drier conditions might harm birds and mammals, by studying species' metabolisms and how much water they lose through evaporation. Ecological modellers can combine these findings with the latest population data to better project how the desert ecosystem might fare as the planet warms.

Ideally, scientists would revisit these forecasts in a few decades using fresh data. But fieldwork of this sort is falling out of favour. Staring at the blue mountains on the horizon, Patton says that he doesn't know who will replace him: very few students today train as naturalists, and museums and national parks are chronically underfunded. "Everyone wants to know how nature is changing and why," he says. "But there's almost nobody doing this kind of work."

Journal name:
Nature
Volume:
550,
Pages:
168–169
Date published:
(12 October 2017)
DOI:
doi:10.1038/550168a

Comments

There are currently no comments.

Gene-expression study raises thorny ethical issues

Project obtains tissues from recently deceased individuals to look for the origins of disease.

11 October 2017

Marc Asnin/Redux/eyevine

Tissues are taken from organ donors after consent has been given by their loved ones.

Sharon Napper was getting ready for school one morning five years ago, when her four-year-old daughter said, “Daddy fell off the bed.” Her husband, Ronald, a retired US Marine who worked as a police officer on an army base, was lying on the floor. He had suffered an aneurysm that spread to the

temporal artery in his head.

At the hospital, the only way to relieve the swelling would have been to open Ronald's skull, leaving him unable to eat or breathe on his own. "There was a quality-of-life issue. We had discussed this, and so I let everything kind of take its course," says Napper, who had been planning Ronald's 50th birthday party the evening before.

The couple had previously discussed Ronald's desire to be an organ donor, but another request followed: would Napper also donate his tissues for research after he died?

Ronald's myriad tissues, and those of almost 1,000 other anonymous deceased donors, are now the basis of a first-of-its-kind database. Supported by the US National Institutes of Health, the US$150-million Genotype-Tissue Expression (GTEx) project is amassing data about gene sequences and activity, and other information, across 44 types of tissue, from blood vessels to 10 different brain regions.

"It's creating a 'Google Maps' of the body," says Kristin Ardlie, a geneticist at the Broad Institute of MIT and Harvard in Cambridge, Massachusetts, who is part of the project's data-analysis team. It routinely releases new data, which are freely available to qualified researchers. And in this week's *Nature*, GTEx is publishing its latest and biggest analysis, based on tissue from 449 donors[1–4].

In assembling so much information from such a large number of deceased donors, the project has raised some thorny ethical issues concerning informed consent and scientists' moral obligations to families who donate the tissues of their loved ones for nothing in return.

The study aims to plug a gap in the search for the genetic origins of disease. Scientists have identified thousands of DNA variants linked to different conditions, but most lie in stretches of the genome that are devoid of protein-coding genes and are, instead, likely to alter the activity of other genes. By relating genes active in different tissues to variations in donors' genomes, researchers hope that GTEx can join the dots between non-coding variants and gene expression.

When the project was proposed in 2008, many researchers were sceptical that it could succeed, says Manolis Dermitzakis, a human geneticist at the University of Geneva Medical School in Switzerland and an early proponent of GTEx. That is because RNA molecules (a readout of gene activity) start to decompose after a person dies, and no one had ever attempted to measure gene expression in so many different tissues across so many people.

The challenge of amassing that much human tissue wasn't merely technical. Soon after learning of the deaths of their loved ones, the relatives of GTEx donors, such as Sharon Napper, were asked to donate dozens of tissue samples and to consent to the genome, medical history and other data of their loved ones being made widely available to researchers, albeit with most identifying details removed.

"They are being asked to donate to this strange project about which they have never heard anything like it before," says Laura Siminoff, a bioethicist at Temple University in Philadelphia, Pennsylvania, who led a project on GTEx that involved re-contacting donor families to see how they felt about the entire process. Her team found that the stress of suddenly losing a family member had fogged people's memories of what they had consented to. Most recalled that they had agreed to donate their relatives' tissue for research, but often didn't recall much else.

LISTEN

Reporter Shamini Bundell learns about the grieving families contributing to a huge genetics project.

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Siminoff suggests that some form of genetic counselling should be made part of the informed-consent process for tissue-donation projects such as GTEx. She also thinks that the project missed an opportunity by seeking tissue donations only from organ donors, because African Americans, Latinos and

other ethnic-minority groups are less likely to register.

Larry Gavan donated his older brother Mark's tissues to GTEx in August 2014, he says, even though he and his family weren't entirely clear how they would be used. Mark, who died of cardiac arrest following a stroke, was born with type 1 diabetes and had lost most of his sight. Gavan says his family saw the donation of Mark's tissues as "an opportunity to make a contribution to future people's lives and be directly related to the diseases my brother suffered from."

Napper, who along with other donor families was part of a GTEx community advisory group, emphasized that altruism motivated her decision to donate her husband's tissues. But Siminoff's research has found[5] that most donor families, including Napper's, want to know the results of tests, such as genome sequencing, conducted on the remains of their loved ones.

The study was not designed to return such findings. But Nicole Lockhart, a programme director at the National Human Genome Research Institute in Bethesda, Maryland, who coordinated the ethical, legal and social aspects of GTEx, says that future tissue-donation studies might consider providing families with medically important results.

"A standing policy of simply 'we will not return results' is becoming less and less common," says Susan Wolfe, a lawyer and bioethicist at the University of Minnesota in Minneapolis. Studies such as GTEx should plan to enable families to be identified if researchers discover, for instance, a mutation that dramatically increases the risk of cancer for relatives who inherit it, she says.

GTEx and other tissue-donation studies are likely to offer enormous benefits to scientists and companies (which can also apply for free access to the data), says Siminoff. "We should also think about what we can do for people who are generous and make these kinds of donations that benefit everybody."

Napper, who works as a nurse in cancer and chemotherapy, accepts that her late husband's tissues are now a code in the GTEx database. But, still, she checks the study's website to keep track of new research (191 studies are listed on the project website, and several more appear today in *Nature* and other journals). She sees his participation as an important legacy for their

family, which includes six sons, two daughters and nine grandchildren.

In June, she and other GTEx donor families attended the project's annual meeting in Rockville, Maryland. She met some of the scientists involved, who told her about the research they were doing on tissues such as those from her husband. "To know he's still there is a wonderful thing," she says.

Journal name:
Nature
Volume:
550,
Pages:
169–170
Date published:
(12 October 2017)
DOI:
doi:10.1038/550169a

Comments

Comments

There are currently no comments.

The rise and fall and rise again of 23andMe

How Anne Wojcicki led her company from the brink of failure to scientific pre-eminence.

11 October 2017

Credit: Gabriela Hasbun for *Nature*

There's a placard in Anne Wojcicki's office enshrining the attitude that nearly ran her company, 23andme, aground. Tucked behind a toy unicorn, the small, wood-veneered nameplate reads: “I'm CEO, bitch.”

It was with this kind of brashness that Wojcicki set out to disrupt the health-care industry in 2006. Her goal was to put sophisticated DNA analyses into

the hands of consumers, giving them information about health, disease and ancestry, and allowing the company to sell access to the genetic data to fuel research. But in 2013, that vision hit a snag. Wojcicki didn't think she needed regulatory approval to provide information about her customers' health risks. The US Food and Drug Administration (FDA) disagreed, and ordered the company to stop.

The FDA action prompted months of soul-searching and strategizing on how to reorient the company to work with regulators. “You just accept at some point, you're regulated, and there's no Silicon-Valley, 24-hour, easy fix,” Wojcicki says.

After years of effort, the pay-off came in April this year, when the FDA agreed to allow 23andme to tell consumers their risks of developing ten medical conditions, including Parkinson's disease and late-onset Alzheimer's disease. Surfing a wave of positive news, the company has since launched an advertising blitz to dramatically expand its customer base to 10 million people.

23andme has always been the most visible face of direct-to-consumer genetic testing, and it is more formidable now than ever before. In September, the company announced that it had raised US$250 million: more than the total amount of capital raised by the company since its inception. Investors estimate that it is worth more than $1 billion, making it a 'unicorn' in Silicon Valley parlance — a rare and valuable thing to behold. But for scientists, 23andme's real worth is in its data. With more than 2 million customers, the company hosts by far the largest collection of gene-linked health data anywhere. It has racked up 80 publications, signed more than 20 partnerships with pharmaceutical firms and started a therapeutics division of its own.

“They have quietly become the largest genetic study the world has ever known,” says cardiologist Euan Ashley at Stanford University, California.

But as it matures, 23andme faces new challenges. It must sustain customers' trust, fight off competition and prove that it can use genetic data to make new medicines — a notoriously difficult goal. And 23andme still has a long way to go with the FDA, which won't allow it to tell customers many genetic results directly relevant to human health, such as those for the *BRCA* genes,

which are linked to breast cancer.

Still, Wojcicki is undeterred. “I'm very stubborn,” she says.

In the picture

23andme's headquarters in Mountain View, California, have a start-up vibe that belies the company's 11-year history. Pink and green foil balloons float over cubicles to commemorate employees' work anniversaries. The kitchenette is stocked with healthy snacks. And Polaroid photographs of all employees line the wall of the free cafeteria. Each picture is scrawled with a quirky fact about the person. (“Her favorite drink is green tea,” reads one. “Once won a lip-sync contest singing a New Kids on the Block song,” boasts another.) Arranged by the order in which employees joined the company, the photos make clear where everyone fits in.

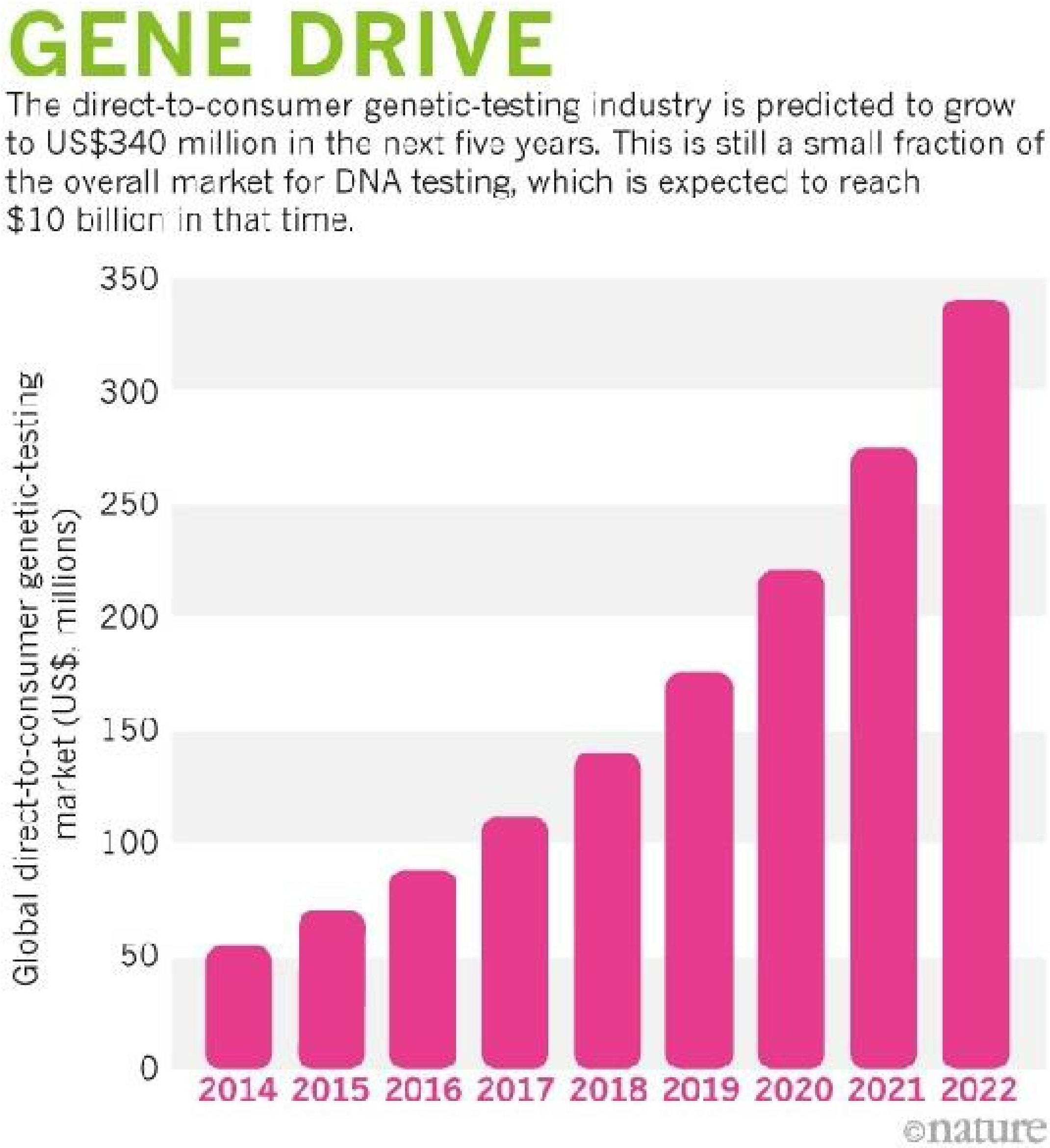
The first photo, of course, is of Wojcicki, who grew up on the campus of Stanford University, the child of a teacher and a physics professor. She majored in biology at Yale University in New Haven, Connecticut, where she played ice hockey. (She's still an avid athlete; the bike she rides to work is often parked in 23andme's lobby.)

In 1996, after graduating, Wojcicki worked for investment companies and hedge funds analysing heath-care ventures. She eventually came to dislike how the industry incentivized the development of expensive products and services that earn maximum insurance payments, rather than treatments and devices that consumers can afford to pay for on their own.

Wojcicki founded 23andme in 2006 with Linda Avey and Paul Cusenza with a goal of upending conventional models of health care. The following year, it received $8.95 million from a number of high-powered investors, including the biotechnology powerhouse Genentech in South San Francisco and Google, whose co-founder Sergey Brin was married to Wojcicki from 2007 to 2015.

Wojcicki aimed to attract millions of customers by selling an inexpensive test that would reveal genetic predispositions for dozens of traits. It would

provide disease risks, but also genetic propensity for baldness, obesity and trivial features such as earwax consistency. Wojcicki wanted to make the genome fun and engaging, the better to attract customers. She hosted celebrity 'spit' parties to get the product in the hands of tastemakers and stir up media interest: after taking one of the company's tests, Ivanka Trump gloated that she had a very low genetic risk of becoming obese. As the tests hit the market in late 2007, Wojcicki and Avey were hailed as visionaries (Cusenza had left in 2007; Avey would depart in 2009).



Source: Credence Research; Grand View Research

Scientists, meanwhile, were dubious. Family history was and is still a more powerful indicator than genes are for predicting the risk of most diseases. “The evidence is increasingly strong that the benefits of direct-to-consumer testing for these kinds of indications are somewhere between small and zero,” says Stanford University lawyer and ethicist Hank Greely, a long-time critic of the company.

There were also questions about 23andme's plan to sell customer data to help develop medicines. Companies have been trying to mine genetic data to design drugs for at least a decade, with little success. Take deCODE genetics, founded in Reykjavik in 1996, which recruited about half of the adult population of Iceland into a genetic study. Although the company's research has provided insights into the genetic mechanisms of disease, it hasn't yet yielded a drug.

Scientists' scepticism didn't deter hundreds of thousands of customers from signing up to 23andme, nor did it stop investors from ploughing $118 million into the company in its first five years — but a problem was emerging in the background. In 2009, the FDA started asking 23andme for evidence that the company's products worked as advertised and wouldn't harm customers. The agency was worried that people might take drastic medical measures on the basis of their test results, such as deciding to change the dosage of their medications without consulting a doctor or undergoing unnecessary surgery, such as a mastectomy, or treatment based on false positives. Regulators demanded evidence that the tests were accurate, and that customers were well informed what the results meant.

The next years were difficult ones for 23andme. It communicated with the agency on a few occasions and promised in January 2013 that data would be forthcoming. According to the FDA, it then ceased communicating with regulators entirely in May, even as it started a new advertising campaign. Fed up, the agency sent Wojcicki a strongly worded warning letter on 22 November 2013 ordering her company to stop marketing its product.

It was a self-inflicted wound for the company. “There was a bit of arrogance,” says Richard Scheller, who was an executive at Genentech at the

time. As a result, 23andme was forced to drastically cut its customer offerings, threatening its viability.

Wojcicki was stunned. “It became clear that we had pissed them off,” she says. “I really didn't know that we had done so many things that angered them.”

Back on track

Soon after the letter arrived, Wojcicki called Kathy Hibbs, a lawyer then working for Genomic Health, a gene-testing company in nearby Redwood City, California.

“Can I get my whole company back in one year?” Wojcicki asked Hibbs.

“You can get it back, but it will take years,” Hibbs replied. And to get there, she counselled, Wojcicki would have to cooperate with regulators.

It was a tough adjustment for Wojcicki; she didn't think that the FDA should be able to stop customers from learning their own genetic information. But Hibbs and others convinced her that capitulating to the FDA's demands was the fastest way to rescue her company.

“It's almost like being in a relationship,” Wojcicki says. “There's things that you might disagree with, but you just have to do them.” Wojcicki hired Hibbs, who began gathering evidence to respond to the FDA's concerns — a formidable task, because the FDA and the company had tussled over many issues over the years. By the end of 2014, Hibbs felt that the company was ready, so she asked the FDA to approve one test, intended to tell customers whether their children might inherit a genetic risk for a disease called Bloom syndrome.

The FDA approved the test in February 2015. The news didn't make a huge public splash: Bloom syndrome is a very rare disorder, affecting about 1 in 50,000 people with Ashkenazi Jewish heritage. But 23andme was now the first company approved to market a direct-to-consumer genetic test for a disease in the United States, although it had already been offering the test

overseas.

But even after the FDA's decision this April, 23andme is still barred from giving customers lots of available information, such as whether they carry gene variants that raise their risk for certain cancers or that predict how well certain medications will work. Before the FDA lockdown, it had been providing information on hundreds of health conditions.

Greely says that the restrictions make sense: there is very strong evidence that genetic variants cause the ten conditions listed in the FDA's approval in April. But the predictive value is much weaker for the variants linked to the vast majority of common health conditions that 23andme would like to tell its customers about.

Paths of discovery

Even as the company confronted resistance at the FDA, it was making moves into drug development. Key to this plan was bringing Scheller aboard. Wojcicki e-mailed him on the day he announced his retirement from Genentech in December 2014. Four months later, Scheller arrived in Mountain View to start 23andme's therapeutics group; by July, Wojcicki had raised $115 million more from investors.

Scheller was attracted not just by the size of 23andme's database, but by its richness. Customers have each answered an average of 300 questions on a huge array of traits, including their medical histories. That enables Scheller's team to try a different approach for gene-driven drug development.

The standard method has been a genome-wide association study, or GWAS, in which scientists gather people with a disease or trait, and then look for gene variants that seem to contribute to it. Scheller's team can do the reverse. They start with a particular gene that known drugs target, and then look for the diseases or health traits — the phenotypes — that are associated most strongly with different variants in the gene. “We just let the database show us what to work on,” Scheller says.

It's a study design called a phenome-wide association study, or PheWAS —

and Erik Karrer, director of drug discovery, calls it the company's “secret sauce”. 23andme is banking that it will speed drug discovery by allowing scientists to select drug targets that are important in human biology, that can be targeted by drugs and that are less likely to cause side effects.

To see if it works, computational biologist Fah Sathirapongsasuti studied whether 23andme's genetic and health data could predict the success of drugs developed over the past few decades. Sathirapongsasuti surveyed a database of thousands of drug compounds, some of which were approved for sale by regulators.

He compiled a list of all the genes encoding proteins targeted by drugs in this database, and compared it against variations in these genes among 23andme's customers, checking to see what medical conditions they had reported to the company. The process helped to validate the genetic basis for some drugs in humans in a way that mouse studies and other preclinical research often can't. Sathirapongsasuti also found instances in which 23andme customer data correctly predicted side effects of approved drugs.

And the data were able to predict which drugs approved for some conditions might work better for others. Isofagomine tartrate, for instance, was initially intended to treat Gaucher's disease, a rare genetic disorder, but it stalled after a failed clinical trial in 2009. Sathirapongsasuti's data suggest that the drug might also affect the processes underlying Parkinson's disease. The compound has been tested for this condition as well.

Sathirapongsasuti's data suggested that the PheWAS approach could be useful in drug development — and helped to convince 23andme that it should invest in its own drug programme. Using the results of additional phenome-wide association studies, Scheller and his team have now decided to focus on seven drug targets in four categories of disease: cancer, cardiovascular disease, skin disease and immune disorders, such as asthma.

Most scientists no longer see 23andme as a frivolous undertaking. The ability to recruit two million customers, and potentially many more, has been a huge draw, and researchers are lining up to collaborate with the company. Other major biobanks can boast no more than half a million people in their ranks. “They have the power of '*N*',” says cardiologist Eric Topol, director of the

Scripps Translational Science Institute in La Jolla, California.

In October, the US National Institutes of Health awarded the company a $1.7-million grant to sequence the genomes of hundreds of thousands of its African American customers who had already bought the company's standard product, which provides an overview of the genome rather than an in-depth analysis. The project — one of several sequencing initiatives that the company has started — is intended to help rectify the paucity of sequencing data on racial and ethnic minorities.

It's still an adjustment for scientists to work with 23andme data, because the company asks its collaborators to follow unusual rules. Its agreement with customers forbids it from sharing their actual data with collaborators, so scientists see only the results of analyses run by the company and never have access to the raw data that inform the studies.

And some scientists are uneasy about the self-reported data resulting from 23andme questionnaires. Neurogeneticist Ashley Winslow, for instance, who led a high-profile collaboration with Pfizer to identify genetic markers associated with depression, says that peer reviewers of the resulting paper were concerned about the veracity of 23andme's customer data. They argued that people who said that they had been diagnosed with clinical depression might just have been feeling low on the day that they took the company's survey. Winslow's team ran internal studies on the validity of the data, such as analyses showing the percentage of people who also reported using selective serotonin re-uptake inhibitors. The analyses were sufficient to get the paper published, but such concerns will probably come up again.

“Some communities might still be more dubious and demand more from the data to prove its relevance,” says Winslow, who is now at the University of Pennsylvania in Philadelphia. But, she adds, the results of a large study such as hers, which has since been validated by another large psychiatric genetics consortium, are encouraging more scientists to work with the company. “There is definitely an openness that didn't used to exist,” Winslow says.

But that doesn't mean that 23andme's model will definitely lead to new drugs. Several high-profile drugs based on human-genetics research have failed to live up to their potential, or have failed entirely. In May, for instance,

pharmaceutical company Amgen, based in Thousand Oaks, California, announced that its genetically targeted osteoporosis drug romosozumab raised the risk of heart disease by as much as 30% in a clinical trial with 4,000 people. “The idea of developing drugs as a result of genetics isn't as straightforward as many of us would like,” Topol says.

The direct-to-consumer genetic testing market has been transformed since 23andme's early years. And although it is a small slice of the gene-testing market, it is expected to grow to $340 million in the next five years (see 'Gene drive').

And a growing crop of genetic-analysis companies are now competing for 23andme's customers. They include firms offering inexpensive, targeted medical sequencing (Color Genomics in Burlingame, California); ancestry testing (Ancestry DNA, based in Salt Lake City, Utah); whole-genome sequencing, either on its own (Veritas, based in Danvers, Massachusetts) or in combination with medical testing (Craig Venter's Human Longevity in San Diego, California) or with apps for interpreting genomic data (Helix of San Carlos, California).

Wojcicki's competitors give her credit for showing that there may be a business in gathering and selling genetic data. “I'm a big admirer of 23andme and what they've done for the entire industry in pioneering both consumer genetics and this difficult regulatory road,” says Mirza Cifric, chief executive of Veritas. 23andme is still the only company offering FDA-approved direct-to-consumer health tests and no competitors have indicated a willingness to go down that path.

Wojcicki, for her part, still wants to stay ahead. “There's all kinds of ways we want to approach genetics,” she says. For instance, 23andme is watching closely as technology companies such as Apple and Google develop sensors and mobile health-data applications, and the company is looking for pilot projects in this space, which could allow it to seamlessly collect continuous data from its users. And she has no doubt that the company will achieve her goal of recruiting 10 million customers. “Just based on natural growth we'll get there,” she says.

In the 23andme company cafeteria, the fun fact on Wojcicki's Polaroid

picture seems at once trivial and telling: “I once ate so many carrots that I turned orange and was told not to eat carrots for a year.”

Wojcicki's colour has come back. She took the advice. But whether her resolve and ability to correct course can also push 23andme from earwax and ancestry to life-saving drugs remains an open question. If she has her way, it's her doubters who will one day become the real unicorns of Silicon Valley — so rare and shy, you'd hardly believe they exist.

Journal name:
Nature
Volume:
550,
Pages:
174–177
Date published:
(12 October 2017)
DOI:
doi:10.1038/550174a

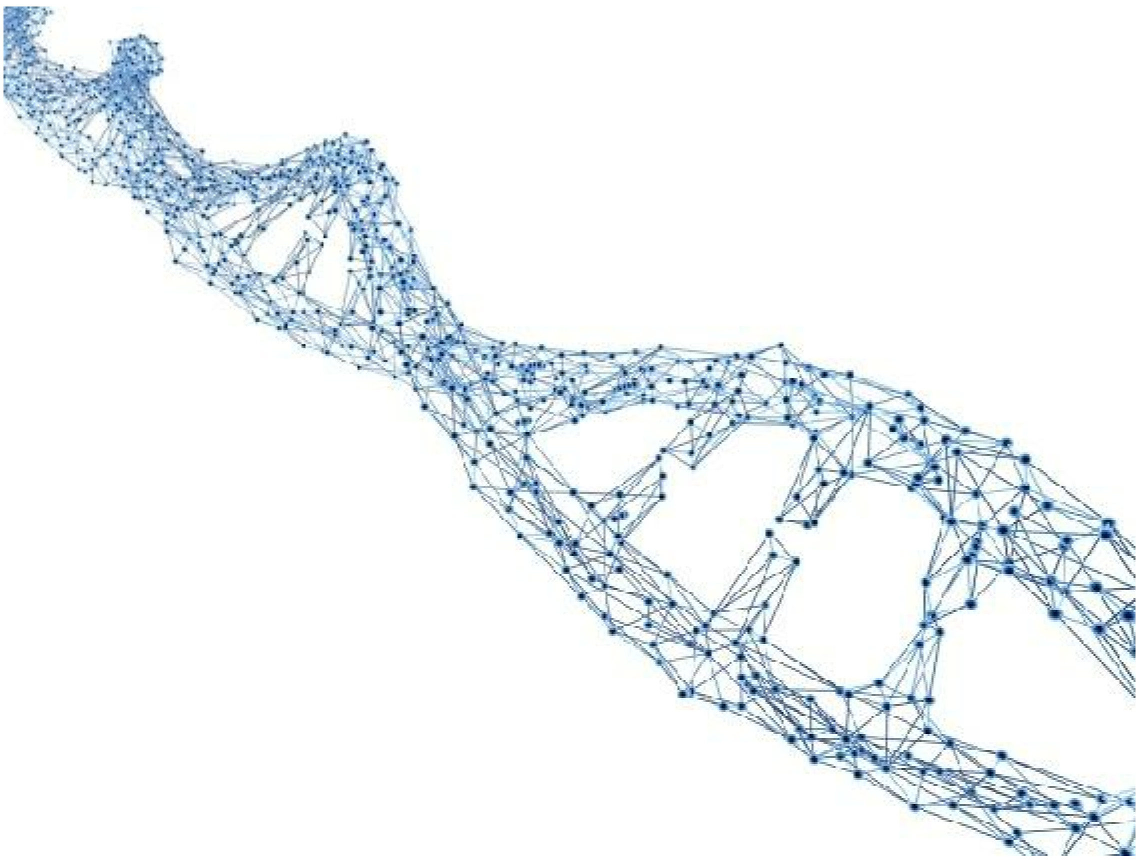
Comments

Commenting is currently unavailable.

The future of DNA sequencing

11 October 2017

Eric D. Green, Edward M. Rubin and Maynard V. Olson speculate on the next forty years of the applications, from policing to data storage.



Alfred Pasieka/SPL

Researchers have an insatiable appetite for DNA-sequence data.

Forty years ago, two papers[1, 2] described the first tractable methods for determining the order of the chemical bases in stretches of DNA. Before these 1977 publications, molecular biologists had been able to sequence only

snippets.

The evolution of DNA sequencing from these nascent protocols to today's high-throughput technologies has occurred at a breathtaking pace[3]. Nearly 30 years of exponential growth in data generation have given way, in the past decade, to super-exponential growth. And the resultant data have spawned transformative applications in basic biology and beyond — from archaeology and criminal investigation to prenatal diagnostics.

What will the next 40 years bring?

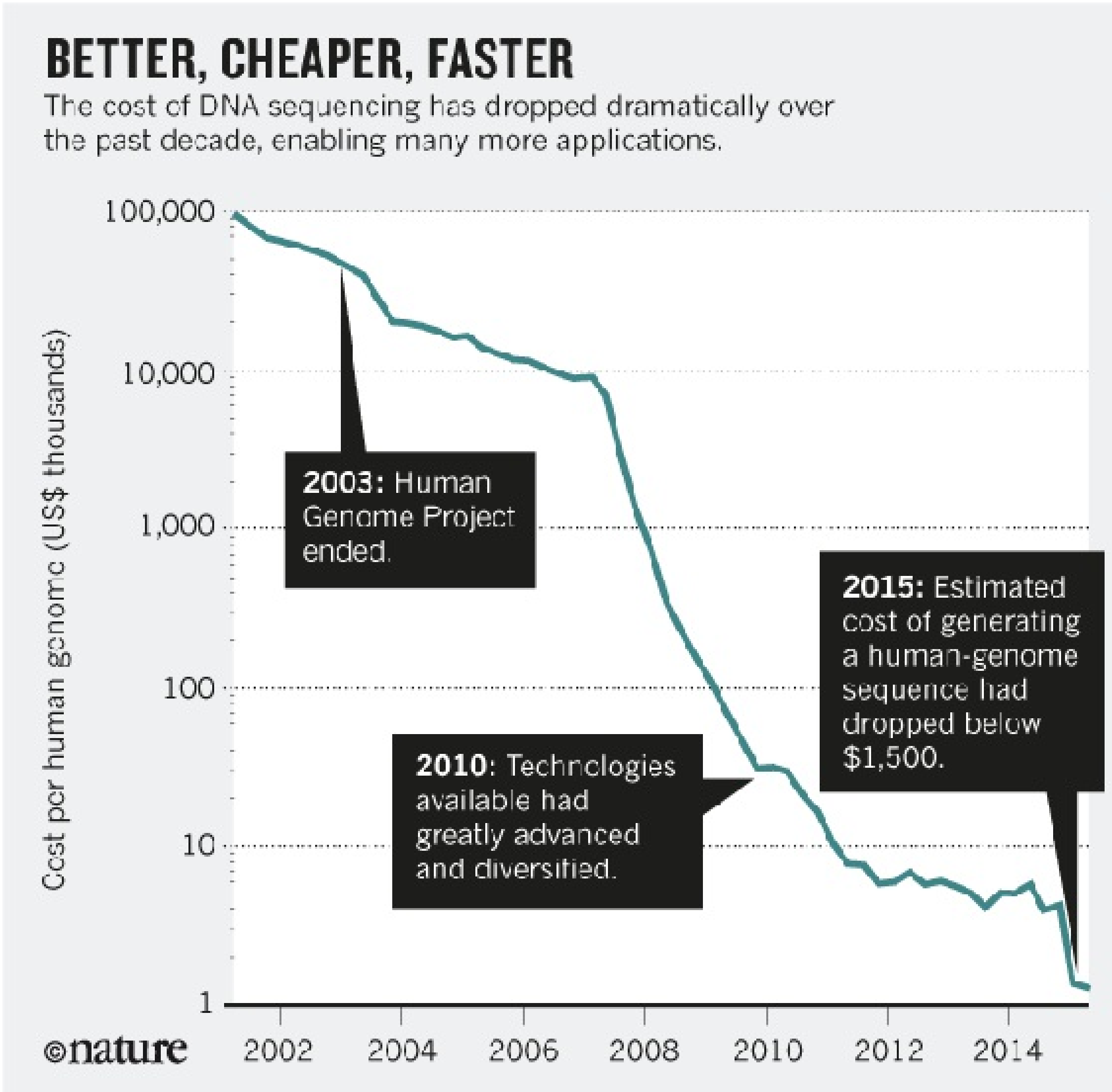
Prognosticators are typically wrong about which technologies — or, more importantly, which applications — will be the most disruptive. In the early days of the Internet, few predicted that e-mail that would achieve staggering popularity. Similarly, traders on Wall Street and investors in Silicon Valley failed to foresee that games, online video streaming and social media would come to dominate the use of today's available processing power and network bandwidth.

We would probably fare no better in predicting the future of DNA sequencing. So instead, we offer a framework for thinking about it. Our central message is that trends in DNA sequencing will be driven by killer applications, not by killer technologies.

In demand

Improvements in a technology can either increase or decrease demand. Microsoft co-founder Bill Gates famously cited radial tyres as an example of the latter: because they were more durable than earlier designs, the need for tyres dropped and the tyre industry shrank.

We think that DNA sequencing will follow the pattern of computing and photography, not of tyres. As it becomes cheaper and more convenient, applications will proliferate, and demand will rise (see 'Better, cheaper, faster'). As DNA sequencing breaks out of the research market and into clinical, consumer and other domains, the rule of 'more supply means more demand' will hold ever more strongly.



SOURCE: National Human genome research Institute

Researchers have an insatiable appetite for DNA-sequence data. In the 1990s, the idea of sequencing a human genome seemed daunting. Now, geneticists would like to have DNA sequences for everyone on Earth, and from every cell in every tissue at every developmental stage (including epigenetic modifications), in health and in disease. They would also like to get comprehensive gene-expression patterns by sequencing the complementary DNA copies of messenger RNA molecules. Meanwhile, archaeologists are beginning to reconstruct the flow of genes through ancestral populations, just as they previously deduced the flow of languages, cultural practices and

material objects. And taxonomists, ecologists, microbiologists and evolutionary biologists are seeking to analyse the genomes of all living (and extinct) species — and even whole ecosystems.

Obviously, a sustained demand for data would require that the vast cataloguing efforts proffer actual understanding. At present, the bottleneck is analysing and interpreting all the DNA-sequence data. But just as new informatics approaches and massive data sets have dramatically improved language translation and image recognition, we predict that massive DNA-sequence data sets coupled with phenotypic information will enable researchers to deduce the biological functions encoded within genome sequences.

LISTEN

Reporter Anand Jagatia speaks with Eric Green about the past and future of DNA sequencing.

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What's more, much of the basic science needed to interpret the data is already in place for a growing repertoire of practical applications (such as high-quality reference sequences of bacterial genomes, or the rules by which certain gene networks operate in healthy people). These range from recognizing microbial DNA sequences in unbiased surveys of environmental or clinical samples to identifying genome changes associated with known biological consequences.

Killer applications

Over the years, the platforms for DNA sequencing have changed dramatically (see 'Many ways to sequence DNA'). Yet the trajectories of other technologies for which there is a seemingly insatiable demand —

smartphones, the Internet, digital photography — suggest that the real disrupters will be the resulting applications, not the new technologies.

Many ways to sequence DNA

Over the past 40 years, the platforms for DNA sequencing have repeatedly been replaced.

By 1985, almost all DNA sequencing was performed with the Sanger or dideoxy chain-termination method[2]; reaction products were labelled with radionucleotides, separated on acrylamide slab gels, and detected with autoradiography (the use of X-ray or photographic film to detect radioactively labelled samples). By 2000, the four-colour-fluorescence method reigned supreme; reaction products were labelled with chain-terminating nucleotide analogues, separated electrophoretically in capillaries filled with a jelly-like media, and detected with energy-transfer fluorescent dyes. By 2010, the techniques had diversified. The dominant instruments were based on massively parallel analyses of DNA 'polonies' (clonal amplifications of a single DNA molecule) and on sequencing-by-synthesis chemistries (these rely on reversible chain-terminators).

From now on, the requirements for each DNA-sequencing platform will depend on what it is to be used for. In oncology and medical genetics, the goal will often be to identify every base correctly and to define every variant of genomic segments that exist in multiple copies. By contrast, when a yes or no 'match' is required — for instance, in species identification — the ability to run tests quickly and easily in the field may be more important than accuracy.

Another factor that will probably change is the relative need for centralized versus decentralized DNA sequencing. An epidemiologist trying to assess in real time what virus has affected a particular village in Sierra Leone might need cheap, portable devices. But for those generating massive data sets, it might be more efficient and cost effective to ship samples to centralized commercial operations, especially when the laboratories are required to meet exacting standards for quality control and sample tracking, as in clinical

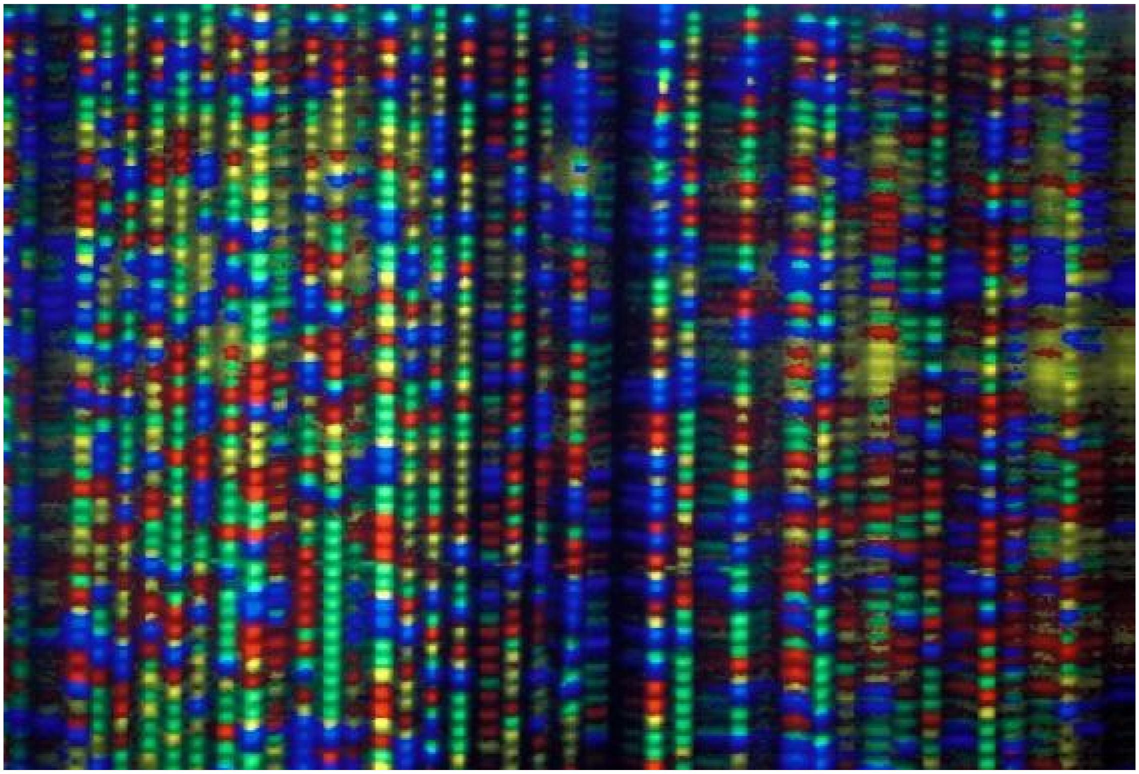
applications.

One domain where we are confident that DNA sequencing will be truly transformative is medicine.

Today's 'breakout' clinical application of DNA sequencing — in terms of the sheer number of tests conducted — is prenatal testing for the presence of an abnormal number of chromosomes, such as trisomy 21, which causes Down's syndrome. This test now relies on detecting the small amount of cell-free fetal DNA that circulates in maternal blood. Not even imagined at the end of the Human Genome Project, it has been described as “the fastest growing genetic test in medical history”[4]. In fact, experts in the field estimate that some 4 million to 6 million pregnant women are now receiving this test each year worldwide, and that the number will surpass 15 million within a decade (D. Bianchi, D. Lo and D. Zhou, personal communication). Some of the hallmarks of the test seem likely to characterize many future applications of DNA sequencing in primary care: it is non-invasive, easy to perform and has low requirements for nucleotide-level accuracy (chromosomes can be counted without assessing sequence variation).

In high-income countries, genome sequencing is already used routinely to evaluate children with ill-defined congenital conditions. Analyses of the resulting sequences can reveal the disease-causing mutations in around 30% of such cases[5, 6] — a figure that will only rise as the ability to interpret the data matures. In some instances, the resulting diagnoses have led to dramatic improvements in clinical management7,8. More typically, they benefit both families and physicians by ending a diagnostic odyssey and providing clinical clarity.

In oncology, considerable investments are being poured into the development of liquid biopsies[9]. It is easy to imagine such a sequence-based cancer test becoming a routine screening tool, used much like Pap smears and colonoscopies. With the advent of cancer treatments that target specific mutations, rather than tumour types[10], liquid biopsies could ultimately guide therapeutic interventions even when tumours are known to exist only from DNA-sequence signatures present in blood samples.



Karen Kasmauski/NGC

Coloured DNA bands.

Various applications can be envisioned outside the clinic, too, particularly for hand-held DNA sequencers. Epidemiologists and even caregivers working in rural areas could use such devices to test air, water, food, and animal and insect vectors, not to mention human throat swabs and body fluids. In fact, easy access to DNA-sequencing technologies in low- and middle-income countries is already facilitating projects such as the Global Virome Project. This aims to sequence numerous samples of wildlife DNA to identify a significant fraction of the viruses that can be transmitted into humans and cause disease.

Meanwhile, public-health specialists are starting to discuss how they might sequence the DNA of all the microorganisms in the waste-water outlets of entire cities to speed up the recognition of disease outbreaks. And marine biologists are exploring ways to monitor the health of the oceans through systematic metagenomic studies.

On the street, portable instruments could bring DNA analysis out of the crime lab and make it a front-line policing tool. Police might be able to 'read' people's DNA, much as they currently check car number plates or identification documents. In fact, the degree to which cheap and easy DNA sequencing opens up possibilities for mass surveillance has recently sparked concern among human-rights groups.

In the home, DNA-sequencing appliances could become the next 'smart' or 'connected' devices, after smoke alarms and thermostats. One commentator even identified the toilet as the ideal place to monitor family health through real-time DNA sequencing[11].

Hitting limits

What are the stumbling blocks?

In a mere 40 years, the central goal of putting molecular data about cells to practical use has changed from an informational challenge to a meta-informational one.

Take clinical applications of genome-sequence data. It may soon be possible to use DNA sequencing routinely to analyse body fluids obtained for any clinical purpose. But only a vast amount of well-organized data about the multi-year medical histories of millions of people will provide the meta-information needed to establish when to ignore such data and when to act on them.

With respect to medicine, we echo the recommendations of advisory groups such as the US National Research Council's Precision Medicine Committee[12] on the need to create a vast “information commons”. This would overlay molecular and clinical data onto the germ-line genome sequences of millions of individuals. Several such population-scale efforts are under way, including the UK Biobank resource and the US All of Us Research Program.

Here we have laid out our best guesses. Surprises are a certainty. In fact, it is possible that decades from now, much of the world's data (now residing on

hard drives or in the cloud) will be stored in DNA, and that the main driver of DNA sequencing will be not our quest to tackle disease, but our insatiable appetite for data storage.

Journal name:
Nature
Volume:
550,
Pages:
179–181
Date published:
(12 October 2017)
DOI:
doi:10.1038/550179a

Comments

Comments

There are currently no comments.

Publishers threaten to remove millions of papers from ResearchGate

Take-down notices “imminent” as lawsuit is filed alleging widespread copyright infringement.

10 October 2017 Updated:

1. 10 October 2017

Millions of articles might soon disappear from ResearchGate, the world’s largest scholarly social network. Last week, five publishers said they had formed a coalition that would start ordering ResearchGate to remove research articles from its site because they breach publishers' copyright. A spokesperson for the group said that up to 7 million papers could be affected,

and that a first batch of take-down notices, for around 100,000 articles, would be sent out “imminently”.

Meanwhile, coalition members Elsevier and the American Chemical Society have filed a lawsuit to try to prevent copyrighted material appearing on ResearchGate in future. The complaint, which has not been made public, was filed on 6 October in a regional court in Germany. (ResearchGate is based in Berlin). It makes a “symbolic request for damages” but its goal is to change the site’s behaviour, a spokesperson says.

ResearchGate may already have begun taking articles down, according to a 10 October statement by the coalition. The group said it had noticed that the site had removed "a significant number of copyrighted articles", although ResearchGate hadn't shared information about this with publishers. "At this point, not all violations have been addressed and ResearchGate will need to take additional steps to cease unauthorized distribution of research articles," the statement says.

The clash has been a long time coming. Researchers are increasingly posting paywalled research papers online, many of them on ResearchGate, a network often likened to Facebook for scientists. The site boasts more than 13 million members and has raised more than US$80 million in start-up funding from investors including Microsoft founder Bill Gates and the Wellcome Trust, the London-based biomedical-research funder.

Not only do academics upload articles to the site, but ResearchGate also scrapes material online and invites researchers to claim and upload these papers, says James Milne, a spokesperson for the five-publisher group, which calls itself the Coalition for Responsible Sharing. In February this year, information scientist Hamid Jamali at Charles Sturt University in Wagga Wagga, Australia, reported that he had examined 500 articles at random from ResearchGate, and found that 40% of them breached copyright[1].

Access issues

In September, the International Association of Scientific, Technical, and

Medical Publishers, a trade group based in Oxford, UK, sent a letter to ResearchGate suggesting that the network introduce an automated filtering system, through which uploaded articles would be shared publicly or privately depending on their copyright status. Publishers generally say that paywalled articles for which they own copyright can be shared only privately; scientists are allowed to upload preprints, and peer-reviewed but unedited manuscripts, online for general access.

“ResearchGate refused to engage with us on that,” says Milne. The Coalition for Responsible Sharing, which also includes publishers Wiley, Wolters Kluwer and Brill, says it is “now left with no other choice” but to issue take-down notices.

Litigation has been tried before: in 2013, Elsevier sent 3,000 notices under the US Digital Millennium Copyright Act to scholarly networks including Academia.edu, demanding that they take down papers that breached Elsevier’s copyright. Those notices were passed on to the networks’ academic users. But the new actions would be on a larger scale.

Terms and conditions

ResearchGate declined to comment on the coalition’s statement, but its terms of service ask users not to store information that infringes copyright. They also state that because the site neither previews nor automatically reviews information that users have stored on it, ResearchGate can’t know about — and isn’t liable for — any possible infringements. The site says it will quickly disable access to infringing material after being notified of a problem.

But repeatedly sending lots of take-down notices is not a long-term solution, Milne says — hence the lawsuit, which aims to clarify what responsibility ResearchGate has to prevent copyright breaches. Milne says Elsevier and the American Chemical Society are hoping that the German court will tell the social network that it has a duty to identify copyrighted material on its website, and remove it; that the site must check whether material it scrapes from the Internet is copyrighted before users are invited to ‘claim’ it and upload it; and that ResearchGate will also be told it cannot modify

copyrighted material.

“The expectation is that ResearchGate will be told by the courts to cease certain behaviours. This could take months or years,” says Milne.

Not all publishers have stopped discussions with ResearchGate. On 9 October, the company posted a joint statement with *Nature*’s publisher Springer Nature, saying that the two firms had been in “serious discussions for some time” about sharing journal articles online while protecting intellectual-property rights, and that they were “cautiously optimistic” that a solution could be found. (*Nature*’s news and comment team is editorially independent from its publisher.)

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22793

Updates

Updated:

Updated to include details of a 10 October statement by the coalition of five publishers, which said that ResearchGate had begun removing from public view some copyrighted articles.

Comments

Commenting is currently unavailable.

Trump EPA begins push to overturn Obama-era climate regulation

The agency's plan to reverse limits on greenhouse-gas emissions is likely to draw legal challenges.

10 October 2017

Jabin Botsford/The Washington Post/Getty

EPA administrator Scott Pruitt has questioned his agency's legal authority to regulate greenhouse-gas emissions.

The US Environmental Protection Agency (EPA) is moving to repeal former

president Barack Obama's landmark regulations to reduce greenhouse-gas emissions from power plants.

The plan, introduced on 10 October, is a step towards fulfilling President Donald Trump's promises to reverse Obama-era climate regulations and end the "war on coal". But any attempt to repeal the power-plant rule is certain to face lawsuits from environmental groups and many states that support Obama's climate policies.

"The Trump Administration's persistent and indefensible denial of climate change — and their continued assault on actions essential to stemming its increasing devastation — is reprehensible," said Eric Schneiderman, attorney general for the state of New York, in a prepared statement. "I will use every available legal tool to fight their dangerous agenda."

US emissions from electricity generation have been falling in recent years as energy utilities have shifted away from coal, and towards cheap natural gas and renewables. The Obama administration established the power-plant regulations to hasten that progress, and to help the United States to meet its commitments under the 2015 Paris climate accord.

The power-plant rule would reduce greenhouse-gas emissions to 32% below 2005 levels by 2030 — but it is mired in legal challenges. In 2016, the US Supreme Court blocked the regulations from taking effect. Legal challenges from 27 state governments are still pending, although a federal appeals court has put the case on hold while the Trump administration reviews the rule.

Trump has shown no fear of challenging environmentalists on climate issues: he has already announced plans to pull the United States out of 2015 Paris climate pact. But his administration's attempts to roll back various environmental regulations have faced legal setbacks. One of the latest rebukes came on 4 October, when a federal court rejected an effort by the Department of the Interior to delay implementing curbs on methane emissions from oil and gas operations on public lands.

A long fight

The power-plant rule that Trump's administration plans to challenge was made possible by the Supreme Court's decision in 2007 that carbon dioxide and other greenhouse gases are pollutants under the terms of the Clean Air Act. Two years later, the EPA ruled that these gases are a threat to human health and the environment — a decision known as an 'endangerment finding'. That allowed the agency to draft regulations to limit greenhouse-gas output from various sources.

EPA administrator Scott Pruitt sued to overturn the endangerment finding in his former role as Oklahoma's attorney general, before Trump took office. More recently, as EPA's chief, he has questioned his own agency's authority to regulate CO_2. Environmentalists fear that he will attempt to repeal the endangerment finding, which would inevitably prompt a flurry of lawsuits.

The legal fight over the EPA's new plan to repeal the Obama power-plant regulations will almost certainly focus on whether the Clean Air Act allows the agency to require that utilities alter their energy portfolios to reduce emissions. The Obama administration set limits on emissions and then allowed states and utilities to decide how to meet those limits, with options that included expanding efforts to reduce energy consumption and developing new sources of renewable energy.

The Trump administration's proposal says that the EPA overstepped its legal authority when it finalized the Obama-era rules. The administration argues that the Clean Air Act limits the EPA to crafting regulations that can be implemented at power plants themselves. The proposal also says that the EPA is still considering whether and how to craft alternative regulations for power-plant emissions.

Jonathan Adler, who heads the Center for Business Law and Regulation at Case Western Reserve University School of Law in Cleveland, Ohio, says the Trump administration can reasonably argue — as many states have — that the Clean Air Act was not designed to regulate greenhouse gases. Courts often give a certain amount of deference to federal agencies on regulatory matters, he says, but only if the agencies show that they have followed all legal and procedural requirements for finalizing new rules.

“Some of the same legal doctrines that helped the Obama administration

defend its regulatory decisions will now help the Trump administration defend its decisions going in the opposite direction," Adler says. "This will certainly be a test for whether this administration is capable of engaging in this sort of heavy lift."

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22813

Comments

Comments

There are currently no comments.

Climate meetings pose serious test in the Trump era

Annual jamborees fail to ignite public passion but are crucial to progress on global-warming.

10 October 2017

Adrien Morlent/AFP Photo/Getty

In the aftermath of the successful 2015 Paris climate conference, the public remained unengaged.

Climate change is a popular topic in Germany right now. Leading researchers are converging in Potsdam this week to take stock of the economic and societal impacts of global warming across sectors from health to agriculture.

In Berlin, experts are meeting to discuss the potential and risks of various geoengineering technologies intended to counteract the effects of climate change. And next month, at the climax of the climate-meeting season, thousands of delegates will flock to the United Nation's annual climate summit, this year in Bonn.

At the UN meeting, governments will discuss the next steps in implementing the global climate agreement that they reached in Paris almost two years ago. The landmark deal, which came into force last November, aims to limit global warming to 1.5 °C above pre-industrial temperatures. To achieve this ambitious (many say unrealistic) goal, the world's major economies might need to phase out emissions of heat-trapping greenhouse gases entirely within a few decades.

The Paris accord, although based on merely voluntary national contributions, was undoubtedly a rare triumph for international climate diplomacy. It was the most that was possible and the least that was needed. Alas, the excitement did not last long. The subsequent U-turn of the United States — President Donald Trump has resolved to leave the deal, deeming it half-baked, essentially unnecessary and intolerably unfair to the US economy — has dampened spirits. Even so, the rest of the world has pledged to stand firm. The first conference of the parties to the agreement in the Trump era must now work out how to proceed without the world's largest economy. In theory, the annual climate roller coaster is idling through one of the low-key phases in which success is measured by nothing going wrong. In practice, the Bonn meeting will serve as a litmus test of how the rest of the world plans to stand united and to keep the spirit of Paris alive.

Keynote speakers in Bonn (and presenters in Berlin and Potsdam) will no doubt reiterate the severity of the global-warming threat and the urgent need to act. Major meetings often galvanize debate among researchers, pundits and policy watchers. But beyond this predictable fuss in the expert world, do high-level climate meetings and policy events, and the media coverage they bring, help push the wider public to engage with the climate problem?

Not quite, it seems. Results of a survey of the German public, published this week in *Nature Climate Change*, suggest that extensive media coverage of the Paris climate summit had a soothing rather than a mobilizing effect (M.

Brüggemann *et al. Nature Clim. Change* http://dx.doi.org/10.1038/nclimate3409; 2017). Respondents who had taken notice of media reports (and many said they had not) had slightly more trust in the efficacy of global climate policy after the unusually successful meeting. However, fewer were in favour of their own country taking a leading role, and most said that they did not intend to change their behaviour. In essence, respondents were relieved that a political deal had finally materialized, but were disinclined to engage further with the issue.

The researchers who conducted the survey say that this is a missed opportunity. The annual UN meetings bring guaranteed media attention to a topic that many news editors are bored with, and so they are an opportunity to mobilize action. As such, the study authors go so far as to suggest that the lack of public engagement is a failure of journalism.

It might indeed seem worrying that despite the avalanche of information, climate change remains marginal to most people's personal and political choices — Germany's strong green movement notwithstanding. It might even seem like a bad case of civil indifference. Does it matter? There is an argument that climate action does not have to depend on media-stirred engagement from agitated citizens. People often choose to leave responsible decision-makers to deal with complex global problems that only concerted international effort can hope to solve, and this has brought progress on issues such as nuclear non-proliferation and the phase-out of ozone-depleting chemicals.

But climate change is a more complex issue, and one that cuts across many overlapping and sometimes contradictory concerns, from cultural and political issues to ethical and psychological ones. As such, organizations, businesses, scientists, policymakers and others who advocate action on global warming must continue to strive to take the public with them. As many experts have pointed out, that will take creativity and more than repeated references to the serious nature of the problem — in Bonn and elsewhere.

Journal name:
Nature
Volume:
550,

Pages:
158
Date published:
(12 October 2017)
DOI:
doi:10.1038/550158a

Comments

Comments

There are currently no comments.

A. Awad

Developing nations need more than just money

Grants from big science funders can be hard to use without better administration and mutual understanding, says Rana Dajani[1].

10 October 2017

As a molecular biologist based in Jordan, I'm used to colleagues from outside the Middle East and North Africa assuming that brain drain and a lack of funds are the chief obstacles to science in my region. That is not my experience. Like me, many scientists return home after studying in the United States or Europe, and successfully apply for grants, often from international philanthropies or funders.

The real problem is using the money. There is a disconnect between the funding systems that we can tap into and the institutions where we work. Granting agencies often fail to appreciate the constraints we're operating under. Current practices by both funders and universities practically guarantee that our funds — already limited — are spent inefficiently. We need more investment in administrative systems and more flexibility, because science is unpredictable and creative.

I hear the same sorts of struggles again and again. For example, a researcher in the Middle East received a grant from a US institution to study vectors of disease. It included a line item to cover capturing insects in the desert. But the local university overseeing the funds would not disburse them to cover transport, because the team could not supply officially stamped receipts from a petrol station; services at remote locations in developing nations are rarely equipped to provide such documentation. The scientist has not applied for an international grant since.

Another colleague in the region received a grant budgeting for some human genetic analysis to be performed by a third party in the United States, because the necessary capacity doesn't exist in the Middle East. It took more than a year to get the funder, local university and third party to sign the agreements. But after the samples were shipped, university administrators said they could not process invoices because a bid to supply DNA-analysis services had not first been advertised in local newspapers. It took another year, many committees and much heartache to resolve the issue.

The situation is improving as more grants are awarded. For example, a newly appointed dean of scientific research at my university, Majd Mrayyan — herself a practicing scientist — has reduced the paperwork and minimized the levels of approval needed to begin projects. And the American University in Beirut has set up a department to handle funding logistics, staffed by people who understand the process. It has greatly increased the amount of funding that the university can receive.

Still, few university administrators in developing countries know much about science or how grants are typically handled. Postdoc and technician positions are rare across the Middle East and North Africa. When I hired a lab manager to handle administrative tasks such as ordering equipment, several people told me I was indulging in a luxury.

Institutions such as Harvard University in Cambridge, Massachussetts, where I am currently a visiting fellow, receive as much as 69% of awarded funds as indirect costs, which they put towards infrastructure and overhead — the costs of maintaining a system. By contrast, international grants to researchers in developing countries rarely cover infrastructure or capacity building; in some cases, philanthropists' charters explicitly prohibit them from putting

money into anything not directly related to a funded project.

Even when overhead funds are available, local universities are often wary of spending them on intangibles such as salaries or training. They prefer to use grants to buy instruments and equipment. In one typical occurrence, an award covered the purchase of a DNA sequencer, but not maintenance. The instrument was effectively rendered useless in three years.

How can we solve this? Through capacity and systems building. Funders need to find ways to ensure that recipients have the administrative staff and skills to use their money well, and to help build these foundations where they are lacking. Agencies should encourage the appointment of administrators who have research experience. They might even consider sponsoring training and exchange programmes for administrators.

People involved also need to sit around a table and talk about these issues in real time. When discussions happen — if they happen at all — it is through e-mail, and most communication occurs within groups rather than across them. People at institutions talk among themselves and then formally approach funders; those at funding agencies take the same approach. Each group misses out on nuance and connection with the other.

For every grant awarded, funders, university administrators and scientists should talk about the project together to identify needs and potential conflicts. They could then take the initiative to make changes, which builds ownership and creates useful precedents.

These discussions might reduce many roadblocks that keep scientists in the developing world from being able to use grants more efficiently. Core facilities that allow expensive equipment to be shared would cut down on redundancies and free up available funds. Provisions for maintaining equipment and paying and training technicians should be built into the budgets of both grants and institutions.

People from developed countries might feel noble when they give money to those in developing countries. What is really needed is more complicated — but it’s doable. For funders to have the most impact, they need to sit down with administrators and scientists in developing countries, listen to their

challenges and decide together what to do. That is the way to genuinely make a difference.

Journal name:
Nature
Volume:
550,
Pages:
159
Date published:
(12 October 2017)
DOI:
doi:10.1038/550159a

Comments

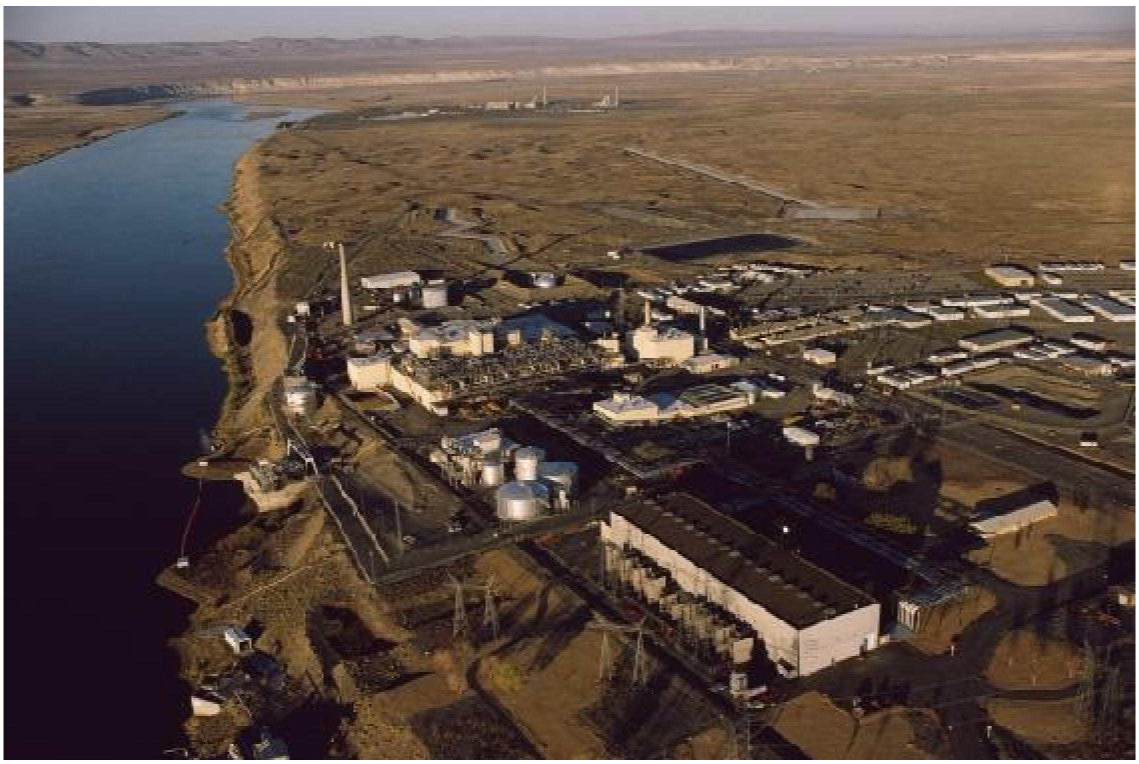
Comments

There are currently no comments.

How the United States plans to trap its biggest stash of nuclear-weapons waste in glass

After decades of delays, a challenging clean-up project is gaining ground.

10 October 2017



Karen Kasmauski/NGC

Waste from decades of nuclear-weapons production is buried at the Hanford Site in Washington state.

There's a building boom at the Hanford Site, a once-secret complex on the windswept plains of southeastern Washington state. Construction crews are

working to finish a 27-metre-tall concrete structure there by June. If all goes well, the facility will finally enable the US Department of Energy (DOE) to begin treating the toxic, radioactive waste that accumulated at the site for more than 40 years, starting during the Second World War.

Decades after the site stopped producing plutonium for nuclear weapons, the legacy of Hanford's activities is still causing trouble. Just this year, a tunnel holding railway carriages full of radioactive material collapsed. Separately, at least a dozen employees who were tearing down a contaminated building reportedly tested positive for plutonium inhalation. But the site's biggest challenge lies underground, in 177 carbon-steel tanks. Together, these buried containers hold more than 200 million litres of highly hazardous liquids and peanut-buttery sludge — enough to fill 80 Olympic-size swimming pools. More than one-third of the tanks have leaked, contaminating groundwater with radioactive and chemical waste.

In a 1989 legal agreement with the state of Washington and the US Environmental Protection Agency, the DOE committed to immobilizing the most dangerous waste in sturdy glass logs through a process called vitrification. Several years later, the agency agreed to vitrify other tank waste as well. All told, the process is expected to generate tens of thousands of logs, each weighing multiple tonnes. Those containing high-level waste would be shipped to a permanent storage facility; the rest could be stored on site. But the effort has been plagued by cost overruns, delays and safety concerns. Although the DOE has spent roughly US$20 billion on the tank problem since 1997, no waste has been vitrified.

Four years ago, the agency hit reset. Rather than making a single vitrification plant, it split the project in two. One plant — the building now under construction — would begin vitrifying the less-hazardous, 'low-activity' liquid in the tanks. A bigger, more-complex plant to process the high-level sludge would follow once researchers resolved some thorny safety questions.

On both fronts, there have been signs of progress. This year, the DOE reported that it had resolved crucial questions related to treating the high-level waste. And a laboratory needed for real-time analysis of the low-level waste is nearing completion. If work continues as planned, the site could crank out its first glass logs as early as 2022.

Hanford's critics, accustomed to missed deadlines and management scandals, remain sceptical. But even officials with the state of Washington, which has battled the DOE in court for nearly three decades over clean-up goals and deadlines, are hopeful that efforts are now on track. “There's reason for optimism,” says Suzanne Dahl, who oversees tank activities for the Washington Department of Ecology.

Scientists have been studying vitrification since the 1950s, and a number of countries have used the process to stabilize nuclear waste, including France, India, Russia and the United Kingdom. The United States vitrifies waste at the DOE's Savannah River Site in South Carolina. But the size and complexity of the problem is on a different scale at Hanford.

Established as part of the Manhattan Project during the Second World War, the Hanford Site delivered the plutonium that went into the first nuclear-weapon test and the bomb that was dropped on Nagasaki, Japan, in 1945. It went on to produce the bulk of the plutonium for the US nuclear arsenal. “Hanford is the whole history of nuclear development,” says Ian Pegg, a physicist at the Catholic University of America in Washington DC, who works with the DOE on vitrification experiments.

Toxic brews

The ever-shifting suite of technologies used at the site produced uniquely toxic brews that include radioactive caesium, strontium, americium and residual plutonium; salts; heavy metals; and myriad industrial chemicals. The containers also hold other surprises. People “threw everything imaginable into those tanks”, says Albert Kruger, a glass scientist with the DOE in Richland, Washington. His list includes contaminated gloves, planks of wood, rocks and tape measures.

Once such detritus is removed, vitrification calls for the waste to be combined with ingredients that include silica and boron, then heated to nearly 1,150 °C. The molten mixture is next cooled in stainless-steel canisters to create large cylinders of borosilicate glass — the same material used in oven-safe glassware.

The process is complicated by that fact that each tank contains a cocktail of chemicals and radionuclides that cannot be fully characterized until the waste is extracted. Some of those substances can weaken glass. Others, such as iodine, can't be readily trapped and must be removed. Hanford scientists will have to tailor glass recipes for each batch of waste — a bit like blending different vintages to produce a fine cognac. “Nobody will test the nose, and nobody will take a taste test, but it's an equivalent mechanism,” Kruger says.

Multiple contractors have worked on the Hanford project since 1989, including British Nuclear Fuels Limited, a UK-government-owned company that exported the technology it was using at the Sellafield nuclear-decommissioning complex. After price estimates rose, in 2000 the DOE hired construction and engineering giant Bechtel of San Francisco, California, as the primary contractor.

At that time, the Hanford plant was expected to cost $4.3 billion and to begin making logs in 2007. But as engineers began working through the safety and technical details, the project ballooned in price and complexity. By 2012, senior officials — including a former DOE employee and two contractors who later filed whistle-blower complaints after being fired — were raising concerns. One was that hydrogen, which is generated when heat and radiation split water molecules, would build up in tanks and pipes, creating a risk of explosion. Another was that mixing vessels meant to keep heavy particles moving would not be powerful enough. Over time, enough residual plutonium could settle out to create a dangerous chain reaction.

Then-DOE secretary Steven Chu assembled an expert panel to investigate. Ultimately, Bechtel was ordered to first construct a plant that would vitrify only liquid waste. The liquid represents 90% of the waste volume but just 10% of its radioactivity, and requires less processing than the high-level waste: it can be skimmed off, stripped of highly radioactive caesium and then sent directly to vitrification. “It makes sense,” says David Kosson, a chemical engineer at Vanderbilt University in Nashville, Tennessee, who was on Chu's expert panel. If you have got to pick one place to start, he says, “the low-activity waste is not a bad choice”.

Lingering questions

The high-level-waste facilities remain on hold, but the DOE and its contractors have spent years investigating the technical issues using computer models and prototypes. In February, the agency announced it had resolved issues related to hydrogen build-up and uncontrolled reactions. Scientists familiar with the effort says tests of a newly designed mixing vessel are nearing completion, apparently without any major hitches. The vessel is equipped with six 'pulse jet mixers' that pull waste in and out like turkey basters, to keep solids from settling.

Researchers are also making progress on the glass recipes. Kruger and external scientists have shown that certain compositions can accommodate more waste than previously estimated, and so potentially save on costs. The number of glass logs produced in the high-level waste facility could drop from 18,000 to as few as 7,000, Kruger says. The low-level plant may need to make just 70,000 logs or so, instead of 145,000.

But questions remain. A 2015 DOE report documented more than 500 vulnerabilities that could affect low-level plant operations — including some in the electrical and mechanical systems that would be used to handle radioactive materials. Tom Carpenter, executive director of the watchdog group Hanford Challenge, hopes the plant will work as advertised. But he is concerned that the DOE, its contractors and even the state of Washington are too eager to bring the facility online. “Everyone is desperate to show progress,” he says. “I get that, but you can't paper over the safety issues.” Senior DOE officials at Hanford declined to be interviewed for this story; a Bechtel spokesperson said the company has addressed the vast majority of concerns raised in the report and has submitted its responses to the DOE for verification.

Not everyone is convinced that vitrification is the way to go. The DOE is bound by legal agreements and nuclear-waste regulations to pursue the process, but from a technical standpoint there are better options, says Jim Conca, a consultant and former director of an independent research centre that supports the Waste Isolation Pilot Plant (WIPP) outside Carlsbad, New Mexico, the nation's only operating deep geological repository.

Hanford's high-level wastes are currently slated for disposal at Yucca Mountain, a long-stalled geological repository in Nevada. Water infiltration

is a concern there, so the waste must be encased in glass to help ensure that it remains stable over thousands of years. But Conca says that the tank sludge is safe enough to simply be dried out and sent to WIPP — if regulations could be changed to allow it. Similarly, low-activity waste could be mixed with grout to create concrete-like material, which would be cheaper and, many believe, just as safe. “Does all of that waste technically need to be vitrified for environmental safety? Probably not,” says Kosson. But in the end, Kosson believes that the DOE will press forward with the plan.

Chu remains confident that vitrification can work, but says the DOE should be receptive to new science and shift course as needed. More generally, he says, the country has a long way to go in resolving questions about how — and where — it will dispose of all its nuclear waste. “This is a significant problem, and there has to be a lot of good science in figuring out a better path forward,” he says. “Always keep your mind open.”

The price tag on Hanford's vitrification facilities now stands at $16.8 billion. Assuming that the latest timetable holds, the plant for high-level waste will open for business in the early 2030s, and operations will continue for decades. In the meantime, dangerous waste will remain underground, out of sight but not out of mind.

Journal name:
Nature
Volume:
550,
Pages:
172–173
Date published:
(12 October 2017)
DOI:
doi:10.1038/550172a

Comments

Comments

There are currently no comments.

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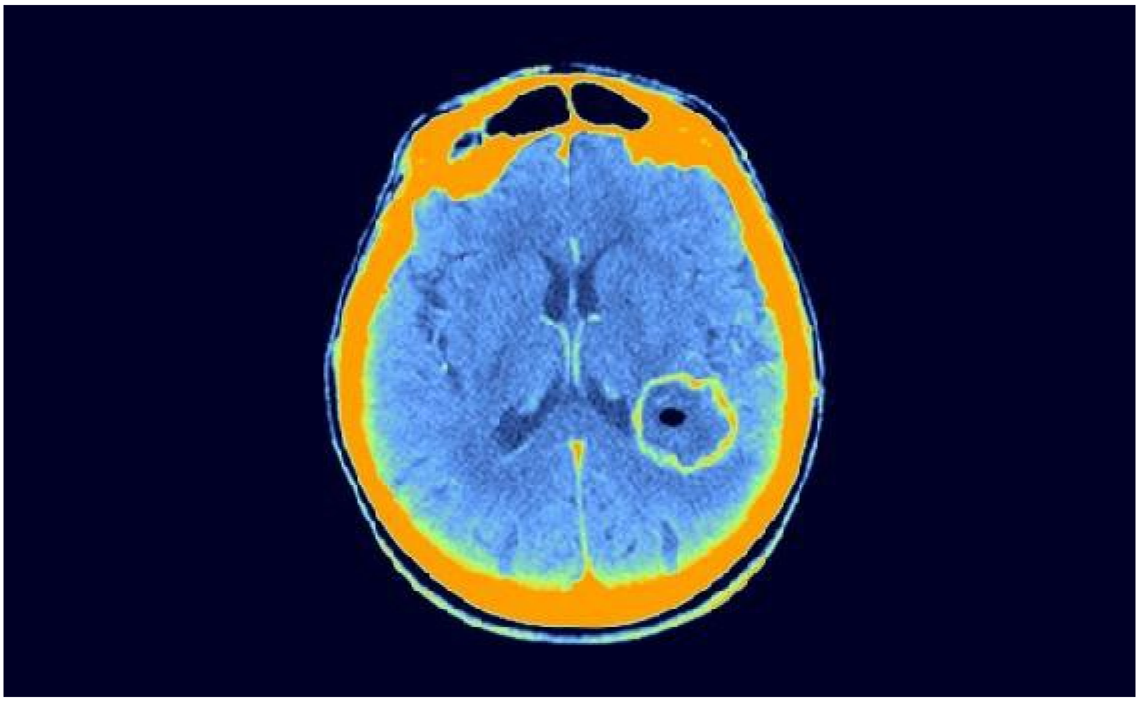
Cancer-genome study challenges mouse 'avatars'

Grafting human cancer cells into mice alters tumour evolution.

09 October 2017



Centre Jean Perrin/ISM/SPL

A brain tumour called glioblastoma, shown here as the circular region in a patient's brain scan, is among the cancers that have been tested in mouse avatars.

An analysis of more than 1,000 mouse models of cancer has challenged their ability to predict patients’ response to therapy.

The study, published today in *Nature Genetics*[1], catalogues the genetic

changes that occur in human tumours after they have been grafted into mouse hosts. Such models, called patient-derived xenografts (PDXs), are used in basic research and as ‘avatars’ for individual patients. Researchers use these avatar mice to test a bevy of chemotherapies against a person's tumour, in the hope of tailoring a treatment plan for the patient's specific cancer.

But fresh data from geneticists at the Broad Institute of MIT and Harvard in Cambridge, Massachusetts, suggest that transplanting human cancer cells into a mouse alters the cells' evolution, reshaping the tumour's genome in ways that could affect responses to chemotherapy.

“The assumption is that what grows out in the PDX is reflective of the bulk of the tumour in the patient,” says cancer geneticist Todd Golub, a lead author on the study. “But there’s quite dramatic resculpting of the tumour genome.”

No animal model is perfect, and researchers have long acknowledged that PDXs have their limitations. To avoid an immune assault on the foreign tumour, for example, PDXs are typically grafted into mice that lack a functioning immune system. This compromises scientists' ability to study how immune cells interact with the tumour — an area of increasing interest given the success of cancer therapies that unleash the immune system.

PDXs can also take months to generate, making them too slow to serve as avatars for those patients who need to make immediate decisions about their therapy.

Reasonable reproductions

But previous research had suggested that the PDXs were reasonably faithful reproductions of the human tumours they are meant to model, offering researchers a chance to explore the tumour’s interaction with its environment in ways that are not possible using cells grown in a Petri dish. The US National Cancer Institute has developed a library of more than 100 PDXs for distribution to researchers, and European scientists have launched EurOPDX, a consortium that boasts more than 1,500 models for more than 30 tumour

types. One company, Champions Oncology of Hackensack, New Jersey, creates and tests mouse avatars for individual patients and for pharmaceutical companies to use in research.

For the latest study, Golub and Broad Institute cancer geneticist Rameen Beroukhim, together with their colleagues, decided to examine how PDXs changed over time. The researchers studied data from tumour cells that were implanted into a mouse, allowed to grow into a tumour, and then harvested and re-implanted into a fresh mouse — sometimes for multiple cycles.

The researchers looked for alterations in the number of copies of a given gene in the cell. They did so for more than 1,000 PDX samples representing 24 cancer types, often extrapolating gene copy number from data on gene expression.

The analysis suggests that tumours implanted in mice change in ways that are not commonly seen in the human body. For example, human brain tumours called glioblastomas tend to gain extra copies of chromosome 7. But the mouse PDXs tend to lose those extra copies over time, says Beroukhim.

Some of these genetic changes were also associated with differences in how the PDXs responded to cancer drugs. For researchers studying many PDXs and looking for relationships between genetics and drug sensitivity, the finding does not spell disaster, says Golub. “That’s not to say that PDXs should be abandoned as a model — far from it,” he says. “But they’re not a panacea.”

Golub is more worried about using PDXs to predict outcomes in individual patients. “It raises some important questions around how to interpret the results of avatars,” he says.

But Champions Oncology founder David Sidransky, an oncologist at Johns Hopkins University School of Medicine in Baltimore, Maryland, points to his team's study of 92 patients, published in August. That showed an 87% association between the drug responses in a patient and their corresponding PDX[2].

The genetic analysis by Golub and his team could offer clues as to what goes

wrong in the other 15% of PDXs, Sidransky says.

The work is important, says David Tuveson, a cancer researcher at Cold Spring Harbor Laboratory in New York. But Tuveson also notes that PDX approaches are changing. Researchers are increasingly likely to graft a human tumour into the analogous location in the mouse avatar — for instance, by transplanting human pancreatic cancer cells into a mouse pancreas — rather than merely grafting them under the skin. This, he says, is thought to be an environment that is more similar to that of the original tumour.

Researchers are also turning to mice that have been ‘humanized’ in various ways, perhaps by introducing aspects of a human immune system or human versions of proteins that interact with the tumour.

As for those PDXs that have already been generated, researchers will continue to embrace them, says Carlos Caldas, a researcher at the Cancer Research UK Cambridge Institute at the University of Cambridge, UK.

Caldas notes that his own studies with breast cancer PDXs have not found such dramatic differences between PDXs and the tumours from which they were made. “We’re going to continue to see a lot of activity with these models — they are a great development, not a hindrance,” he says. “They are here to stay.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22782

Comments

Comments

There are currently no comments.

LIGO's unsung heroes

Nature highlights just a few of the people who played a crucial part in the discovery of gravitational waves — but didn't win the Nobel Prize.

09 October 2017

Joe McNally/Getty

LIGO hunts gravitational waves with the help of two laser interferometers — and hundreds of people.

Every October, the announcements of the Nobel Prizes bring with them some controversy. This year's physics prize — in recognition of the Laser Interferometer Gravitational-Wave Observatory (LIGO) in the United States — was less debated than most. The three winners — Kip Thorne and Barry Barish, both at the California Institute of Technology (Caltech) in Pasadena,

and Rainer Weiss at the Massachusetts Institute of Technology (MIT) in Cambridge — had attracted near-universal praise for their roles in the project’s success.

But the award has still put into stark relief the difficulty of singling out just a few individuals from the large collaborations of today’s 'Big Science'. The LIGO collaboration uses two giant laser interferometers to listen for deformations in space-time caused by some of the Universe’s most cataclysmic events. Physicists detected their first gravitational waves — interpreted as being produced by the collision of two black holes more than a billion years ago — in September 2015. The resulting paper, published in February 2016[1], has a mind-boggling 1,004 authors.

Some of those are members of the LIGO Laboratory, the Caltech–MIT consortium that manages LIGO’s two interferometers in Louisiana and Washington State. But the list also includes the larger LIGO Scientific Collaboration: researchers from 18 countries, some of which — such as Germany and the United Kingdom — have made crucial contributions to the detectors.

Yet more authors are from LIGO’s sister Virgo Collaboration, led by France and Italy, which built the Virgo interferometer near Pisa, Italy. The two experiments pool their data and analyse them together. Countless other people not named on the paper have also been involved in LIGO’s design, development, construction and operation since Weiss first detailed how to build a laser interferometer in 1972.

To honour the many unsung heroes of gravitational waves, *Nature* collected testimonials about just a few of them. Like the Nobel Prize, this list is inevitably very incomplete.

1. The pioneer: Joseph Weber

Researchers using two detectors in the United States shook the world when they announced their discovery of gravitational waves. The year was 1969, and the detectors were not LIGO but tonne-sized cylinders of aluminium built

by Joseph Weber, a physicist at the University of Maryland in College Park. His claim was later found to be invalid, but many physicists still credit Weber for having founded the field. “Joe Weber indeed started thinking about how to detect gravitational waves in about 1957,” Virginia Trimble, an astrophysicist and Weber’s widow, told *Nature* in an e-mail. At that time, many researchers were not even sure that gravitational waves existed. In the 1960s, Weber was also one of the first researchers to consider the possibility of using interferometers to detect them.

2. The German connection: Heinz Billing

The founder of Germany’s side of LIGO, Heinz Billing, a physicist at the Max Planck Institute for Astrophysics near Munich, first heard of Weiss’s pioneering interferometer designs in 1975, when he was asked to review Weiss’s request to the National Science Foundation to fund a prototype at MIT. Billing and his team liked it so much that they started building one themselves. “The Munich group quickly invented some of the most important ingredients that made the detectors possible,” says Karsten Danzmann, a director at the Max Planck Institute for Gravitational Physics in Hanover, Germany. Billing, in particular, came up with an idea to stabilize the laser that was later used in the UK–German GEO600 interferometer based near Hanover — and in LIGO itself. GEO600 is still a crucial testing and development centre for technologies introduced in the successive rounds of LIGO upgrades. “There is an awful lot of GEO in LIGO,” says Danzmann. Billing, who died on 4 January at the age of 102, was also a pioneer in magnetic data storage.

3. The laser expert: Alain Brillet

The 1980s were years of intense research and development for gravitational-wave detectors. Alain Brillet, an optical physicist with extensive experience in interferometers, then at the University of Paris-Sud in Orsay, France, saw an opportunity to contribute. “I decided to start with the optical part, the lasers and optics, because that was my specialty,” he says. Brillet went on to co-found Virgo. But many of his ideas — in particular, the type of laser that

would give the most stable signal — were implemented in LIGO and other interferometers as well, says MIT physicist David Shoemaker, who studied with Brillet in Orsay and is now LIGO's spokesperson.

4. The facilitator: Richard Isaacson

Gravitational theorist Richard Isaacson went to Washington DC to work at the National Science Foundation (NSF) in 1973 for what he thought would be a brief stint as one of the programme directors. During the handover, his predecessor advised him to pay attention to an "interesting guy" called Rainer Weiss. Isaacson secured Weiss a small grant for his 1975 prototype, and later became LIGO's chief advocate inside government. He was instrumental in the project's winning hundreds of millions of dollars in funding, despite the uncertain prospect of success. It was the first time that the NSF had managed a large project: US facilities such as particle accelerators were traditionally the remit of the Department of Energy, which had field offices staffed with dozens of experts. Isaacson did it by himself for more than ten years, and by the early 1990s he had paid a high personal cost. "Eventually, my health broke and my marriage went bad," says Isaacson. By the time he retired in 2001, the construction of LIGO had been completed.

5. The first director: Rochus 'Robbie' Vogt

Before Barry Barish took the reins of LIGO, another director had left his mark on the collaboration: Rochus Vogt. The Caltech physicist, a veteran of the NASA Voyager mission, was put in charge in 1987. Until then, the project had been led by the 'troika' of visionary founders — Thorne, Weiss, and the physicist Ronald Drever, who started UK research on gravitational waves at the University of Glasgow before moving to Caltech — but managing large organizations was not their strength. "Thank God that was done," Weiss recalled in a talk at NSF headquarters last year. "You don't manage it with three guys who are sort of a little bit flaky." Vogt, who was once described as a taller and leaner Henry Kissinger, had a booming voice and forceful style that did not please everyone. But he was able to put together the first major request for NSF funding and, Thorne recalled in a 5

October press conference, “laid the foundations for moving LIGO forward to our construction”.

6. The theorist: Alessandra Buonanno

As Thorne realized early on, in the future field of gravitational-wave astronomy, it would not be enough to collect data; researchers would also need to know what signals to look for. But it is notoriously difficult to extract quantitative predictions from the equations of Einstein’s general relativity. Theoretical physicist Alessandra Buonanno had devised formulae for calculating the approximate orbits of spiralling objects and the gravitational waves they would generate in work she had done, in part with her PhD adviser Thibault Damour, at the Institute of Advanced Scientific Studies near Paris. The LIGO and Virgo collaborations use a database of hundreds of thousands of these waveforms for spotting gravitational waves in their data in real time. Buonanno is now a director at the Max Planck Institute for Gravitational Physics in Potsdam and a senior member of the LIGO Scientific Collaboration.

Journal name:
    Nature
DOI:
    doi:10.1038/nature.2017.22786

Comments

4 comments

1. *Pentcho Valev* • 2017-10-11 07:14 AM
    The "discovery" of gravitational waves is just one of those "major breakthroughs" imposed by science bureaucrats like Ms. Davis: "LEONARD: I have to say I'm a little nervous. Ms. DAVIS: You should be. LEONARD: Look, I know I screwed up, but it was only one interview. How much damage could it have caused? Ms. DAVIS: Would you like for me to read you the e-mails from

donors asking why are they giving us money if physics is a dead end? LEONARD: I didn't say it was a dead end. I just said that I was worried it might be. Ms. DAVIS: So if I just said I was worried you might not have a job next week, how would you feel? LEONARD: Light-headed, and glad you asked me to sit down. Okay, just tell me what I can do. Ms. DAVIS: I'm gonna need you to make a statement saying that you misspoke, and that you're confident the physics community is close to a major breakthrough. LEONARD: You want me to lie. Ms. DAVIS: Look, Dr. Hofstadter, I'm counting on you. I think that you are the smartest physicist at this university. LEONARD: Really? Ms. DAVIS: See? Lies. They're not that hard." [END OF QUOTATION] https://www.youtube.com/watch?v=GDNP9KOEdh0 Physicist Leonard Hofstadter tries to repent but in the end comes to the following conclusion: LEONARD: "I know I said physics is dead, but it is the opposite of dead. If anything, it is undead, like a zombie." "Physics is dead" is a commonplace knowledge - scientists express it in various ways: Peter Woit: "If, as seems increasingly all too possible, we're now at an endpoint of fundamental physics, with the field killed off by a pseudo-scientific argument..." http://www.math.columbia.edu/~woit/wordpress/?p=9444 Peter Woit: "I think the worst thing that has happened to theoretical physics over the past 25 years is this descent into ideology, something that has accelerated with the multiverse mania of the last 10-15 years." http://www.math.columbia.edu/~woit/wordpress/?p=9375 Correct, except for the number 25 - it should be replaced by 112: "This paper investigates an alternative possibility: that the critics were right and that the success of Einstein's theory in overcoming them was due to its strengths as an ideology rather than as a science. The clock paradox illustrates how relativity theory does indeed contain inconsistencies that make it scientifically problematic. These same inconsistencies, however, make the theory ideologically powerful. [...] The gatekeepers of professional physics in the universities and research institutes are disinclined to support or employ anyone who raises problems over the elementary inconsistencies of relativity. A winnowing out process has made it very difficult for critics of

Einstein to achieve or maintain professional status. Relativists are then able to use the argument of authority to discredit these critics. Were relativists to admit that Einstein may have made a series of elementary logical errors, they would be faced with the embarrassing question of why this had not been noticed earlier. Under these circumstances the marginalisation of antirelativists, unjustified on scientific grounds, is eminently justifiable on grounds of realpolitik. Supporters of relativity theory have protected both the theory and their own reputations by shutting their opponents out of professional discourse. [...] The triumph of relativity theory represents the triumph of ideology not only in the profession of physics bur also in the philosophy of science." Peter Hayes, The Ideology of Relativity: The Case of the Clock Paradox http://www.informaworld.com/smpp/content~content=a909857880 And when ideology replaces science, bureaucrats replace scientists of course: Mike Alder: "It is easy to see the consequences of the takeover by the bureaucrats. Bureaucrats favour uniformity, it simplifies their lives. They want rules to follow. They prefer the dead to the living. They have taken over religions, the universities and now they are taking over Science. And they are killing it in the process. The forms and rituals remain, but the spirit is dead. The cold frozen corpse is so much more appealing to the bureaucratic mind-set than the living spirit of the quest for insight. Bureaucracies put a premium on the old being in charge, which puts a stop to innovation. Something perhaps will remain, but it will no longer attract the best minds. This, essentially, is the Smolin position. He gives details and examples of the death of Physics, although he, being American, is optimistic that it can be reversed. I am not. [...] Developing ideas and applying them is done by a certain kind of temperament in a certain kind of setting, one where there is a good deal of personal freedom and a willingness to take risks. No doubt we still have the people. But the setting is gone and will not come back. Science is a product of the renaissance and an entrepreneurial spirit. It will not survive the triumph of bureacracy. Despite having the infrastructure, China never developed Science. And soon the West won't have it either." https://www.highbeam.com/doc/1G1-172684821.html Pentcho

Valev

2. *Pentcho Valev* • 2017-10-10 01:08 AM
   Gravitational waves (ripples in spacetime) don't exist because spacetime doesn't exist: Nima Arkani-Hamed (06:09): "Almost all of us believe that space-time doesn't really exist, space-time is doomed and has to be replaced by some more primitive building blocks." https://www.youtube.com/watch?v=U47kyV4TMnE Nobel Laureate David Gross observed, "Everyone in string theory is convinced...that spacetime is doomed. But we don't know what it's replaced by." https://www.edge.org/response-detail/26563 What scientific idea is ready for retirement? Steve Giddings: "Spacetime. Physics has always been regarded as playing out on an underlying stage of space and time. Special relativity joined these into spacetime... [...] The apparent need to retire classical spacetime as a fundamental concept is profound..." https://www.edge.org/response-detail/25477 And spacetime doesn't exist because the underlying premise, Einstein's constant-speed-of-light postulate, is false: "Special relativity is based on the observation that the speed of light is always the same, independently of who measures it, or how fast the source of the light is moving with respect to the observer. Einstein demonstrated that as an immediate consequence, space and time can no longer be independent, but should rather be considered a new joint entity called "spacetime." http://community.bowdoin.edu/news/2015/04/professor-baumgarte-describes-100-years-of-gravity/ Is the speed of light "always the same, independently of who measures it"? Of course not - even Einstein knew that this is nonsense: John Stachel: "But this seems to be nonsense. How can it happen that the speed of light relative to an observer cannot be increased or decreased if that observer moves towards or away from a light beam? Einstein states that he wrestled with this problem over a lengthy period of time, to the point of despair." http://www.aip.org/history/exhibits/einstein/essay-einstein-relativity.htm In the quotation below, the statement "four pulses are received in the time it takes the source to emit three pulses" means that the speed of light is VARIABLE - the speed of the pulses

relative to the receiver (observer) is greater than their speed relative to the source, in violation of Einstein's relativity: http://www.einstein-online.info/spotlights/doppler Albert Einstein Institute: "The frequency of a wave-like signal - such as sound or light - depends on the movement of the sender and of the receiver. This is known as the Doppler effect. [...] Here is an animation of the receiver moving towards the source: Stationary receiver: http://www.einstein-online.info/images/spotlights/doppler/doppler_static.gif Moving receiver: http://www.einstein-online.info/images/spotlights/doppler/doppler_detector_blue.gif By observing the two indicator lights, you can see for yourself that, once more, there is a blue-shift - the pulse frequency measured at the receiver is somewhat higher than the frequency with which the pulses are sent out. This time, the distances between subsequent pulses are not affected, but still there is a frequency shift: As the receiver moves towards each pulse, the time until pulse and receiver meet up is shortened. In this particular animation, which has the receiver moving towards the source at one third the speed of the pulses themselves, four pulses are received in the time it takes the source to emit three pulses." [END OF QUOTATION] Pentcho Valev

3. *Pentcho Valev* • 2017-10-09 02:33 PM

   "As Thorne realized early on, in the future field of gravitational-wave astronomy, it would not be enough to collect data; researchers would also need to know what signals to look for. But it is notoriously difficult to extract quantitative predictions from the equations of Einstein's general relativity. Theoretical physicist Alessandra Buonanno had devised formulae for calculating the approximate orbits of spiralling objects and the gravitational waves they would generate in work she had done, in part with her PhD adviser Thibault Damour, at the Institute of Advanced Scientific Studies near Paris. The LIGO and Virgo collaborations use a database of hundreds of thousands of these waveforms for spotting gravitational waves in their data in real time." Not true. Actually LIGO conspirators don't use theoretically calculated waveforms in detecting (more precisely, faking) gravitational wave signals: The

Nobel Committee for Physics: "While these waveforms provide a reasonable match, further important improvements are obtained using numerical methods that are very computationally intensive [23]. The analytical methods are crucial to producing the big library of template waveforms used by LIGO. While the waveforms produced in this way are necessary for determining the detailed properties of the objects involved, as well as identifying weak signals, they were not essential for the very first detection of GW150914. This was a model-independent detection of a gravitational-wave transient." https://www.nobelprize.org/nobel_prizes/physics/laureates/2017/adv physicsprize2017.pdf According to Rana Adhikari, professor of Physics at Caltech and a member of the LIGO team, LIGO conspirators have no preliminary knowledge about the signals. Adhikari declares: "the only thing that we really know is what we measure. And that's the mantra of the true empirical person": Rana Adhikari: "You split it in two and you send it in two separate directions, and then when the waves come back, they interfere with each other. And you look at differences in that interference to tell you the difference in how long it took for one beam to go one way, and the other beam to go the other way. The way I said it was really careful there because there's a lot of confusion about the idea of, these are waves and space is bending, and everything is shrinking, and how come the light's not shrinking, and so on. We don't really know. There's no real difference between the ideas of space and time warping. It could be space warping or time warping but the only thing that we really know is what we measure. And that's the mantra of the true empirical person. We sent out the light and the light comes back and interferes, and the pattern changes. And that tells us something about effectively the delay that the light's on. And it could be that the space-time curved so that the light took longer to get there. But you could also imagine that there was a change in the time in one path as opposed to the other instead of the space but it's a mixture of space and time. So it sort of depends on your viewpoint." https://blog.ycombinator.com/the-technical-challenges-of-measuring-gravitational-waves-rana-adhikari-of-ligo/ Pentcho Valev

4. *Pentcho Valev* • 2017-10-09 04:23 PM

Another sword of Damocles hanging over LIGO conspirators (and over the Nobel committee as well). They had no idea what they were measuring (faking) and produced signal correlation but also noise correlation that they are unable to explain: James Creswell, Sebastian von Hausegger, Andrew D. Jackson, Hao Liu, Pavel Naselsky, June 27, 2017: "As a member of the LIGO collaboration, Ian Harry states that he "tried to reproduce the results quoted in 'On the time lags of the LIGO signals'", but that he "[could] not reproduce the correlations claimed in section 3". Subsequent discussions with Ian Harry have revealed that this failure was due to several errors in his code. After necessary corrections were made, his script reproduces our results. His published version was subsequently updated. [...] It would appear that the 7 ms time delay associated with the GW150914 signal is also an intrinsic property of the noise. The purpose in having two independent detectors is precisely to ensure that, after sufficient cleaning, the only genuine correlations between them will be due to gravitational wave effects. The results presented here suggest this level of cleaning has not yet been obtained and that the identification of the GW events needs to be re-evaluated with a more careful consideration of noise properties." http://www.nbi.ku.dk/gravitational-waves/gravitational-waves.html James Creswell, Sebastian von Hausegger, Andrew D. Jackson, Hao Liu, Pavel Naselsky, August 21, 2017: "In view of unsubstantiated claims of errors in our calculations, we appreciated the opportunity to go through our respective codes together - line by line when necessary - until agreement was reached. This check did not lead to revisions in the results of calculations reported in versions 1 and 2 of arXiv:1706.04191 or in the version of our paper published in JCAP. It did result in changes to the codes used by our visitors [LIGO conspirators]. [...] In light of the above, our view should be clear: We believe that LIGO has not yet attained acceptable standards of data cleaning. Since we regard proof of suitable cleaning as a mandatory prerequisite for any meaningful comparison with specific astrophysical models of GW events, we continue to regard LIGO's claims of GW discovery as interesting but premature." http://www.nbi.ku.dk/gravitational-waves/gravitational-waves-comment2.html Here is Sabine Hossenfelder's article: Sabine Hossenfelder: "Was It All Just Noise? Independent Analysis Casts Doubt On LIGO's Detections. A team of five researchers - James Creswell, Sebastian von Hausegger, Andrew D. Jackson, Hao Liu, and Pavel Naselsky - from the Niels Bohr Institute in Copenhagen, presented their own analysis of the openly available LIGO data. And, unlike the LIGO collaboration itself, they come to a disturbing conclusion: that these gravitational waves might not be signals at all, but rather patterns in the noise that have hoodwinked even the best scientists working on this puzzle. [...] A few weeks ago, Andrew Jackson presented his results in Munich. A member of the local physics faculty (who'd rather not be named) finds the results "quite disturbing" and hopes that the collaboration will take the criticism of the Danes to heart. "Until LIGO will provide clear scientific(!) explanation why these findings are wrong, I would say the result of the paper to some extent invalidates the reliability of the LIGO discovery." https://www.forbes.com/sites/startswithabang/2017/06/16/was-it-all-just-noise-independent-analysis-casts-doubt-on-ligos-detections/ In a world different from our post-truth world the disclosure of the noise correlation would mark the end of the LIGO project and the beginning of an interrogation. In the post-truth world the glory of the fraudsters can only increase - if the absurd noise correlation cannot topple them, nothing can! Immediate Nobel prize - should have been given to LIGO fraudsters a year ago! Pentcho Valev

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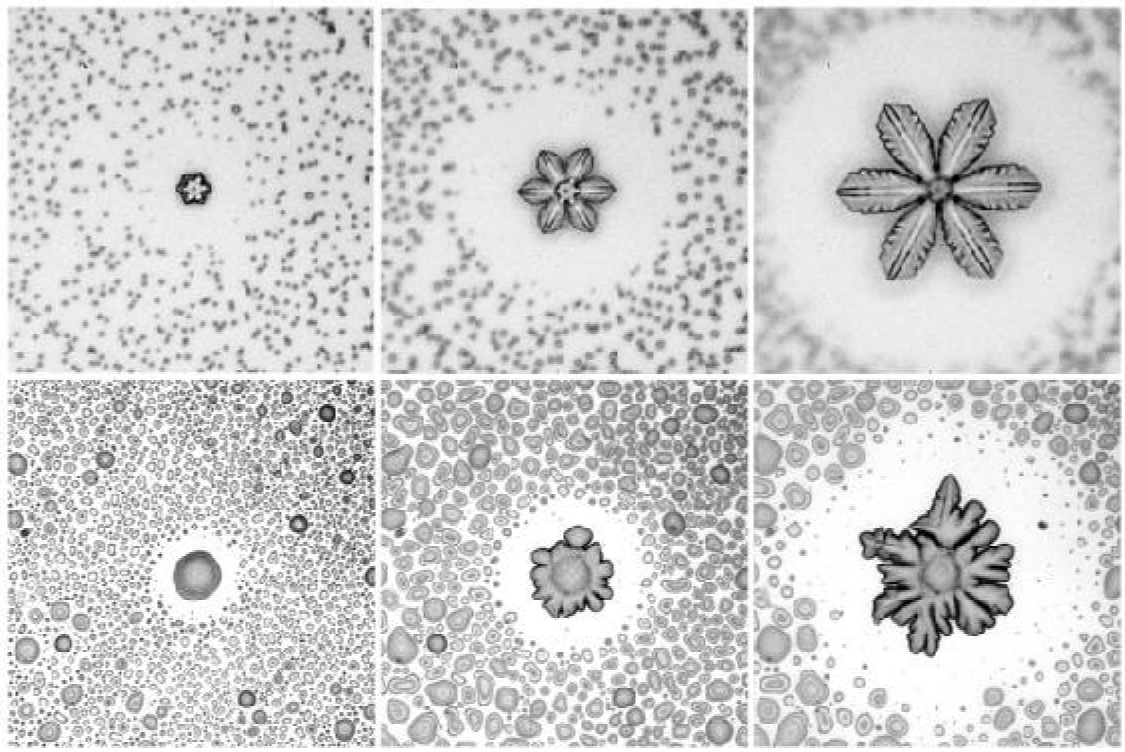
Water-repellent coatings could make de-icing a breeze

Coatings that force ice to grow upwards from the surface could make it easier to remove.

09 October 2017



Wang et al., DOI 10.1073/pnas.1712829114

Ice growth on hydrophillic (top layer) and hydrophobic surfaces

When water droplets suspended in the air freeze, they generate snowflakes — ice crystals with six-fold symmetry. But when ice grows along a solid surface, like frost growing on windows, it can take on an almost infinite range of different shapes.

These crystalline patterns are affected by whether a surface repels or absorbs water, says a team led by chemists Jie Liu of the Chinese Academy of Sciences Institute of Chemistry in Beijing and Chongqin Zhu of the University of Nebraska–Lincoln. The researchers showed that when a surface tends to repel water, ice crystals can be cultivated to grow away from the surface at an angle, resembling a clover with six leaves.

The work was published on 9 October in the *Proceedings of the National Academies of Science*[1].

Clover crystals

Using a high-speed camera attached to a microscope, the team captured imagery of ice forming on aluminium that had been covered with a hydrophobic, or water-repellent, coating. Water drops sprayed on the surface remained taut and spherical instead of spreading out.

The researchers triggered ice formation across the entire surface by spraying it with silver iodide nanoparticles, which acted as seeds for ice growth. As the ice developed, the crystals grew outwards and up from the nanoparticle, forming a symmetrical, six-leafed clover with only a single point of contact with the surface.

On hydrophilic, or absorbant, surfaces, water spread out quickly, and so did ice — forming a sunflower-shaped crystal in full contact with the surface.

And, when the team prepared a hybrid surface with both hydrophilic and hydrophobic parts, ice spreading on the hydrophilic side came to a halt at the boundary with the hydrophobic side.

The researchers also observed that the clover-like ice crystals growing away from a hydrophobic surface could be removed by wind more easily than crystals on a hydrophilic surface.

They suggest that this could be exploited to make surfaces such as car windscreens more resistant to icing by embedding nanoparticles inside them. “The key is to have these stable ice-nucleation sites,” says Jianjun Wang, a materials scientist at the Chinese Academy of Sciences Institute of Chemistry and a co-author of the paper.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22790

Comments

Commenting is currently unavailable.

Build on the outer space treaty

09 October 2017

Fifty years on, the agreement is being pushed to its limits by changing geopolitics, technology and commercial interests, warns Joan Johnson-Freese.

Reuters

The Long March-5 Y2 rocket takes off from Wenchang Satellite Launch Center in Wenchang, Hainan Province, China in July 2017.

On 10 October 1967, the Outer Space Treaty went into force. Agreed on during a golden age of cooperation between the then-dominant superpowers, the Soviet Union and the United States, the treaty deems space a domain to

be shared by all nations. It states: “The exploration and use of outer space, including the moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind.”

The treaty gave rise to a series of others that govern space today: the Rescue Agreement (1968), the Liability Convention (1972), the Registration Convention (1976) and the Moon Agreement (1984). Although the United States and Soviet Union declined to sign the Moon Agreement, to avoid having to share lunar resources and technologies, most issues were seemingly covered — liability for damage caused by space objects, the safety and rescue of spacecraft and astronauts, and the rules governing the exploitation of space resources and settling disputes.

A lot has changed since. Launch costs have plummeted — from US$20,000 to send one kilogram into orbit in the late twentieth and early twenty-first centuries to as little as $5,000 now. And more nations, people, businesses and organizations are seeking to establish themselves in space. 'NewSpace' entities — non-governmental actors, often with commercial interests and financed through personal wealth — are diversifying the space landscape, with motivations ranging from human settlement to economic development. SpaceX founder Elon Musk, for example, has said that becoming an interplanetary species is the only way for humanity to avoid an eventual extinction event on Earth, and that he wants to “die on Mars, just not on impact”. Planetary Resources, a US-based asteroid-mining company, states that its vision is to extend the economy into space.

Meanwhile, conventional interests of prestige, geostrategic influence and military missions in space have come to the fore. Access to space is considered a “vital national interest” by the United States[1], an area of revitalized national interest by Russia, and an aspiration of China, India[2] and a growing number of other countries. India and China's 'space race', crucial to each country's national prestige, is arguably fiercer than even the twentieth-century US–Soviet race.

In terms of military competition, the United States sees China's encroachment

on space as heightening the risk of a space war[3]. China's launch of a 'science mission' in May 2013 that nearly reached geosynchronous orbit (about 36,000 kilometres above Earth) caused quiet panic in the Pentagon and in US intelligence circles. The United States had considered that orbit a sanctuary, out of reach of foes, for some of its most strategically important spy satellites, such as those in the Keyhole series.

LISTEN

Earlier this year, the Nature Podcast marked half a century since the Outer Space Treaty was opened. Here, reporter Adam Levy looks at its relevance to our relationship with space today.

You may need a more recent browser or to install the latest version of the Adobe Flash Plugin.

Fifty years on, the Outer Space Treaty and its spin-offs are still appropriate. But interpretations of its provisions are, more than ever, being influenced by commercial interests and politics. Supplementary rules and norms are needed. In an era in which international cooperation on treaties is tenuous, informal agreements and resolutions must guide space-faring actors, protect the environment and prevent wars.

Competing interests

The United States is the largest player in terms of space spending, capabilities and assets in orbit. The government alone spends about $40 billion each year on space activities through the Department of Defense and NASA, with China and Russia next, at about $6 billion each. Japan, France, Germany, Italy, India, Canada and the United Kingdom together spend around $11 billion. As of 1 January, there were 1,459 satellites in orbit, of which 593 belong to the United States, 135 to Russia and 192 to China.

US strategic thinking will largely shape the direction of future global space policies. And the 2011 US National Security Space Strategy described the

official US view of space as “congested, contested, and competitive”. Active satellites and debris from old missions clutter the skies. More than 500,000 pieces of debris, ranging in size from a baseball to a school bus, are being tracked in Earth orbit. Millions of smaller but nonetheless dangerous pieces are not.

The number of countries, consortia and companies involved in space is growing. In 1959, when the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) was formed, there were 24 members. Today, there are 84. Although few countries can afford to develop their own launch capabilities, none wishes to be left out of the expanding information age facilitated by space technology. Data that were once available only to or through governments, such as remotely sensed data, are now available through private companies. Commercial communications satellites increasingly carry military traffic. In 2013, US troops operating in Africa began using a Chinese Apstar-7 satellite to carry data.

Almost 50 commercial and non-profit organizations are listed in the informal directory of the Space Frontier Foundation in Arlington, Virgina, which is committed to facilitating the human settlement of space. These companies are exploring ideas from satellite refuelling to mining asteroids for water and providing extraterrestrial human habitats, among other projects.

The main driver of change in US thinking about space security is the number of countries that are developing capabilities with potential military uses. Since the 1990–91 Gulf War, when the use of the Global Positioning System (GPS) allowed coalition troops and equipment to be moved across the desert without being detected, the US military has reaped the advantages of its advanced space-based technologies. Satellites are used for command, control, communications, reconnaissance and intelligence.

AL SEIB/Los Angeles Times/Getty

Sir Richard Branson presents Virgin Galactic SpaceShipTwo, part of the company's space-travel efforts.

Many countries desire similar capabilities and are developing a wide range of 'dual-use' space technologies, which are of value to both the civil and military sectors. China and Russia have their own versions of GPS. Missile-defence systems being built by the United States, China, Russia and India use targeting systems similar to those required for an anti-satellite weapon. Yet, so far, no country has crossed the Rubicon of explicitly and officially developing a space weapon.

Space security

Two debates have broken out among space-security analysts. First, are more rules needed for managing the space environment sustainably for all? Second, is space warfare inevitable or how should one deter it?

Space-resource ownership and traffic need to be managed. In 2015, the US Congress enacted legislation to protect the interests and investments of US companies, such as Planetary Resources, that seek to harvest the potentially vast mineral and water resources of the asteroid belt as early as the 2020s. The Spurring Private Aerospace Competitiveness and Entrepreneurship Act of 2015, or SPACE Act, entitles US citizens to “possess, own, transport, use and sell” extracted materials, subject to the obligations of the United States under the various treaties it has previously signed[4].

Some argue that this act violates Article II of the Outer Space Treaty. It states: “Outer space, including the moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means.” Even without making territorial claims, appropriation of resources could restrict access to resources for others and potentially encourage environmentally risky exploitation of the Moon, planets and asteroids.

Space-traffic management is the equivalent of air-traffic control. It is in no one's interest to have thousands of planes flying around unchecked, and so is the case with satellites. You need to know where they are and where they will be. Traffic-management systems must be able to notify parties of potential collisions and events, such as when a satellite 'goes rogue' and is beyond control, or suddenly comes back to life, as the LES-1 satellite did in 2016 after 46 years of silence.

Public organizations such as the US military's Joint Space Operations Center (JSpOC) and private bodies such as the Space Data Association are making progress on these issues, including coordination between the public and private sectors. The addition of a Commercial Integration Cell, where commercial operators are able to interact with their military counterparts, at JSpOC in 2015 was seen as a landmark in commercial–military cooperation. Nevertheless, some satellite owners, especially intelligence agencies, are reluctant to share too much information. That spurs the question of whether traffic rules for operation are needed, or even acceptable. Rules restrict actions, which neither companies nor governments welcome.

The United States has largely shunned multilateral rules for coordinating and limiting space operations beyond the provisions already in place through the

Outer Space Treaty. Three key arms-control provisions of the Outer Space Treaty reside in Article IV. First, parties should not place in orbit around Earth any objects carrying nuclear weapons or other weapons of mass destruction, install such weapons on celestial bodies or station them in outer space. Second, the Moon and other celestial bodies must be used exclusively for peaceful purposes. And third, it is forbidden to establish military bases, installations or fortifications, or to test any type of weapon or conduct military manoeuvres on celestial bodies.

However, military personnel's involvement in scientific research or other peaceful endeavours is not prohibited. Many early astronauts and cosmonauts were members of the military. Similarly permitted is the use of military equipment or facilities for peaceful purposes. But the dual-use nature of many space technologies means that civilian efforts often concurrently improve military capabilities. For example, developing tracking stations for human spaceflight missions also improves missile-tracking ability. The many definitions of peaceful — ranging from non-military to non-offensive — have allowed space to slip through the cracks of arms-control efforts since 1984.

Although weapons of mass destruction are banned in space, weapons in general are not. Releasing energy or kinetic force in space, through lasers and electromagnetic pulses, flak or collisions, can pollute the orbital environment for decades. From the 1962 US Starfish Prime test of nuclear weapons in space to the more recent anti-satellite weapons test carried out by China in 2007, the debris created can take decades to clear. The 2007 Chinese test generated some 3,000 pieces of space debris through some of the most populated low-Earth-orbit positions. As more satellites switch off and remnants break up, space becomes more difficult, expensive and dangerous to use. The International Space Station, for example, has had to manoeuvre several times to avoid colliding with space junk.

Since the contentious May 2013 Chinese launch, the United States has shifted its position on space warfare. Previously, its stance was strategic restraint, refraining from introducing offensive space capabilities in the hope of moderating the behaviour of friends and potential foes; since 2013 it has been preparing for war in space, whatever that might look like. US officials are

now actively exploring offensive and defensive space-based activities, with the only caveat being to avoid creating debris.

In 2008 and again in 2014, China and Russia submitted a joint proposal to the United Nations for a Treaty on Prevention of the Placement of Weapons in Outer Space and of the Threat or Use of Force Against Outer Space Objects, dubbed the PPWT. Each time, the United States rejected the proposal as “fundamentally flawed”. Among the reasons cited are that it is unverifiable — it is difficult to define a space weapon owing to the dual-use nature of most of the technology; it does not prohibit the development and stockpiling of space arms; and it does not consider ground-based space weapons, such as that demonstrated by the Chinese in 2007.

Rather than shift to aggressive policies, nations should instead show further restraint and cooperation.

The way forward

Space laws need to be updated for our time. Extending the Outer Space Treaty or writing a new one is unlikely to work, as US hesitancy to sign the PPWT shows. 'Soft law', driven by need, seems the best option for revising the rules for space operators.

Soft law comprises rules or guidelines that have legal significance but are not binding. It sets standards of conduct for agreeing parties, much like those that protect the environment and endangered species. 'Rules of the road' and best practices for space should be developed. These could take a similar form to the navigation guidelines set out in the 1972 Convention on International Regulations for Preventing Collisions at Sea, which govern when one vessel should give way to another, as well as other interactions.

Soft law works when it is in the interest of all parties to abide by it. If countries and companies want to maintain the space environment as a usable domain, then it is in their interests to accommodate a variety of operations. Space is more complex to manage than air, land or sea because of the distance, physics and technology involved. Just as in the cyber domain,

technology has preceded regulation, making it difficult to impose after the fact.

The first focus of an analogous set of space guidelines should be environmental protection and debris avoidance, areas that most spacefaring nations agree on. Governments are engaged in groups such as the 13-member Inter-Agency Space Debris Coordination Committee (IADC). The 84-member COPUOS works through two subsidiary bodies to develop best practices for sustaining the space environment, including mitigating debris. COPUOS working groups will begin meeting again in January 2018 to continue developing best practices, with new proposals to be presented to the committee in June 2018. Commercial perspectives should be included through national delegations and external observers.

Politicization of any guiding principles must be resisted, for example, by seeking consensus. The IADC Steering Committee releases information and materials to the public only when all parties agree, and it works through sub-committees operating from a technical rather than a political perspective. COPUOS discussions are progressing, albeit slowly.

Encouraging mutual understanding and building trust between nations is crucial to avoid conflict. It is impossible to verify exactly what is happening in space if a satellite ceases to function: has there been an intentional attack, an act of nature or a technical glitch? This problem of distance and the nature of dual-use technology create ripe circumstances for mishaps. Transparency and confidence-building measures developed in 2013 by the UN-sponsored Group of Governmental Experts are designed to help avoid misunderstanding and miscalculations and should be widely adopted.

A coordinated human spaceflight mission, in which different nations work together towards a common goal, could build the kind of space environment envisioned in the Outer Space Treaty. US–Russian cooperation on the International Space Station has shown that when terrestrial tensions get high, working together can maintain ties.

Coordination is easier than cooperation when there are technology-transfer concerns. Proposing a big mission and inviting other countries to join would give the US human spaceflight programme a direction, as well as serving

strategic purposes. A crewed fly-by mission of Venus and Mars, for example, has been on the table since the days of the Apollo missions and could yet be resurrected. An encouraging example is the 'space armada' of coordinated missions to study Halley's comet in 1986, involving the Soviet Union, European Space Agency and Japan.

With the expansion of national and commercial space activities, the Outer Space Treaty will be stretched to its limits. In that regard, it will be serving its intent — paving the way for the peaceful exploration and development of space.

Journal name:
Nature
Volume:
550,
Pages:
182–184
Date published:
(12 October 2017)
DOI:
doi:10.1038/550182a

Comments

Comments

There are currently no comments.

The scientist who spots fake videos

Hany Farid discusses how to detect image manipulations — and the increasing sophistication of forgers.

06 October 2017

Eli Burakian/Dartmouth College

Hany Farid.

Hany Farid, a computer scientist at Dartmouth College in Hanover, New Hampshire, specialises in detecting manipulated images and videos. Farid, who provides his services to clients as varied as universities, media organizations, and law courts, says that image manipulation is becoming both more frequent and more sophisticated. He spoke to *Nature* about the arms race to stay ahead of the forgers.

Where do you start when trying to spot a fake image?

One simple but powerful technique is reverse image search. You give the image to a site such as Google Image Search or TinEye, and they show you all other instances of it. A project at Columbia University, in New York City, is taking this to the next level, and starting to find parts of images that have been repurposed from other images**.**

Generally, we think about which patterns, geometries, colours or structures are going to be disrupted when someone manipulates a photo. For example, when people add an object into a scene, we know that where they put the shadow is usually wrong. A viral video called Golden Eagle Snatches Kid from 2012 is one of my favourite examples. It took us only 15 minutes of analysis to show shadow inconsistencies: the eagle and baby were computer-generated.

What about if fake images make only slight tweaks?

There are a number of analyses we can do. In a colour picture, every pixel needs three values — corresponding to the amounts of red, green and blue at that point. But in most cameras, every pixel records just one colour, and the camera fills in the gaps by taking the average values of the pixels around it. This means that, for any given colour in an image, each missing pixel has a particular correlation with its neighbours, which will be destroyed if we add or airbrush something, and we can detect that**.**

Another technique is JPEG compression. Almost every image is stored in a JPEG file, which throws away some information to save on storage. There is a huge amount of variation in how each camera does that. If a JPEG is unpacked — opened in Photoshop — and then put back together, it is always repackaged slightly differently, and we can detect that. I wish you could just upload any image and we could tell you if it's real or not, but it's still a very

difficult process and requires expertise to understand different components.

Who uses your digital forensic services?

I do analysis for organisations such as the Associated Press, Reuters, and *The New York Times*. There are only a handful of academics worldwide who are specialists in this, so it doesn't scale — and that means you can only do the analysis of really high-stakes images. But there are efforts under way to scale this up. Last year, the US Defense Advanced Research Projects Agency (DARPA) got into this game with a large project of which I'm part. Over the next five years they're trying to create a system that will allow you to analyse hundreds of thousands of images a day. It's a very ambitious programme.

I also do a lot of work in the courts. For example, here in the United States, child pornography is illegal, but computer-generated child pornography counts as 'protected speech' under the First Amendment. If someone's arrested they might say that the offending image isn't real, and I might have to prove that it is. I also get lots of e-mails from people about photo hoaxes — almost daily.

Do you apply your techniques to scientific papers?

I have worked on many cases of scientific misconduct, hired by universities conducting internal investigations. When I visited the US Office of Research Integrity recently, they asked me "how do we get our hands on automated tools?" The reality is we're still not there. But creating something that uses some of the tools, such as clone detection, which looks to see whether parts of an image have been copied and pasted from elsewhere, would be possible as a semi-automated process looking at dozens, not millions, of images a day. It's something my colleagues and I are thinking about, and it's a small but not insignificant part of the DARPA programme.

How about fake videos?

Researchers are now able to splice together footage to create videos of famous people seeming to say things they never said — for instance, this video of President Obama. And they can create fake images or short videos using machine learning techniques: in particular, generative adversarial networks (GANs), which learn to generate fake content. These pit a network that generates fake content against a 'classifer' network that attempts to discriminate between real and fake content, so that the faking network rapidly improves.

I've seen the technology get good enough that I'm now very concerned. In 5 or 10 years, this is going to get really good. At some point we will reach a stage where we can generate realistic video, with audio, of a world leader, and that's going to be very disconcerting. I would say that the field of digital forensics is now behind in video.

How can you detect fake video?

JPEG compression has an analogous construct in video, which is a bit harder to detect because video uses a more sophisticated version. Another approach is to use machine learning for detection. But we're taking an approach similar to what we do with images — which is based on the observation that computer-generated content lacks the imperfections that are present in a recorded video. It's created in almost too perfect a world. So one of the things we look at is, are we not seeing the statistical and geometric patterns we'd expect to see in the physical world?

Another technique is based on some beautiful work by William Freeman and colleagues at the Massachusetts Institute of Technology in Cambridge, who showed how if you magnify really small changes in a video of a person, you can see subtle changes in the colours in their face that correspond to their pulse rate. We showed that you can use this to distinguish real people from computer-generated people.

Couldn’t machine learning algorithms learn to include these features?

Perhaps in principle. But in practice, these algorithms have limited time and training data, and there is little control over which features a neural network will pick up on to discriminate between real and fake videos. A GAN is only trying to fool the classifier it’s trained on. That’s no guarantee that it will learn all aspects of what makes an image or video real or fake, or that it will fool another classifier.

My adversary will have to implement all the forensic techniques that I use, so that the neural network can learn to circumvent these analyses: for example, by adding a pulse in. In that way, I’ve made their job a little harder.

It’s an arms race. As we are developing faster, folks are creating more sophisticated technology to augment audio, images and video. The way this is going to end is that you take the ability to create a perfect fake out of the hands of the amateur. You make it harder, so it takes more time and skill, and there’s a greater risk of getting caught.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22784

Comments

Comments

There are currently no comments.

Navajo Nation reconsiders ban on genetic research

Tribal leaders are developing a policy for genetic research and data sharing, potentially ending a 15-year moratorium.

06 October 2017

Ricky Carioti/The Washington Post/Getty

Children play on the Navajo Nation's vast reservation in the southwestern United States.

When the Navajo Nation opens its first oncology centre next year in Tuba City, Arizona, clinicians there may be able to offer a service that has been banned on tribal lands for 15 years: analyzing the DNA of Navajo tribe

members to guide treatments and study the genetic roots of disease.

That's because the Navajo, the second-largest Native American group in the United States, are considering whether to lift their longstanding moratorium on genetic research. The tribal government banned DNA studies in 2002 to prevent the misuse of its members' genetic material. Although there is still some apprehension about the risk of allowing researchers access to Navajo DNA, the tribe's leaders increasingly see genetic research as a tool to improve medical care for the 174,000 residents of their sprawling reservation, which is roughly the size of Scotland.

As it now stands, Navajo people who live on the reservation must drive hundreds of kilometres to access specialized medical care off tribal lands, in large cities such as Phoenix, Arizona. “We spend millions of dollars outsourcing [care] for cancer and diabetes,” says Walter Phelps, a delegate to the Navajo Nation Council. As the tribe — a nation independent of the United States — tries to expand the health services it offers to its members, he says, “the moratorium could become a barrier when blood and tissue have to be collected”.

Phelps is working on the effort to create a policy by which the Navajo Nation would approve genetic-research projects and maintain control of DNA samples. The research-ethics board run by the tribal government’s department of health is working with tribal officials and traditional leaders and holding a series of public hearings to solicit opinions on the matter from tribe members. The group hopes to deliver a draft proposal by the end of October. Whatever the tribe decides could influence the hundreds of other Native American groups, who have tended to be wary of genetic studies because of a history of scientists conducting research without consent or adequate privacy controls.

The Navajo Nation's new oncology centre provides part of the impetus for revisiting the genetic-research ban. It will be the first such facility on Native American lands outside of Alaska. Allowing some genetic testing at the centre could help physicians to identify the most effective therapies for each patient, says Lynette Bonar, chief executive of the Tuba City Regional Health Care Corporation in Arizona, which will run the facility.

That would match the standard of care that many Navajo people with cancer

have received at medical facilities off the reservation. And creating a repository for such genetic material on Navajo land would enable research into the genetic and environmental factors underlying a broad range of diseases, not just cancer.

So far, Phelps says, the idea of allowing some genetic research has not drawn major opposition. Many tribe members consulted about lifting the moratorium have generally supported the idea after learning how physicians could use genetic data to diagnose disease and tailor treatments. And the number of Navajo tribe members who are geneticists and medical experts has grown since 2002, bolstering the tribe's ability to evaluate proposed protocols and represent its own interests.

Fraught history

Still, some Navajo have lingering questions about whether the tribal government can protect the privacy of their genetic material and maintain control over its use. Such concerns helped to shape the current ban back in the early 2000s, when the Navajo Nation's department of health conducted an outreach campaign about genetics and medical research. "In the absence of a research code and lack of expertise at the time, they decided it was not a good time to move forward with genetic research until they were able to develop a research policy," says Nanibaa' Garrison, a member of the Navajo Nation who is a geneticist and bioethicist at Seattle Children's Hospital in Washington.

The tribe had reason to be cautious. "As Native Americans, we have a problem with trust because we have been violated so much," says David Begay, a pharmaceutical scientist at the University of New Mexico in Albuquerque and a member of the Navajo Nation's human-research review board. "In the past, our data have been misused."

Native Americans in the southwestern United States want to avoid repeating the experience of the region's Havasupai tribe. In 2004, the group sued Arizona State University in Tempe over alleged misuse of tribe members' blood samples. The Havasupai said that the samples, which had been

collected for diabetes research, had later been used in studies of schizophrenia, migration and inbreeding without their consent. The university made a settlement with the tribe in 2010, paying US$700,000 and returning the blood samples.

Sara Hull, a bioethicist at the US National Human Genome Research Institute in Bethesda, Maryland, says the case helped to change how researchers engage with the people they study, by raising awareness of the complexities of dealing with vulnerable minority populations. For Native Americans, such thorny issues can include privacy. Science-funding agencies and journals often require researchers to put the genetic data they collect into public repositories, but the relatively small size of many Native American tribes can make it easy to identify individual members in a genetic data base. In recognition of this, the US National Institutes of Health sometimes works with researchers it funds to develop methods for sharing data on a minority group without compromising its privacy.

Garrison, who is helping the Navajo Nation develop its new policy, says that the plan is likely to include rules on what types of research will be allowed, who will have access to tribe members' genetic material and information, and who will provide oversight. It is also likely to require that the tribe maintain ownership of its members' DNA samples and data.

The policy that the Navajo Nation ultimately produces could serve as a template for other Native American groups considering how — or whether — to engage with genetic research, says Ellen Clayton, a bioethicist at Vanderbilt University in Nashville, Tennessee. She expects other tribes to watch the development of the Navajo Nation's new policy. "If they reach an agreement, I think it will be influential."

Journal name:
Nature
Volume:
550,
Pages:
165–166
Date published:
(12 October 2017)

DOI:
doi:10.1038/nature.2017.22780

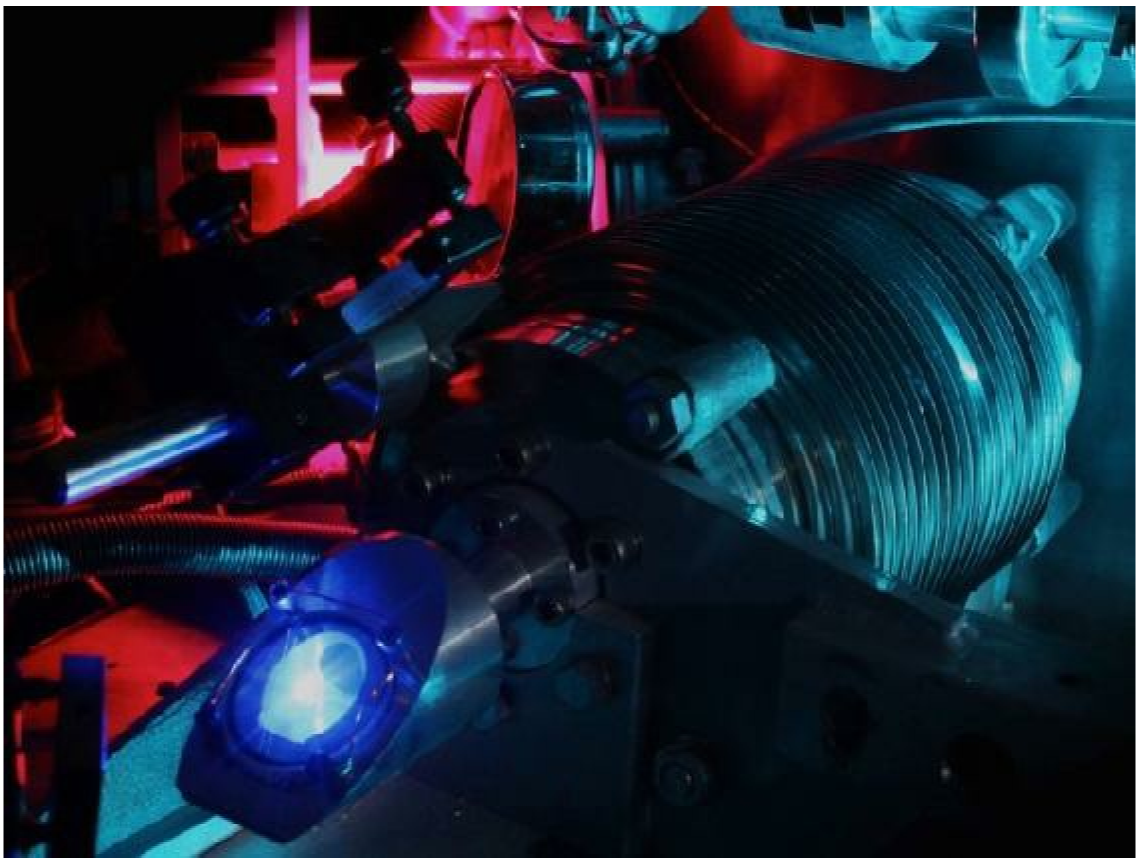
Comments

Commenting is currently unavailable.

Proton-size puzzle deepens

Measurement in ordinary hydrogen agrees with a surprising 2010 result on the element's exotic cousin — but gives a smaller value than virtually every other experiment.

05 October 2017



Axel Beyer

Researchers shone lasers at hydrogen atoms in a vacuum chamber to pinpoint the size of the protons inside.

The proton might truly be smaller than was thought. Experiments on an exotic form of hydrogen first found[1] a puzzling discrepancy with the

accepted size in 2010. Now, evidence from a German and Russian team points to a smaller value for the size of the proton with ordinary hydrogen, too.

The results, which appeared on 5 October in *Science*[2], could be the first step towards resolving a puzzle that has made physicists doubt their most precise measurements, and even their most cherished theories.

Still, “before any resolution, this new value has to be confirmed”, says Jan Bernauer, a physicist at the Massachusetts Institute of Technology in Cambridge. If other labs confirm it, he adds, “then we can find why the old experiments were wrong, hopefully”.

Method mix-up

For decades, physicists have estimated the size of the proton using one of two main techniques. Atomic physicists use spectroscopy to measure the energy levels of electrons orbiting an atomic nucleus — consisting of either the single proton in a hydrogen atom, or a bigger nucleus. The size of the nucleus affects those energies because electrons spend some time moving through the nucleus as they orbit it.

Meanwhile, nuclear physicists have used a similar technique to the one that enabled Ernest Rutherford to discover atomic nuclei in the first place. They hit the atoms with beams of fast-moving electrons and measure how the electrons bounce off.

As their precision improved, both methods roughly came to agree on a radius of about 0.8768 femtometres (millionths of a millionth of a millimetre).

But in 2010, a novel kind of experiment completed at the Paul Scherrer Institute in Villigen, Switzerland, disrupted the consensus. After a decade of unsuccessful attempts, a multinational collaboration led by Randolf Pohl, then at the Max Planck Institute of Quantum Optics (MPQ) in Garching, Germany, measured energy transitions not in ordinary hydrogen, but in lab-made ‘muonic’ hydrogen. These are atoms in which the electron has been replaced by a muon — a particle similar to an electron in most of its

properties, but 200 times more massive. The heavier particle spends more time inside the nucleus, which means that the proton’s size has a much larger effect on the muon’s energies — which, in turn, should lead to a much more precise estimate of the proton’s radius.

Pohl’s team found the proton to be 4% smaller than the accepted value. Some researchers speculated that perhaps some previously unknown physics could make muons act differently than electrons. This would have required a revision of the standard model of particle physics, which predicts that muons and electrons should be identical in every way except for their masses — and might have pointed to the existence of yet-to-be-discovered elementary particles.

Exciting technique

In the latest paper[2], Pohl, now at the Johannes Gutenberg University in Mainz, Germany, and his collaborators tickled hydrogen atoms — containing ordinary electrons — with two different lasers. The first one sent the atoms’ electrons into an excited state, and the second one put them into a higher-energy excitation. The team then detected the photons that the atoms released as their electrons fell back into lower-energy excitation states.

The team combined its data with an earlier, high-precision measurement to calculate the Rydberg constant, which expresses the energy that it takes to rip the electron off the hydrogen atom. Standard theory then enabled the researchers to calculate the radius of the proton from this constant. The value they found was consistent with the muonic-hydrogen measurement, and 5% smaller than the 'official' proton radius.

To ensure that they eliminated any spurious experimental effects, the team spent three years analysing its data, says Lothar Maisenbacher, a co-author of the paper and an atomic physicist at the MPQ.

Bernauer, who works on the electron–proton scattering technique, is impressed. “It’s a great experiment,” he says. “I think they really advanced their field with this.”

The care that they took is “very impressive”, and makes their measurement more reliable than many others, says Krzysztof Pachucki, a theoretical physicist at the University of Warsaw who is on the task group of the Committee on Data for Science and Technology (CODATA).

CODATA, the international agency that publishes the best-known values of the fundamental constants, is taking notice of the Mainz experiment. “We will take this result very seriously,” says Pachucki. The committee is due to revise the ‘official’ handbook of universal constants of nature next year. Because of this experiment, CODATA will "most probably” change its values for the proton radius and Rydberg constant, he says.

More evidence needed

But the German–Russian group is not quite ready to claim that the puzzle has been solved, Maisenbacher says. “We have not identified any conclusive reason why the other measurements should not be correct themselves,” he says. “We would like to see more experiments from other people.”

A number of teams around the world are doing just that. Bernauer is interested, for example, in the results of spectroscopy experiments being done at York University in Toronto, Canada. If their measurement is also small, “then I would start to believe that the old data has a problem”, Bernauer says. But that would still leave open the matter of the electron–proton scattering results.

In those experiments, researchers have conventionally used electrons that have a range of different energies. Estimating the size of the proton required extrapolating all the way to an ideal situation, in which electrons had zero energy.

Ashot Gasparian, a particle and nuclear physicist at North Carolina A&T; State University in Greensboro and his team have recently conducted an experiment at the Thomas Jefferson National Accelerator Facility in Newport News, Virginia. They injected cold hydrogen gas directly into their electron accelerator, rather than bombarding liquid hydrogen kept in a plastic box, as

was previously done. This technique enabled them to remove some experimental uncertainties and also to use electrons with lower energies than before. In principle, this could reveal whether and where the previous extrapolations went wrong. They are now analysing their data and hope to have results next year. “The ball is in our court,” says Gasparian.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22760

Comments

1 comment

1. *Raji Heyrovska* • 2017-10-10 11:52 AM
   I have just posted a simple relation connecting the CODATA 2014 proton radius with Bohr radius and fine structure constant at: http://viXra.org/abs/1710.0105 (abstract) and http://vixra.org/pdf/1710.0105v1.pdf (full text).

Controversial pesticides found in honey samples from six continents

Neonicotinoids are at the centre of a long-running debate about whether they harm bees.

05 October 2017

Fergus Gill/2020VISION/naturepl.com

Honey is a major source of food for honey bees.

Honey bees on every continent except Antarctica face significant exposure to neonicotinoid pesticides — chemicals that some studies suggest harm bees' health. Researchers who tested honey from nearly 200 sites worldwide found that 75% of their samples contained some level of the pesticides, according to

a report published on 6 October in *Science*[1].

The study is the first attempt to quantify the presence of neonicotinoids in honey on a global scale using standardized methods. Nearly half of the samples tested contained levels of neonicotinoids at least as high as those thought, on the basis of previous research, to impair bees' brain function and slow the growth of their colonies. The study also found that 45% of the samples contained two or more types of neonicotinoid.

"It's not a surprise, in a sense, that we find neonicotinoids in honey. Anybody could have guessed that," says lead author Edward Mitchell, a biologist at the University of Neuchâtel in Switzerland. "What's original is using the same protocol. We now have a worldwide map of the situation."

The research provides additional context for the long-running debate over whether and how neonicotinoids affect bees' health. Some studies have suggested that exposure to neonicotinoids lowers honey bees' nutritional status[2] and impairs their immunity[3]. And in June, a paper published in *Science* reported that neonicotinoids lower honey bees' chances of survival during the winter, and threaten the queen in particular, which can affect reproduction[4].

To assess the scale of honey bees' exposure to neonicotinoids around the world, the authors of the new study collected honey from 198 sites on six continents through a citizen-science project. Then they tested those samples to determine the concentrations of five of the most commonly used neonicotinoids. Honey collected in North America had the highest proportion of samples containing at least one neonicotinoid, at 86%, with Asia (80%) and Europe (79%) close behind.

The extent of the contamination, even in honey from remote places — including islands in the middle of the Pacific Ocean and off the coast of West Africa — is surprising, says Amro Zayed, an insect researcher at York University in Toronto, Canada. The findings suggest that bees the world over are exposed to neonicotinoids constantly over generations, he says, which is worrying because the insects depend so heavily on honey for food. "It's one thing to go out to a restaurant and get a bad meal, but if you have your fridge

at home contaminated with insecticides, that’s an entirely different method of exposure,” Zayed says.

Others say that the widespread presence of neonicotinoids in honey is to be expected, given how commonly the chemicals are used in staple crops such as canola and wheat, as well as in home gardens. “Yes, there is going to be long-term exposure, potentially, to neonics, but that doesn’t say anything about the risk,” says Chris Cutler, an entomologist at Dalhousie University in Halifax, Canada. “Just because it’s there doesn’t necessarily mean there’s a problem.”

Much of the debate about neocotinoids has focused on just this question: how problematic are the pesticides when bees are exposed to them at low levels, but over a long period of time? “One of the issues around assessing the impacts on bees has been the discussion of what a field-relevant level of exposure actually is,” says Nigel Raine, a pollinator-health researcher at the University of Guelph in Canada. “This contributes toward that discussion substantially.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22762

Comments

Comments

There are currently no comments.

Antikythera shipwreck yields statue pieces and mystery bronze disc

Archaeologists think that at least seven life-sized sculptures are hidden nearby.

04 October 2017

Brett Seymour/EUA/ARGO 2017

Archaeologist Brendan Foley discovers a bronze disc, at first thought to be part of the Antikythera mechanism.

Marine archaeologists investigating the ancient shipwreck that yielded the Antikythera mechanism — a complex, bronze, geared device that predicted eclipses and showed the movements of the Sun, Moon and planets in the sky

— have recovered a wealth of treasures, including bronze and marble statue pieces, a sarcophagus lid and a mysterious bronze disc decorated with a bull. The artefacts were trapped under boulders in a previously unexplored part of the site near the island of Antikythera, Greece, and the researchers think that large parts of at least seven statues are still buried nearby.

The discoveries are “extremely exciting”, says Kenneth Lapatin, curator of antiquities at the J. Paul Getty Museum in Los Angeles, California. Only a handful of bronze statues survive from the ancient world, and they have almost invariably been treated and altered by previous conservators, undergoing processes that destroyed much of the information scientists might have gleaned from them. “Technology has improved so much,” says Lapatin. “We can learn from these untreated finds.”

The first-century-BC cargo ship, discovered in 1900 by sponge divers, is famous for yielding a heavily encrusted and corroded geared device that used to predict eclipses and chart the skies. The sponge divers also retrieved many other priceless items, including luxury glassware, jewellery and a two-metre-tall bronze statue, dating from the fourth century BC, nicknamed the ‘Antikythera youth’.

Statue search

Courtesy of ARGO 2017

The bronze arm was one of the most significant recent findings.

The recovery of multiple ‘orphan’ statue pieces — limbs without matching heads or bodies, for example — suggested that several statues still lie buried here. So an international team of archaeologists and divers, co-led by Brendan Foley of the University of Lund in Sweden and Theotokis Theodoulou of the Greek Ephorate of Underwater Antiquities in Athens, is now re-excavating the 50-metre-deep wreck site to look for them.

The team has made a stream of discoveries since work began in 2014, including wine jars, giant anchors, gold jewellery and a human skeleton, which is now being analysed for DNA. But the statues have remained hidden until now.

On 4 October**,** the team announced that during a 16-day dive season the previous month, they found several major statue pieces, including two marble feet attached to a plinth, part of a bronze robe or toga, and a bronze male arm, with two fingers missing but otherwise beautifully preserved. A slim build and “turning hand” gesture suggest that the arm may belong to a philosopher,

says Theodoulou.

In 1900–01, the sponge divers salvaged orphan limbs from a minimum of six bronze statues. The newly discovered arm pushes that total to at least seven, says Theodoulou. The team is particularly excited because the statue pieces were found in an area undisturbed by any previous excavations, buried beneath large boulders dislodged from Antikythera’s steep cliffs over the course of 2,000 years by periodic earthquakes. “We think this means that everything is down there still,” says Foley.

The discovery of seven bronze statues, if they could be recovered, would significantly boost the world’s total from this time period, which stands not much greater than 50, Lapatin estimates. Few of those are complete. And although these ancient figures might look beautiful, they are hard to study because the aggressive treatments by generations of conservators have altered and damaged the bronze.

Technological advances

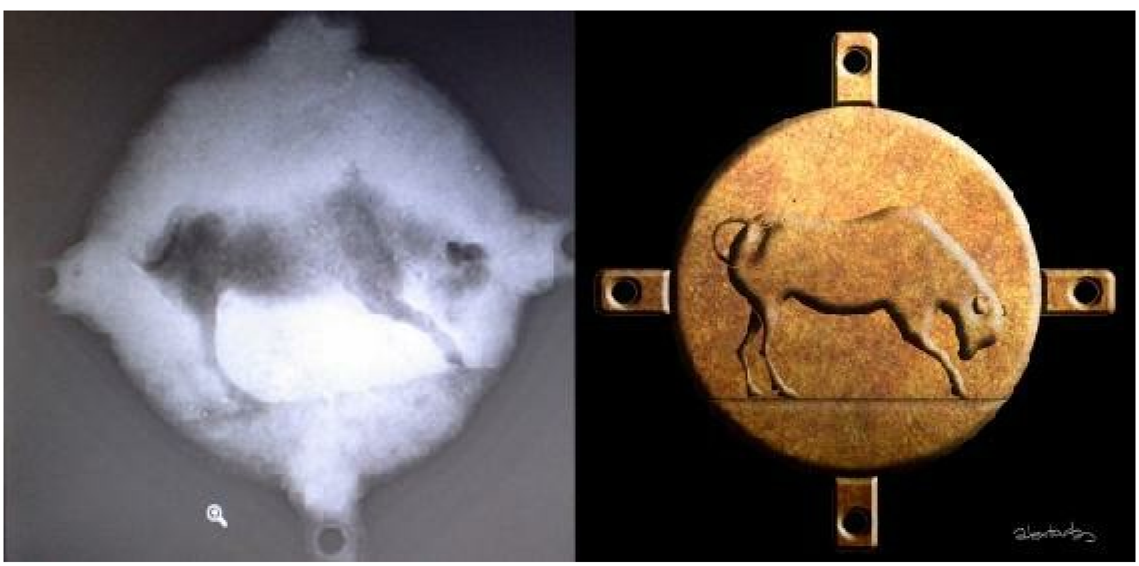
Fresh, untreated finds such as those from Antikythera will give researchers the opportunity to use modern techniques to study a significant aspect of ancient Greek life — for example, by looking at casting methods, which precise alloys were used and whether the statues were made for export or had been previously displayed. Meanwhile, any heads found might enable researchers to identify the people depicted, and to compare their likeness with any existing portraits, for example, marble statues or images etched on coins.

Brett Seymour/EUA/ARGO 2017

The bronze disc, which researchers at first thought might contain some of the lost gears of the Antikythera mechanism.

Foley and Theodoulou’s team also recovered an intriguing bronze disc or wheel, about eight centimetres across, attached to four metal arms with holes for pins. A layer of hardened sediment hides its internal structure, but it superficially resembles the Antikythera mechanism, and researchers had initially hoped that it might be part of that ancient device: perhaps the gearing that calculated the positions of the planets, which is missing from the find.

But preliminary X-ray imaging conducted in an Athens hospital on 25 September revealed a surprise: instead of gear wheels, the image of a bull appeared. The object might have been a decorative element, says Lapatin, perhaps attached to a box or a statue’s shield, or even — because of its sturdy construction — to the doomed ship. More-detailed radiography is planned for the next few weeks.



Left: EUA. Right: Alexander Tourtas.

The X-rays of the bronze disc, and artist's reconstruction of the bull.

Other discoveries this season include a sarcophagus lid made from fine, red marble, more human remains and wooden ship planks and frames that the researchers hope will reveal information about the vessel's size and shape.

The team plans to return to Antikythera in May 2018, to break up the boulders and excavate beneath. "It's going to be a major operation," says Foley. "But we think it will be spectacular."

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22735

Comments

Commenting is currently unavailable.

Crash in sea-turtle births stumps ecologists

Leading suspect — climate change — doesn’t fully explain what is happening to leatherback turtles in the US Virgin Islands.

04 October 2017

Jurgen Freund/NPL/Getty

While buried in the sand, sea-turtle eggs are very sensitive to several environmental conditions that affect whether they hatch or not.

The mystery behind a dramatic fall in the number of leatherback sea-turtle (*Dermochelys coriacea*) hatchlings in the US Virgin Islands remains unsolved, despite the latest efforts of researchers. Rising temperatures and

changes in rainfall patterns — the top two suspects — don't seem to be connected to the decline, according to a study published on 4 October[1]. The finding contradicts previous work, leaving researchers scratching their heads over what could be happening.

The latest study focused on a nesting beach in the Sandy Point National Wildlife Refuge on St Croix island in the Caribbean Sea. The researchers found that about 74% of the leatherback sea-turtle eggs laid there in 1990 hatched, but that rate had plummeted to 55% by 2010.

The study analysed detailed temperature and precipitation data at these nests over the 20 years, and found no corresponding trend in either climate-change factor that could fully account for the decline. The researchers reported their results in *Royal Society Open Science*.

Increases in temperature and more-erratic precipitation patterns do affect the nests, but they aren't the sole reason for the hatching declines, says Anthony Rafferty, a marine biologist at Monash University in Melbourne, Australia, and a study co-author.

This trend is especially confusing in light of the increase in the adult sea-turtle population. "The number of nesting females and the population size has been trending upwards at this site," Rafferty says. "But there's been a decrease in hatching success that we are worried about." That could have negative effects on leatherback populations within one or two decades, he says, when those hatchlings come of age.

Conundrum continues

"It's hard to say how much of that is happening because of climate change," says Vincent Saba, a climate scientist at the US National Oceanic and Atmospheric Administration in Princeton, New Jersey. He co-authored a 2015 study[2] that did find a relationship between air temperature, precipitation patterns and declines in leatherback hatching success. That study examined data from 1982 to 2010 and looked at seasonal rainfall, unlike the latest paper, which analysed rainfall only during the nesting season. The study predicted that, by 2100, Sandy Point would have the most unfavourable climate conditions out of all leatherback nesting sites around the world.

"I like the study. They looked at the effect of climate in finer detail," says Pilar Santidrián Tomillo, a marine biologist and science director of the Leatherback Trust, based in Playa Grande, Costa Rica. She was a co-author on the 2015 study, and appreciates the fuller picture of what could be happening at Sandy Point that the most recent study has provided.

Sea-turtle eggs are exquisitely sensitive to climate because heat, carbon dioxide, oxygen and water all pass freely through their permeable shells. The surrounding temperatures determine the sex of the hatchlings: warmer conditions produce more females, whereas cooler conditions yield males. And rainfall can influence hatchling development and their ability to escape the nest, says Rafferty. Too little rain might mean that the sand is too dry for the young turtles to climb out of it; too much rain during the early stages of egg development might lead to a reduction in oxygen supplies to the growing embryo.

"I think changes in precipitation levels or patterns could explain the decline in hatching success partially, but there could be other reasons, too, like decline in fertility or increase in pollutants, for example," Santidrián Tomillo says.

Rafferty, who specializes in embryo research, now plans to look at how the age and health of a female sea turtle might affect her fertility, or where she lays her eggs.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22748

Comments

Comments

There are currently no comments.

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Supercomputer redesign of aeroplane wing mirrors bird anatomy

Bird-bone structures emerge from an evolution-like algorithm.

04 October 2017

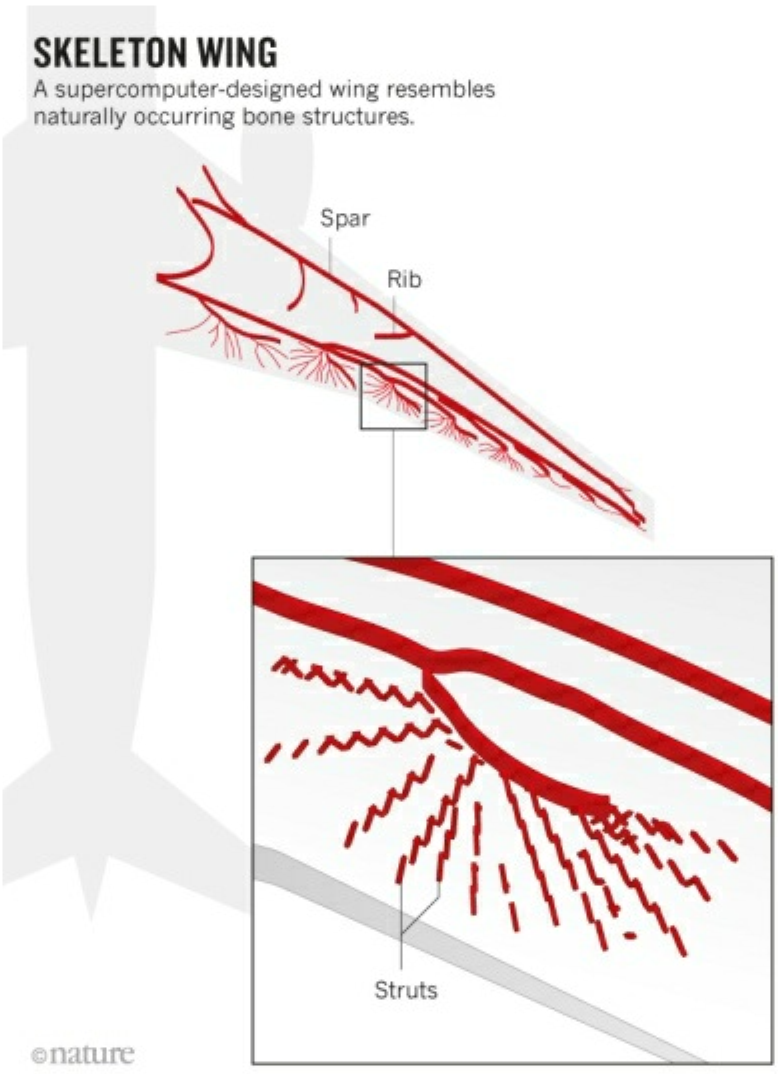
Samuel Taylor/Alamy

Conventional aeroplane wings are supported by straight bars and struts, but a supercomputer has suggested a more organic design.

Engineers have used a supercomputing technique that mimics natural selection to design the internal structure of an aircraft wing from scratch. The

resulting blueprint is not only lighter than existing wings, it also resembles natural formations, such as bird wing bones, that are not present in current aeroplanes. The organic-looking product is as stiff as a conventional aircraft wing but lighter, which could save up to 200 tonnes of fuel per year per plane.

“This is a really nice illustration of how to employ computing-based optimization methods at immensely high resolution,” says Matthew Santer, an aerospace engineer at Imperial College London. The method could feed into the design process, although there are a number of hurdles to using it in aerospace applications in its present form, he adds.



Engineers have been using these kinds of optimization techniques for around

20 years, but only for smaller-scale problems, such as individual wing components, or much simpler structures, says Niels Aage, an engineer at the Technical University of Denmark, near Copenhagen, who led the work[1]. Aage and his colleagues used the Curie supercomputer in Bruyères-le-Châtel near Paris to increase the resolution, enabling them to model the entire 27-metre-long wing of a Boeing 777.

The team started with a wing outline already optimized for maximum lift and minimum drag, known as an aerofoil, and split it into 1.1 billion 3D pixels or 'voxels'. Each is about the size of the smallest Lego brick — a resolution roughly 200 times greater than previous efforts. The algorithm began by simulating the force exerted on every block and distributing material in response to where the wing experienced a load. Without any human guidance, the program then repeated the analysis several hundred times, adding or removing material depending on the strain felt by each brick, until it reached a final optimum design. "The structure evolves through each design cycle," says Aage. "The process has many similarities to nature's own evolution."

Organic flight

Unlike conventional wings, the resulting structure did not contain the usual straight beams running the length of the wings, interspersed by crossing supports. Instead, the design looks organic, says Aage. Curved supports fan out at the trailing edge of the wing, resembling the bones in birds' wings, and intricate support structures in the leading edge look like the internal structure of a beak.

Without compromising stiffness (resistance to deformation), the design weighs 2–5% less than conventional wing structures. That translates into 200–500 kilograms per wing, potentially saving each plane between 40 and 200 tonnes of fuel per year, say the authors. The technique could also be applied to other industries, says Aage, for example, to design high-rise buildings in earthquake-prone zones that maintain their stiffness yet can withstand the dynamics of a quake. It could be used to optimize acoustics, ventilation systems and antennas, as well, he adds.

The technique’s high resolution, which allows the computer to design structures that include features that range in size from millimetres up to tens of metres, could lead to more-innovative designs in these other disciplines, says Liang Xia, a computational engineer at the Huazhong University of Science and Technology in Wuhan, China. But he stresses that running the algorithm requires a heavy computing burden — the equivalent of running a single standard computer for 100 years. This computing cost could be reduced, however, if the team were to employ more-advanced simulation methods, used in artificial intelligence, which in effect model only parts of the wing in such high resolution.

The design is also too intricate to be made by existing manufacturing methods, and would require a giant 3D printer to build. But for now, key aspects of it could be fed into structures produced using conventional methods, says Aage. “We’re speeding up evolution rapidly, meaning we can see how designs should be, and then extract the key features — or those we can afford.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22759

Comments

Commenting is currently unavailable.

Elite Hungarian university may be saved

Hungary-New York agreement could allow Central European University to sidestep law change.

04 October 2017

Bernadett Szabo/REUTERS

Seventy thousand people protested in Budapest last April against a law apparently targeting the Central European University.

The prestigious Central European University (CEU) in Budapest, Hungary, seems to have found a way around a threat to close it down. The university had been affected by a law change that is widely thought to be politically

motivated.

The threat arose in April, when the government rushed through an amendment to its higher-education law, requiring that all international universities operating in Hungary had also to operate as higher-education institutes in their countries of origin.

The law change seriously affected only the CEU, which is legally registered in New York state. The university was founded in 1991 by Hungarian-born philanthropist George Soros, whom Hungarian Prime Minister Viktor Orbán has described as an enemy, because of Soros's statements in support of refugees, which run counter to Orbán's policies. The revised law, which includes other, smaller amendments, comes into effect on 11 October.

New York connection

A CEU spokesperson said on 3 October that the university has now signed a Memorandum of Understanding with Bard College in Annandale-on-Hudson, New York, to provide educational activities. She added that negotiations between the State of New York and the government of Hungary, which opened at the end of June, have now concluded, although the agreement still has to be signed off by Hungary's government and Parliament.

The law change sparked immediate protest last April, when 70,000 protestors took to the streets in Budapest, and the Hungarian Academy of Sciences expressed concern. The European Commission is pursuing an infringement procedure against what it sees as an illegal restriction of academic freedom, and an investigation by legal experts of the Council of Europe, a powerful human-rights organization with 47 member states, published a preliminary opinion in August indicating that the law was inappropriate.

"It's no secret that it has been a hell of a way to treat a university," says CEU rector Michael Ignatieff.

The university has nearly 1,500 mostly postgraduate students from more than a hundred countries, including a large number from Hungary. It operates mainly in the humanities, but recently expanded to include the cognitive and

network sciences.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22761

Comments

Comments

There are currently no comments.

Science without walls is good for all

International mobility and collaboration are linked to stronger research.

04 October 2017

David Williams/Bloomberg/Getty

New studies highlight how closing borders would be bad for science.

Some US biotechnology labs have responded to President Donald Trump’s attempts to restrict immigration by releasing contrasting group photographs showing what less-open international borders would do to their workforces. A first image typically shows everyone who works in the lab. A second image includes only those who are permanent US residents, then just US citizens, and then only those who were born in the United States and whose parents also were (see, for example, go.nature.com/2ft02xj). The shrinkage

from the first to the last image is striking — in some cases, about two-thirds of staff are lost. This reflects a widespread reality in research. A 2012 analysis showed that more than 60% of postdocs in the United States grew up overseas (see *Nature* **490,** 326–329; 2012).

When it comes to co-authorship, researchers in Europe are the most international. In 1981, only about one in six papers by a European scientist included co-authors from a different country. By 2011, that had risen to one in two. Papers with authors from more than one country also tend to be more highly cited (J. Adams *Nature* **497,** 557–560; 2013) .

This week, *Nature*'s Comment section publishes two bibliometric analyses that suggest international mobility has similar science-boosting effects.

The first finds that researchers build strong links between nations as they travel around the world. The authors track 16 million individuals who published papers in 2008–15. Only about 4% of these people changed countries, but those who did had 40% higher average citation rates than those publishing solely in one region, a trend that held true across 13 regions. Importantly, mobile scientists retained ties in the countries they left.

The second argues that countries with mobile scientific workforces produce papers that are more highly cited. (These are the same countries that have the greatest fraction of internationally authored papers.) The analysis shows that a nation's willingness to let scientists cross borders was a better predictor of highly cited papers than was the proportion of its gross domestic product that it spent on research.

These are complex issues. Citation rates are not necessarily a sign of quality, influence or long-term importance. And many confounding factors hamper attempts to link policies to impact. Still, such studies are necessary to provide evidence for policies on how to best support the scientific system.

The benefits of international movement are not entirely clear-cut. Leading scientists who change institutional affiliation (but not country) seem to boost both output and impact (G. Halevi *et al. Publ. Res. Q.* **32,** 22–37; 2016). Further work could reveal whether international papers — or more-open countries — prompt more innovative or worthy science. Details of the

relative benefits of collaboration, or how the effects of an international move are mediated by discipline or career stage, must be teased out. So must the effects of particular policies, such as the ease with which potential trainees and working scientists acquire visas or other travel support.

There is a bigger question: does the flow of leading scientists into a country bring tangible benefits for the citizens whose taxes fund their work? What about when one country's funds flow to a scientist's international collaborators? Evidence from patents and technological advances suggests that such investment is rewarded. But attention must be paid to ensure that a nation's connection to elite international scientists also supports work on local interests and needs.

Meanwhile, the scientific powerhouses of the United States and the United Kingdom seem determined to close their doors. US travel restrictions put in place last week tell working scientists from eight countries to stay away. And Britain's departure from the European Union puts scientific collaboration and access to European funds at serious risk.

Many nations with more-welcoming attitudes are poised to benefit. One long-term trend is clear: existing scientific powerhouses are not destined to stand forever. The picture can change — and quickly.

Journal name:
Nature
Volume:
550,
Pages:
7–8
Date published:
(05 October 2017)
DOI:
doi:10.1038/550007b

Comments

Comments

There are currently no comments.

Nobel prizes, giant telescope and buried treasure

The week in science: 29 September–5 October 2017.

04 October 2017

Events | Research | Funding | Facilities | People | Trend watch

EVENTS

Antikythera wreck yields more treasures Marine archaeologists investigating an ancient shipwreck near the island of Antikythera, Greece, announced on 4 October that they have recovered bronze and marble statue pieces, a sarcophagus lid and a mysterious bronze disc decorated with a bull. The cargo ship, which dates to the first century bc and was rediscovered in 1900, is famous for yielding the Antikythera mechanism, a complex bronze geared device that showed the movements of the Sun, Moon and planets in the sky. A team led by archaeologists Brendan Foley of Lund University, Sweden, and Theotokis Theodoulou of the Greek Ephorate of Underwater Antiquities in Athens found the latest artefacts under boulders in a previously unexplored part of the site. They think that at least seven complete statues are still buried nearby.

Brett Seymour/EUA/ARGO 2017

The bronze disc found near the shipwreck.

Volcano threats More than 100,000 residents on the Indonesian island of Bali have reportedly been evacuated to shelters following increased seismic activity from Mount Agung. The government's Center for Volcanology and Geological Hazard Mitigation said on 29 September that, on the basis of the latest information, an eruption was still a probability. Meanwhile, in Vanuatu, the government ordered the evacuation of all residents of Ambae island — about 11,000 people — on 28 September, after Manaro Voui started ejecting lava, poisonous gas and ash. On 1 October, the Vanuatu Meteorology and Geo-hazards Department said the volcano's activity was settling, and a large eruption was less likely. However, as *Nature* went to press, evacuations continued.

Time capsule On an Arctic island, scientists have buried a stainless-steel tube stuffed with artefacts that they say sum up science and technology in 2017. The time capsule, placed in an out-of-use borehole near the Polish

Polar Station in Hornsund, Svalbard, contains samples that include DNA, silicon-based electronics, an ancient meteorite fragment and other items to inform a future discoverer of our present understanding of technology, geology and biology. A team with the Polish Academy of Sciences described the capsule — created to celebrate the sixtieth anniversary of Poland's polar station — in a report in *Gondwana Research* on 28 September.

RESEARCH

Space-time ripples Physicists have announced the first discovery of gravitational waves made together by observatories in Europe and the United States, and the fourth-such discovery overall. At a 27 September press conference, researchers said that on 14 August, both the Virgo observatory near Pisa, Italy, and the twin laboratories of the US Advanced Laser Interferometer Gravitational-Wave Observatory (LIGO) in Livingston, Louisiana, and Hanford, Washington, had picked up gravitational vibrations emanating from a pair of merging black holes 540 million parsecs (1.8 billion light years) away. Observing the event with three detectors, rather than LIGO's two, enabled scientists to pinpoint the location of and distance to the black holes with much greater accuracy. Virgo rejoined the hunt for the waves only on 1 August, after a five-year upgrade.

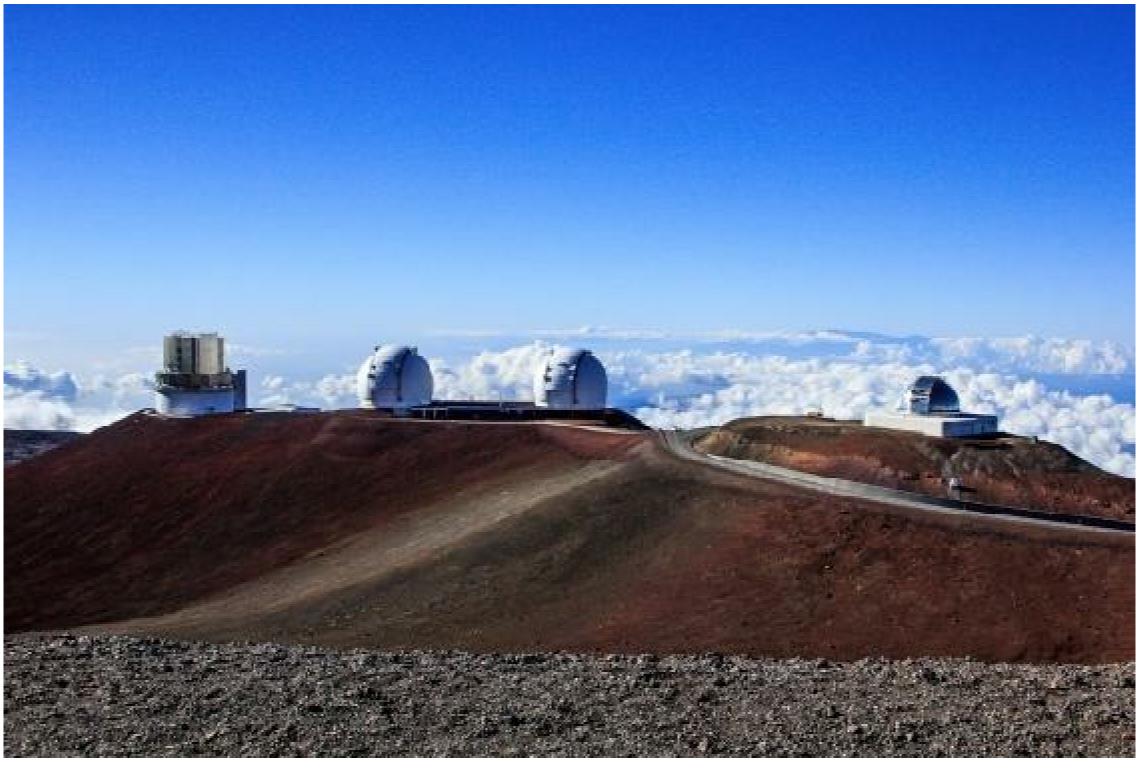
Monkey research The US Food and Drug Administration (FDA) has suspended a study on the effects of nicotine on monkeys after activists, including primatologist Jane Goodall, decried the experiments as cruel. On 25 September, FDA commissioner Scott Gottlieb responded to a 7 September letter from Goodall that called the experiments unnecessary, given that the effects of smoking are well known. The study, which began in 2014 at the FDA's lab in Jefferson, Arkansas, allows monkeys to self-administer nicotine. Gottlieb told Goodall that it would be halted while a team of experts assesses the monkeys' health and determines whether more precautions are needed. The team will also decide whether the study should resume.

FUNDING

French budget French research funding is set for a heartening increase in the country's first budget under President Emmanuel Macron, if draft 2018 plans released on 27 September are voted into law. The research portfolio of France's ministry of higher education, research and innovation would rise by more than 6%, to €8.4 billion (US$9.9 billion) in 2018. And a giant economic-recovery plan unveiled on 25 September by Prime Minister Edouard Philippe should divert an extra €2.4 billion to research over the next five years. Separately, in a 26 September speech, Macron backed the idea of a European Union funding agency to accelerate the commercial applications of basic science, an idea also suggested by EU research commissioner Carlos Moedas.

FACILITIES

Hawaii telescope Hawaii's board of land and natural resources granted a new construction permit to the Thirty Meter Telescope (TMT) on 28 September, reviving the chances that it could be built on the Hawaiian mountain of Mauna Kea. Some Native Hawaiians oppose the TMT, saying that its construction would further violate the sacred mountain, which already hosts multiple telescopes. Hawaii's supreme court invalidated the TMT's first construction permit in December 2015, ruling that the board had not followed appropriate procedures. The new permit gives the project the right to proceed on Mauna Kea, but telescope opponents have filed motions that would put the permit on hold until the state supreme court can hear an appeal.



Julie Thurston/Getty

PEOPLE

Nobel prizes Three biologists were awarded this year's Nobel Prize in Physiology or Medicine for their work on circadian clocks. Jeffrey Hall and Michael Rosbash, both at Brandeis University in Waltham, Massachusetts, split the award with Michael Young at Rockefeller University in New York City. The physics prize was awarded to Rainer Weiss, at the Massachusetts Institute of Technology in Cambridge, and Barry Barish and Kip Thorne, both at the California Institute of Technology in Pasadena, for their work on detecting gravitational waves. *Nature* went to press before the chemistry prize was awarded, but full details will be available at go.nature.com/chem2017.

Science adviser On 26 September, Canadian prime minister Justin Trudeau appointed biochemist Mona Nemer as his country's chief government science adviser, fulfilling his campaign promise to establish the position. Nemer was

most recently vice-president of research at the University of Ottawa and director of the Molecular Genetics and Cardiac Regeneration Laboratory there. Her scientific work has focused on the genetics of cardiovascular disease and birth defects. In her new role, Nemer will have a budget of Can$2 million (US$1.6 million) and report to Trudeau and science minister Kirsty Duncan. The country has been without a science adviser for nearly a decade; the last time such a post existed was from 2004 to 2008.

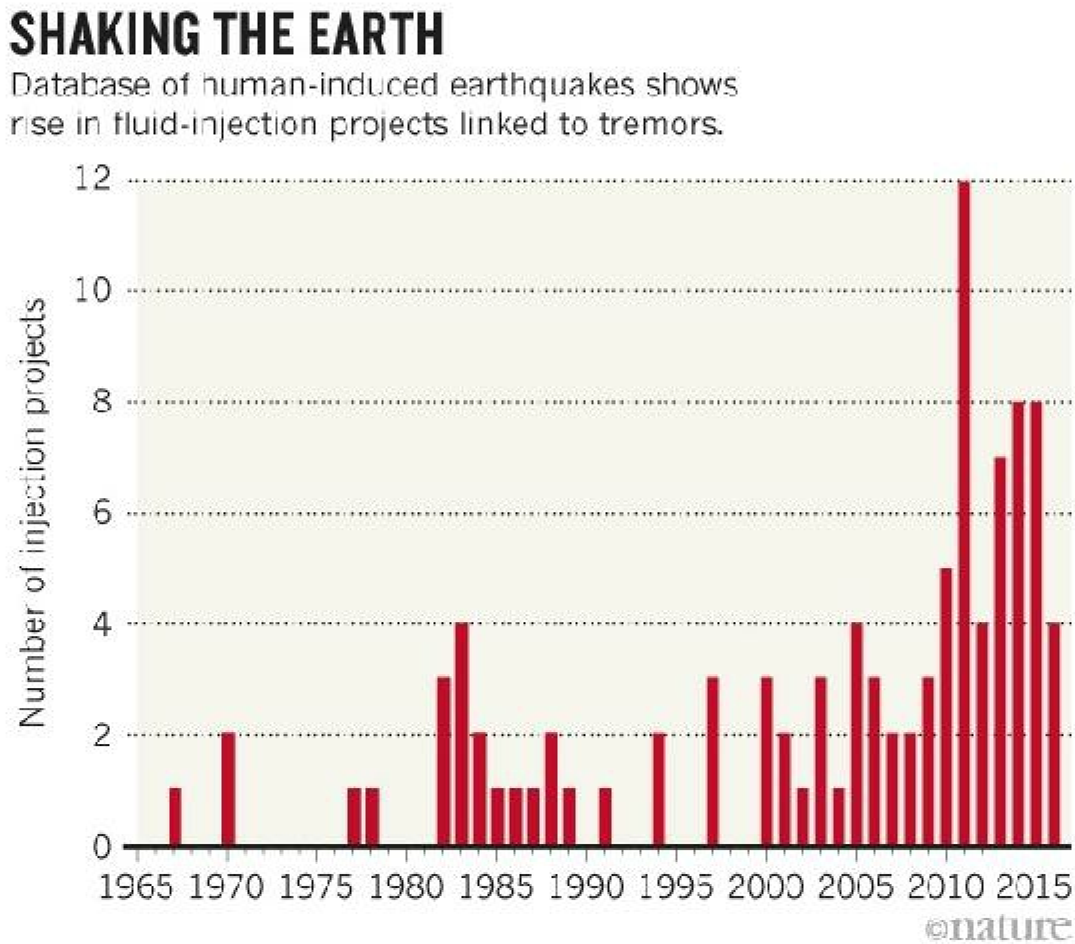
Russian academy After almost six months without a head, the Russian Academy of Sciences (RAS) has a new president: Alexander Sergeyev, a laser physicist and director of the RAS Institute of Applied Physics in Nizhny Novgorod. The academy, which operates a network of hundreds of institutes, is undergoing controversial reforms. In March, its planned presidential elections were unexpectedly cancelled at the last minute, allegedly following a row over voting procedures (see *Nature* **543,** 601; 2017). In the latest elections announced on 26 September, Sergeyev won a majority of votes from the academy's general assembly. A new state law requires that Russia's president Vladimir Putin must also approve the post, which he did the following day.

Defraud alert The FBI has charged bioengineer Yiheng Percival Zhang with defrauding the US government and his employer, the university Virginia Tech in Blacksburg. Zhang was arrested on 20 September and will remain in custody pending a trial, according to court documents. In an affidavit in support of a criminal complaint filed on 18 September, the FBI alleged that Zhang and two of his colleagues at the Tianjin Institute of Industrial Biotechnology in China — Zhiguang Zhu and Chun You — conspired to win US National Science Foundation (NSF) grants for studies that had already been completed in China. The affidavit also claims that Zhang withheld a portion of funds owed to his university from NSF and Department of Energy grants.

TREND WATCH

A database of human-induced earthquakes reveals a rise in tremors linked to wastewater injected into the ground by oil and gas operations. Such projects

spiked in the early 2010s, particularly in the central United States. The HiQuake database is described in *Seismological Research Letters*. Of 728 entries, 37% are linked to mining, 23% to water piling up behind a dam and 15% to conventional oil and gas development. Just 4% are linked to hydraulic fracturing, or fracking, for oil and gas.



Source: M. P. Wilson et al. Seismol. Res. Lett. http://dx.doi.org/10.1785/0220170112 (2017)

Journal name:
Nature
Volume:
550,
Pages:

12–13
Date published:
(05 October 2017)
DOI:
doi:10.1038/550012a

Comments

Comments

There are currently no comments.

Why fake islands might be a real boon for science

The seasteading movement is getting close to building its first prototype, an artificial archipelago where people will live, play and do research.

04 October 2017

Blue Frontiers

Early designs for a floating island in Tahiti aim to mimic a natural landscape.

The view is unbeatable. To the right, steep volcanic mountains, draped in green, rise up from a beachside coconut grove. To the left, the Pacific Ocean glitters turquoise under the midday sun. It is here in this Tahitian lagoon that a group of entrepreneurs plans to build an artificial island — three-quarters of a hectare of floating housing and research space, made up of linked platforms. If the team is successful, the vision could become reality by 2020. But it would be just the first step, says self-described “seavangelist” Joe Quirk. The ultimate goal is to build whole sovereign nations on the open seas, composed of modular floating units.

“French Polynesia has all the stepping stones: lagoons, atolls, shallow waters

right next to deeper waters," Quirk says.

Quirk, one of five managing directors for the company behind the project, and his colleagues propose that artificial islands could serve as laboratories for testing out new technologies and exploring different social structures, or act as life rafts for coastal peoples displaced by sea-level rise.

The non-profit Seasteading Institute was founded by former Google engineer Patri Friedman in 2008, and it has garnered support from influential people in the linked worlds of Silicon Valley, libertarian politics and the anything-goes desert festival, Burning Man. Most media reports have been sceptical, however. The project has been characterized as the dream of "two guys with a blog and a love of Ayn Rand"[1] and "a hacker's approach to government with a *Waterworld*-esque conception of Manifest Destiny"[2].

But the Seasteading Institute and the new for-profit spin-off, Blue Frontiers, have racked up some real-world achievements in the past year. They signed a memorandum of understanding with the government of French Polynesia in January that lays the groundwork for the construction of their prototype. And they gained momentum from a conference of interested parties in Tahiti in May, which hundreds of people attended. The project's focus has shifted from building a libertarian oasis to hosting experiments in governance styles and showcasing a smorgasbord of sustainable technologies for, among other things, desalination, renewable energy and floating food-production. The shift has brought some gravitas to the undertaking, and some ecologists have taken interest in the possibilities of full-time floating laboratories.

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Reporter Geoff Marsh investigates ambitious plans to build artificial floating cities.

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But the project still faces some formidable challenges. The team must convince the people of French Polynesia that the synthetic islands will benefit them; it must raise enough money to actually build the prototype, which it estimates will cost up to US$60 million; and once it is built, the group must convince the world that artificial floating islands are more than just a gimmick. Producing solid science and broadly useful technology would go a long way towards making that case.

“What we are dreaming is that this structure will be a scientific laboratory,” says Winiki Sage, head of the Economic, Social, and Cultural Council of French Polynesia in Tahiti, who has been concerned about brain drain from his country.

Aesthetic appeal

Designs are surfacing for the prototype island, and its look is a key part of Blue Frontiers's public-relations strategy. The company's current plans don't entirely align with the concept art on the Seasteading Institute's website, which swings from tiki bar to Tomorrowland in various iterations. Bart Roeffen, a 'water pioneer' at the Dutch design firm Blue21 in Delft, has been drawing up new plans that fit with the landscape and culture.

“We are working together with Tahitian designers to make something that is not like an alien invasion,” Roeffen says. In particular, he plans to take cues from Polynesian shipbuilding. The elegant outrigger canoes, or *va'a*, used by islanders are stable and light; oceangoing versions are the type of boat rowed by the Tahitian voyagers who discovered Hawaii and New Zealand around AD 1100. Linked platforms would be arranged to ensure that no coral below is completely shaded and killed. The goal is to actually expand the habitat for reef species (see 'Seasteaders in paradise').

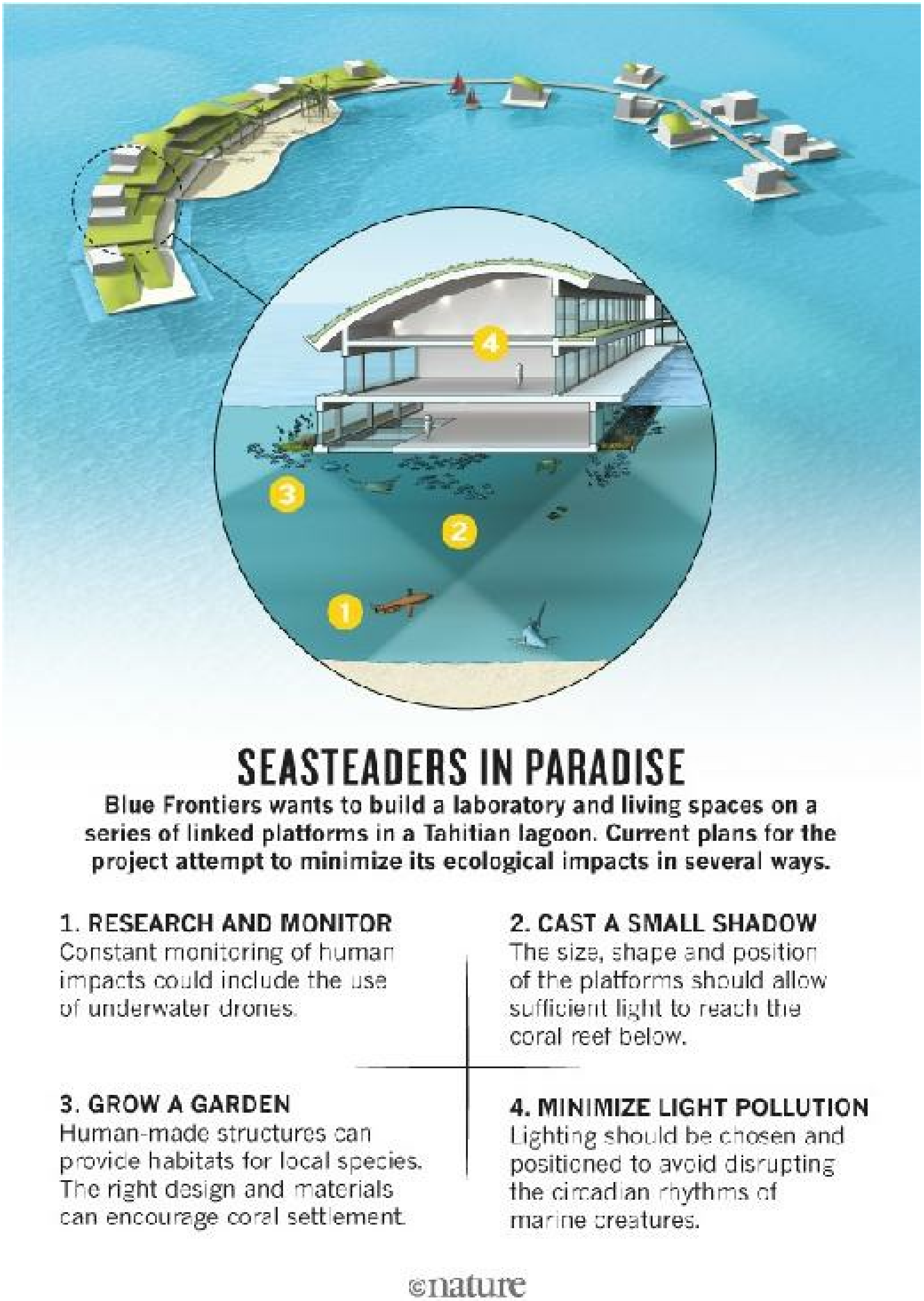

Illustration by Emily Cooper

The team would not provide direct information about funding. Paypal

founder and one-time Donald Trump enthusiast Peter Thiel provided a reported $1.7 million to the Seasteading Institute, but he last contributed to the project in 2014, and any recent investors are keeping a low profile. Quirk says that they have “a nice amount” of seed money and are preparing for what is called an initial coin offering — an investment mechanism that uses digital cryptocurrency. Looking ahead, the company hopes to generate revenue by renting out space on the island and acting as consultants for other would-be island builders. Along with hiring Quirk and the other four managing directors, Blue Frontiers has recruited ten staff members and commissioned environmental, legal and economic studies on the impacts of the project for investors and the government.

The “why?” — everyone's first question about seasteading — is answered differently by everyone involved. Some are captivated by the project because it is an excuse to push sustainable design to the next level. For people on low-lying islands, it looks like a life raft. Félix Tokoragi, mayor of Makemo, an atoll in the Tuamotu archipelago in French Polynesia, told Blue Frontiers that he's interested. The Tuamotus have experienced widespread flooding, and Tokoragi is worried that his people will become climate-change refugees. “We are attached to our atoll; we are attached to our culture,” he says. “We are not against this idea, since the technology can respond to the problems that we face.”

For others, the pull of the project comes down to autonomy and self-reliance, particularly with respect to governance: anyone who decides their island's political style is not for them can detach and depart for another system that they like better.

For at least one scientist advising the project, Neil Davies, executive director of a field station of the University of California, Berkeley, on the neighbouring island of Moorea, the island's appeal is as a base for research that would “fill the gap between oceanographic-research vessels and coastal marine labs”. Ships are on the water, but they are “phenomenally expensive”, he says, and they don't stay put. Coastal labs can gather long time-series of data in one place, but don't provide access to deeper water. Davies dreams about floating “sea stations” that would allow low-cost, long-term access to the ocean for research, especially for students in tropical countries “where

natural systems are among the most sensitive to human activities”, he says. Experiments could include modifying pH or temperature on small sections of a reef to simulate future environmental conditions, and 'planting' different corals to investigate which will thrive best in the future. Data could be gathered using semi-permanent sensors and cameras, along with regular biological-sample collection.

Some scientists not involved in the project see value in the concept, as well. “If you have a floating island and you want long-term study, that is a perfect way to do it,” says Ross Barnes, marine-operations superintendent at the University of Hawaii Marine Center in Honolulu, who oversees two large research vessels and on-shore labs. The university has been conducting research at a spot in the ocean that it calls Station ALOHA, which scientists have visited nearly 300 times by boat since 1988. A floating platform, he says, would mean that scientists could leave behind some instruments — and that some of them could stay as well — allowing for continuous measurement. “It's a good idea,” Barnes says.

Currently, Davies is advising the seasteaders on site selection and environmentally positive design choices. He also plans to help them to document the installation's performance using sensors that measure things such as energy expenditure and waste generation on the platforms, as well as water temperature and quality. And he sees it as a great teaching opportunity for the many students who visit his station. “Seasteading raises many social, legal, ethical, environmental issues, even if it never gets anywhere,” he says.

Whether the seasteaders make progress depends on whether the project is embraced by French Polynesia, a largely autonomous 'overseas collectivity' of France with a population of 287,000 on 67 islands spread out across an area nearly the size of Europe. At one level, a grand floating project could appeal to a nation of voyagers and boat builders. But French Polynesia has been burnt by big-science and technology projects before. From 1966 to 1996, France conducted 193 nuclear tests in its Polynesian possessions, many in the atmosphere. In February 2016, then-president of France François Hollande admitted that the testing had harmed the environment and human health. And the place is littered with defunct projects and closed hotels.

“We have a history of being taken for fools,” says Pauline Sillinger, a

sustainable-development specialist at Te Ora Naho, a federation of environmental groups in French Polynesia, who took a job with Blue Frontiers this year, and also teaches Tahitian dance. “Nuclear testing, big hotels, nice, smiling, white, intelligent people telling us it'll be good for us.”

But their wariness vies against their desperation for new revenue streams, Sage says. After winding down nuclear testing, France began paying French Polynesia more than US$100 million per year in compensation for lost income from military activity. But in 2016, that amount was reduced. Meanwhile, tourism revenues have never recovered from the 2008 recession. Thanks to increased political stability and other factors, things have improved since 2014, when the collectivity was so broke that it risked not being able to pay its civil servants, according to Sage. But it is still dangerously reliant on a small number of income sources — tourism, pearls, coconut oil. Unemployment stands at nearly 18%. “We are looking for new ideas,” Sage says. “We are really open to any ideas, any investors.”

If Sage is sceptical but willing to give it a shot, there are others who have had enough of grandiose project ideas. Among them is a religious leader in Tahiti, Frère Maxime Chan, who heads Association 193, which advocates on behalf of those harmed by nuclear testing. Chan is also vice-president of Te Ora Naho. (Sage, incidentally, is the organization's president.) Chan says that his old friend Sage and the rest of the government are “dazzled” by the flash and money of the Seasteaders. He talks about recent projects — including a tourist resort, an aquaculture scheme and an eco-resort — that were all announced with fanfare and optimistic job projections, only to be cancelled, scaled back or put on indefinite hold. Chan wishes the government would admit that the standard of living for the average Tahitian has been artificially inflated by nuclear-test payments and must come down. This can be done without suffering, Chan contends, by gracefully returning to a version of the pre-1960s subsistence economy. “Small is beautiful,” he says.

Convincing French Polynesia to support the project will fall mainly to Marc Collins, another managing director of Blue Frontiers. Collins is Tahitian and lives there now, but in the early 1990s he lived in Silicon Valley, and fell in love with its fast-paced culture of big ideas and endless possibility. Ever since, he's kept his toe in those waters in part by maintaining a subscription to

Wired magazine. In May 2015, the digital lifestyle glossy ran a story[3] about how the seasteading movement planned to scale back its grand, high-seas concept, reorienting towards safer, shallower waters and looking for “cost-reducing solutions within the territorial waters of a host nation”.

Collins, a serial entrepreneur who has dabbled in every major French Polynesian industry, from hotels to black pearls and telecommunications, saw an opportunity to, as he puts it, “bring some of the DNA of Silicon Valley to Tahiti”. Tahiti joined the world of high-speed Internet in 2010, with the completion of an undersea fibre-optic cable linking it to Hawaii. It has calm lagoons aplenty and daily flights from Los Angeles, California, and, as a minor bonus, is widely regarded as paradise on Earth. Collins fired off a LinkedIn request to the Seasteading Institute's executive director, Randolph Hencken.

The Seasteaders were interested in Collins's pitch, but they wanted a more official gesture of support. So Collins, who served as French Polynesia's minister of tourism in 2007 and 2008, began working his government contacts. By August, the president of French Polynesia, Édouard Fritch, signed a letter formally inviting the Seasteaders to present their ideas. A delegation of nine took him up on the offer the next month, and by January, a memorandum of understanding with pledges of cooperation was signed.

The next step in making the island a reality will be the passage of a law defining the 'special economic zone' that will cover the synthetic island. Blue Frontiers isn't asking French Polynesia for any subsidies to build the island, but it is asking for a 0% tax rate, among other regulatory exceptions. It has hired French firm GB2A, based in Paris, to prepare legal research and a set of requests, which Blue Frontiers presented to the government at the end of September. The team hopes to see a bill emerge before the end of the year.

In the meantime, the Seasteading Institute is building excitement and courting potential investors with a series of gatherings. In May, it held talks, networking events and tours in Tahiti. Speakers included Fritch; Tony Hsieh, chief executive of online retailer Zappos in Las Vegas, Nevada; Tua Pittman, a master canoe navigator from the Cook Islands; and engineers, nanotechnologists and a 'blockchain strategist', a specialist in the distributed information systems behind cryptocurrencies. The seasteaders hope to use

such systems to handle their financials, as well as any scientific data that they generate. But the event wasn't all work. An announcement for a party on outrigger canoes cheerfully suggested: “Do not wear heels. Bring a swimsuit for an optional moonlight swim.”

On 22–29 October, Blue Frontiers will hold an Insiders Access Week for supporters and potential investors, a mix of tours, discussion and morning yoga with Hencken. Always ambitious, the team hopes to have draft legislation from the Polynesian government by then, and some detailed architectural plans. The goal is to break ground — or rather, sea — in 2018.

While all this work goes on behind the scenes, the lagoon remains fairly quiet. On a day in July, locals compete in a stand-up paddle-board race while families play on the shore and young women drink beer with their feet in the waves. By the roadside, freshly caught tuna are for sale. On one level, it is hard to imagine this place being improved upon.

Time will tell whether the Seasteaders' island becomes a refuge for Polynesians facing rising seas and an incubator for Polynesian science and business, or merely a playground for wealthy foreigners who want to dodge bothersome regulations. That is, if it materializes at all.

Journal name:
Nature
Volume:
550,
Pages:
22–24
Date published:
(05 October 2017)
DOI:
doi:10.1038/550022a

Comments

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How fracking is upending the chemical industry

As shale-gas compounds flood the market, chemists are working out the best ways to convert them into the ingredients of modern life.

04 October 2017

Jeff J Mitchell/Getty

A ship carrying US shale gas, the *Ineos Insight*, approaches port in Scotland in September 2016.

As the *Ineos Intrepid* cruised slowly through the sapphire waters of Norway's Frierfjord, chaperone tugboats sprayed jets into the sky to herald her arrival. In giant refrigerated tanks below decks, the ship carried 27,500 cubic metres

of liquid ethane — enough to fill 11 Olympic swimming pools. *Intrepid* also brought a message, painted in giant capital letters along her side: “SHALE GAS FOR PROGRESS”.

The vessel's arrival in March 2016 brought the first ever shipment of shale gas from the United States to Europe — and marked the start of a burgeoning business. More of these 180-metre-long 'Dragon'-class vessels have followed in her wake, forming a 'virtual pipeline' for ethane across the Atlantic Ocean. This gas, which is extracted from the ground through the hydraulic fracturing of shale deposits, isn't destined to fuel power stations or domestic stoves. Instead, it will be transformed into the chemical building blocks needed to make a panoply of products, including plastics, clothes, adhesives and medicines.

Intrepid's voyage is a striking demonstration of how cheap US shale gas is reshaping the chemical industry and changing the origin of countless manufactured objects. For decades, the industry's raw ingredients have mostly come from crude oil. Chemical plants break down long hydrocarbon molecules in crude to produce a smorgasbord of smaller molecules, such as ethene, propene and benzene — all important precursors to polymers.

But shale gas, which is composed mainly of methane, ethane and propane, is turning that pathway on its head. The abundance of the gas has slashed the costs of these molecules. As a result, some are now usurping large hydrocarbons as the preferred starting point for industrial synthesis.

This shift from oil to gas brings enormous opportunities. According to the American Chemistry Council, a trade group based in Washington DC, the shale boom has attracted about US$160 billion in investment from the US chemical industry since 2011, and will help to create half a million jobs in plastics manufacturing over the coming decade[1]. But it also poses huge challenges. Some of the main techniques that are used to turn the components of shale gas into more valuable compounds — processes generally known as upgrading — are decades-old, dirty and energy-intensive. And they rarely produce the same mix of chemicals as conventional oil-based routes, which means that some relatively minor, yet valuable, chemicals such as butadiene, an ingredient of synthetic rubber, are becoming scarcer.

These challenges are driving an intensive research effort, spanning industry and academia, to develop catalysts and reactors that can transmute small hydrocarbons in cleaner, cheaper and more efficient ways.

Translating that research into commercial production will depend on the finely balanced economics of a changeable market. It will also require a reliable supply of gas. The US Energy Information Administration predicts that natural-gas extraction in the United States will continue to grow until at least 2040, but that might be too optimistic (see Nature 516, 28–30; 2014). Meanwhile, concerns that fracking can contaminate groundwater — along with the broader climate implications of extracting fossil fuels — continue to dog the technology. If the glut does persist, however, it could usher in technologies that would form the foundations of a much more sustainable chemical industry. “We could totally redesign our chemical plants,” says Bert Weckhuysen, a chemist at Utrecht University in the Netherlands.

The ethane revolution

Shale gas is extracted from kilometres below ground, and typically contains about 70–95% methane, less than 15% ethane and less than 5% propane. After traces of oil, water and other impurities are cleaned out, the gas is chilled so that ethane and propane can be separated in liquid form, leaving methane behind.

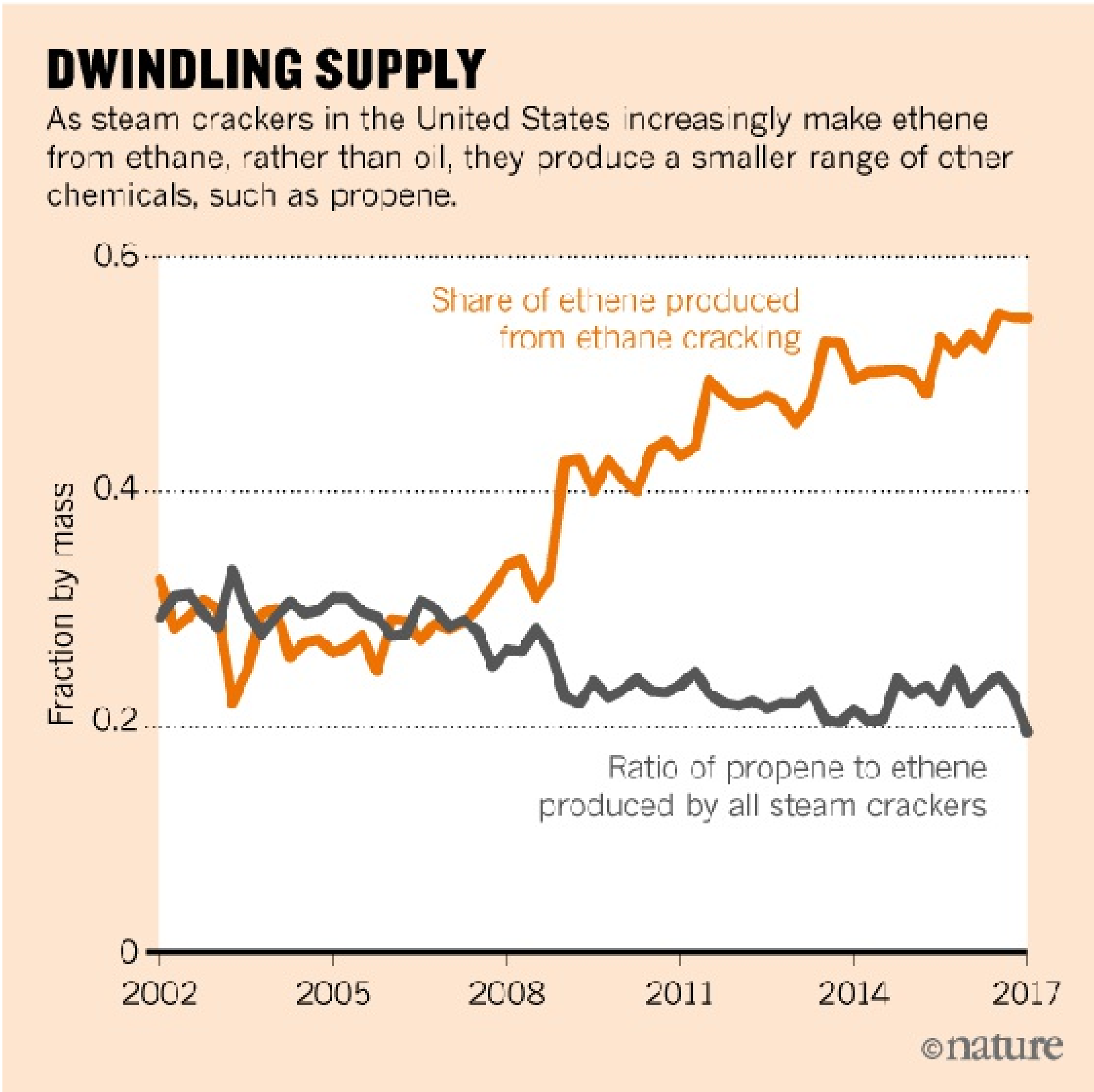
Although ethane makes up a small proportion of shale gas, it has so far had the biggest impact on the chemical industry. That's because chemists can easily use it to make ethene, also known as ethylene. Ethene is used to make various types of polyethylene and the precursors to other plastics, such as polyvinyl chloride (PVC) and polystyrene. So voracious is the world's appetite for these plastics that the chemical industry produces roughly 150 million tonnes of ethene every year, more than any other chemical building block.

Most processes in the chemical industry use catalysts. But ethene can be produced simply by steam cracking ethane or larger hydrocarbons. First developed in the 1920s, steam cracking is a blunt, energy-intensive process

that requires little more than water and 850 °C temperatures. “You basically just heat the snot out of it,” says Jeffrey Plotkin, an industry analyst at IHS Markit in New York City. “The heart and soul of the thing is this gigantic furnace, that's where all the chemistry happens.”

The boom in shale-gas-derived ethane has driven the chemical industry to invest nearly $45 billion in extra steam-cracking capacity[2]. But the transition to this feedstock is also creating a headache. When steam crackers are fed with mixtures of long hydrocarbons from crude oil, they make an array of useful by-products. But when they are supplied with ethane, the output is almost entirely ethene. “So there is a shortage of other building blocks,” says Weckhuysen.

One of those building blocks is propene, arguably the second most important product of the chemical industry after ethene. Propene is turned into polypropylene, a plastic used in packaging and textiles, along with other polymer ingredients such as acrylic acid. But by one estimate, propene production by US steam crackers dropped by almost half between 2005 and 2014, even as global demand rose (see 'Dwindling supply').



Source: S&P; Global Platts

To combat the shortfall, the industry is rolling out alternative ways to make propene. One of the leading routes starts with the shale-gas component propane. A combination of heat and a catalyst to remove two hydrogen atoms can be used to turn it into propene.

The conversion is becoming more profitable: more than 20 of these propane-dehydrogenation units are already operating worldwide, and at least 40 more have been ordered since 2011. But Weckhuysen says that there is much scope to improve the process, which tends to chew up catalysts quickly, requires a

time-consuming and costly catalyst-regeneration step, and can use harsh reagents.

The methane question

Although ethane and propane are already making waves as commercial feedstocks, the big prize for chemists is to upgrade the most abundant component of shale gas: methane.

Most of the world's methane is currently burnt as fuel, its lowest-value application. The gas can also be used as a chemical feedstock, but it contains strong carbon–hydrogen bonds that are difficult to break in a controlled way. When methane is converted into other molecules, it is done mainly through an inefficient sledgehammer of a process called steam reforming. First commercialized in the 1930s, this involves smashing methane and water together at up to 1,100 °C, over a metal catalyst. It produces an extremely useful mixture of carbon monoxide and hydrogen called syngas — and also emits several hundred million tonnes of carbon dioxide per year, accounting for roughly 3% of all industrial emissions[3].

Syngas is the world's principal source of hydrogen, much of which goes to make the ammonia in fertilizer. Syngas can also be used to produce longer hydrocarbons, such as basic components of diesel and waxes.

Such upgrading is typically done through a technique called the Fisher–Tropsch (FT) process, which uses cobalt or iron catalysts and heat to create daisy-chains of carbon atoms. FT was developed in Germany in the 1920s to make petrol and a wide range of other hydrocarbons from syngas derived from coal.

Producing transport fuels in this way is generally more expensive than refining oil. There are just six large-scale FT plants in the world, made economical only thanks to their proximity to huge coal or gas fields and the mind-boggling scale of the plants themselves: the world's largest, in Qatar, cost $19 billion to build and munches through 45 million cubic metres of methane every day, on a par with the natural-gas consumption of Belgium.

Courtesy Velocys

A plant in Oklahoma City owned by ENVIA Energy uses compact reactors developed by Velocys to turn methane-derived gas into products such as diesel.

But the shale boom has prompted chemical engineers to take a fresh look at the FT process. Shale-gas wells typically don't produce enough gas to support a conventional FT plant, so research teams and companies have been developing smaller reactors that can process modest gas flows. One of those is Velocys, based in Houston, Texas, which developed a 5-metre-long reactor that can convert syngas into substances such as naphtha, diesel and wax. Its reactor technology is being used in Oklahoma City in the first commercial mini-FT plant in the United States. The plant, which is owned by ENVIA Energy, started production earlier this year.

Temperature control is a big challenge for the FT process: the reaction kicks in at about 180 °C, then generates huge amounts of heat. If not carefully controlled, it will run away with itself, turning carbon atoms into useless soot. To address this, Velocys's reactor contains corrugated layers of channels that

are alternately stuffed with catalyst or filled with water. This keeps the reaction running at a steady 200 °C, so that the reactor can use an efficient catalyst without risking a runaway reaction. “It allows you to pack a lot of reaction in a very small space,” says Neville Hargreaves, business-development director for Velocys in Oxford, UK.

The reactor in Oklahoma City pulls methane from a landfill site, an activity that comes with renewable-energy credits. But Hargreaves thinks companies could ultimately profit by tapping remote and relatively small natural-gas reserves that are unlikely to get a pipeline. Another potential target is unwanted gas from oil wells, which is often simply burnt off. Such 'flaring' puts about 350 million tonnes of CO_2 into the atmosphere every year. According to the World Bank, it carries enough energy to meet Africa's entire current electricity requirements.

The direct route

The high temperatures involved in producing syngas will always make it a costly way to create complex chemicals — as well as a major source of CO_2 emissions. Researchers have spent decades looking for ways to convert methane directly to methanol or other products, cutting syngas out of the route altogether. The shale boom has given this effort fresh urgency, along with a burst of investment in research and development in both academia and industry.

Turning methane into methanol — itself a key precursor to a wide range of other compounds — involves adding only a single oxygen atom. But first, one of methane's strong carbon–hydrogen bonds must be broken, and the high temperatures or strong oxidants needed to do that can set the molecule on a one-way journey down a thermodynamic roller coaster with a messy end. Methanol sits on a brief crest about halfway down, but it is all too easy to race downhill as the reaction goes too far, producing a mixture of other molecules, including formaldehyde, formic acid or carbon monoxide.

In 2005, however, a team led by Robert Schoonheydt at the University of Leuven in Belgium, found[4] that copper seeded onto a porous material called a

zeolite could unite oxygen and methane to make methanol at less than 200 °C. Crucially, the methanol became trapped in the zeolite's pores, preventing further reactions. But extracting methanol from the pores and reactivating the catalyst would have proved expensive and impracticable in a commercial setting.

Since then, research groups have developed a range of copper–zeolyte catalysts that are more industry-friendly. Others have focused on completely redesigning chemical reactors. The European Union-funded project Adaptable Reactors for Resource- and Energy-Efficient Methane Valorisation, for example, aims to build small reactors that use renewable electricity, rather than heat generated from fossil fuels, to turn methane into compounds such as ethene and methanol. One approach uses microwaves to generate intense hotspots in the catalyst, lowering the heating requirements for the incoming gas.

Another approach to direct methane upgrading aims to couple pairs of the molecule together to make ethene. Since 2015, Siluria Technologies, a start-up in San Francisco, California, has been running a demonstration plant for this process in La Porte, Texas. It relies on a catalyst made of metal-oxide nanowires that collectively offer a surface area of about 200 square metres per gram of catalyst, hundreds of times more than a bulk catalyst could offer.

The company builds its catalysts in a unique way, based on a technique[5] developed by co-founder Angela Belcher, a materials scientist at the Massachusetts Institute of Technology in Cambridge. First, viruses are genetically engineered to express proteins that bind to dissolved metal ions. The ions form orderly arrangements as they stick to the surface of the virus. When the biological template is burned away, it leaves behind a highly stable, crystalline nanowire.

Rahul Iyer, Siluria's vice-president of corporate development, says that the process is cost-competitive with steam cracking ethane, and produces far fewer CO_2 emissions than steam reforming methane. Siluria has already licensed the technology to some chemical companies, and expects the first commercial facilities to be operating in 2019.

Plotkin says that Siluria is currently in the lead in the race to commercialize direct methane upgrading, and is backed by multimillion-dollar investments from big players in the industry. “People are keeping a watchful eye on it,” he says.

Gas that's greener

The shale-gas boom is credited with spurring a major renaissance in the US chemical industry, which has invested heavily in chemical plants and other infrastructure, as well as research and development. Enthusiasm for shale-gas upgrading has fostered major collaborations between academia and industry.

Translating laboratory results into commercial production is an ongoing challenge, although the trend towards small, modular reactors is helping to make it less daunting. The chemical industry is notoriously conservative: if a process succeeds in the lab but fails at commercial scale, tonnes of catalyst can be wasted and a plant shut down for months. “Industry will not take the risk unless they are sure it will work,” says Weckhuysen.

Despite these challenges, he is optimistic that gas upgrading could have a huge impact — not only on the chemical industry's processes, but also on its environmental footprint. Some of the reactor technologies being developed to feed on shale gas could be adapted to use bio-based feedstocks, such as methane from landfills, as Velocys has found. Meanwhile, shortages in some compounds caused by the shift to shale gas could improve the economic case for starting with ethanol from crops, or lignin from wood[6]. There has already been movement along these lines. In 2013, for example, French tyre-maker Michelin and partners launched a €52-million (US$61-million) project to make butadiene from bioethanol.

But for now, US shale ethane continues its relentless march around the world. More chemical companies are commissioning ships to transport the gas to destinations in Europe, Brazil and India. By 2022, according to one estimate, about 8 million tonnes of ethane will flow through these virtual pipelines each year. They will carry this revolution in the US chemical industry to the rest of the globe — both its challenges and its opportunities.

Journal name:
Nature
Volume:
550,
Pages:
26–28
Date published:
(05 October 2017)
DOI:
doi:10.1038/550026a

Comments

Commenting is currently unavailable.

Scientists have most impact when they're free to move

04 October 2017

An analysis of researchers' global mobility reveals that limiting the circulation of scholars will damage the scientific system, say Cassidy R. Sugimoto and colleagues.

Spencer Platt/Getty Images

Measuring the global movements of researchers will help to assess the effects of political actions on science.

Recent political upheavals portend an era of increased isolationism in

science, with a chilling effect on collaboration and mobility. Last month, US President Donald Trump issued his third travel ban in a year, suspending entry of individuals from several countries into the United States, and placing restrictions on many more for visa renewals. These orders have stranded scholars abroad and prevented those who were in the country from engaging in international work. In March, UK Prime Minister Theresa May began the process of formally severing ties with the European Union. As a result, British institutions face a potential exodus of non-resident EU researchers and will have to overcome barriers to participating in and receiving funding for European collaborative projects. The list of countries engaging in these isolationist actions, and the list of actions themselves, grows longer.

To assess the impacts of such political actions, we need better ways to measure researcher mobility. Although the size and composition of the scientific workforce is fairly well established through national surveys and registries[1], less is known about how often researchers move, where they go, what networks they form, and how important their movement is to the scientific impact of their work[2].

We present here a new analysis based on the records of 14 million papers from nearly 16 million unique individuals who published between 2008 and 2015. In our study, some 96% of researchers had only one country of affiliation; we classed these as non-mobile. About 4% (more than 595,000 researchers) were mobile — meaning that they had more than one affiliation during that period. Our analysis revealed surprising trends.

Chain reaction

Over the study period, Europe and Asia saw a dramatic net loss of researchers, whereas North America saw large gains. Many commentators have anguished about 'brain drain' or 'brain gain', assuming that receiving countries get the lion's share of scientific capital at the expense of the nations from which researchers originate. The reality is more complicated (see 'Brain circulation').

We found that the majority of scientists didn't cut ties with their country of

origin but instead built a chain of affiliations that linked nations together. Many researchers returned to their home country. Brain circulation may be a more apt term for the movement of contemporary scholars[3].

Different nations have different roles in the circulation of elite scholars (for which our proxy is highly cited researchers). But wherever they are, wherever they stop off and wherever they come from, mobile scholars have about 40% higher citation rates, on average, than non-mobile ones (see Supplementary Information; Table S7). Closing borders takes these elite scholars out of circulation.

Origin stories

Our study looks at the country stated in a researcher's affiliation when they published their first paper, and uses this as their country of scientific origin (this should not be confused with where they were born). We then track whether they moved or gained new affiliations in other countries over the eight years of this study.

The conventional idea of mobility focuses on migrant researchers — those who begin publishing in one country and then move to another, at some point discontinuing their attachment to the previous country. This group made up less than one-third of the mobile researchers in our study (27.3%, or 162,519 researchers). By far the largest proportion were those we call travellers: scholars who retain a footing in their country (or countries) of scientific origin throughout their career, while gathering up more international affiliations to add to their name (72.7%, or 433,375 researchers). Nearly half of the travellers are 'non-directional': they have more than one affiliation in their first year of publication, and they retain all these affiliations in each publication year.

Circulation networks that map the number and flow of researchers reveal the importance of the United States, United Kingdom, France, Canada and Germany as prominent nodes in the global scientific network (see Supplementary Figure S2). Isolation of these countries would have dramatic consequences. Although the United Kingdom is not particularly central to researcher migration in the European Union, it serves a crucial function in providing a bridge for European scientists to other areas of the world (see Supplementary Figure S2). Isolationist policies in the United Kingdom could deconstruct this network, redirecting scholars through other countries.

More patterns emerge if we look only at migrants and directional travellers who moved between and within continents, who first published in 2008, and who published at least eight papers during the study period. Admittedly, our short time window means that we focus on junior scholars. But it avoids conflating them with senior scholars whose movement and networking are likely to differ.

This group comprised 12,046 researchers. Europe provides the largest share (35%) followed by about one-quarter each from Asia and North America (see 'Making tracks'). The relationship between these latter continents is strong:

the majority of mobile scholars associated with an Asian address in their first publication in 2008 have a North American address by 2015, and more than one-third of mobile North American scientists end up in Asia. Both of these trends can probably be explained by the same underlying phenomenon — the influx of Asian students into the United States (some of whom publish before their arrival, and others of whom do so afterwards), and their subsequent moves back to Asia.

We see a 22% net loss of researchers from Europe, a 20% loss from Asia, and a nearly 50% gain for North America (see Supplementary Table S4). European scholars make up the largest population of mobile scholars in nearly every country, with the exception of Asian countries, where most scholars are drawn from North America (see 'Scientist shuffle').

It is also of interest to know the degree to which certain countries are responsible for the production and cultivation of high-impact scholars. We assess this by looking at citation scores for mobile researchers before and after their moves (see 'Trip adviser').

Countries in North America and Northern Europe act as strong producers: they put into circulation scholars who are well-cited before they move. The same countries are also strong cultivators, identifying talent early and providing fertile ground for scholars to achieve high impact once they arrive. Asian regions are strong recruiters, gaining affiliations with established scholars who were well-cited before their arrival. Oceania is a notable incubator, affiliated with scholars who realize high potential once they move on.

Some migratory routes tend to be associated with highly cited scholars. Those from North America with the highest impact tend to land in Northern and Western Europe and, to a lesser extent, in Southeastern Asia. Mobile, high-impact Northern Europeans are recruited to Southern Europe; mobile, high-impact Western Europeans are recruited to Oceania and Eastern Asia.

Mobile scholars from Oceania produce particularly high-impact work when they arrive in North America and Southern Europe. Central and Western Asian scholars (including those from countries implicated in the US immigration ban) realized their highest citation rates for work done in North

America and Europe. Barring scholars from these countries is likely to displace high-impact ones to other nations.

Regardless of region, mobility pays in terms of citations. Across all regions, mobile scholars are more highly cited than their non-mobile counterparts. The advantage varies by region. Mobile North Americans see only a 10.8% boost in citations over their non-mobile colleagues. For Eastern European scholars, the gulf is 172.8%.

Mobility measures

Of course, our method has limitations. We cannot tell if our 'country of academic origin' represents country of birth, of academic training or of academic employment — it reveals solely where an individual began publishing. If researchers from some countries tend not to publish first in a journal indexed in the Web of Science, then our measures would underestimate mobility from these places. Those we have counted as 'non-mobile' might really be 'pre-mobile' — meaning that they have not yet moved. Furthermore, examining less than a decade of papers, focusing on journal articles and adding restrictions for number of publications may privilege certain disciplines in the analysis. And our study does not look at mobility rates within each country: for large nations such as the United States, these might be significant and interesting.

Internationally comparable mobility indicators for the scientific workforce are particularly necessary in an era in which mobility is growing, complicated and increasingly threatened. We need indicators that provide more nuanced and dynamic assessments of the exchange of human capital and the effect of this exchange on the knowledge economy, particularly given that the 'travellers' in our analysis account for the majority of mobile scholars. This study provides a start.

It might be argued that collaboration can continue, even when mobility is restricted. However, despite advances in computing, collaboration tends to be initiated and sustained through interactions that happen in person[4]. Limiting mobility is likely to have adverse effects on the scientific system, which is

increasingly dependent on international collaboration[5].

Disruption of the existing network would have serious effects on many nations, including large science producers and cultivators such as the United States. The country benefits significantly both from its centrality in the global knowledge network, and from the educational investments of other countries. Its exceptional contributions are disproportionately made by researchers who are both foreign-born and foreign-educated[6]. Disconnection would also seriously affect those nations that benefit from the United States' role as a cultivator — it invests in researchers who come from Asia and elsewhere and later return home.

Some countries may see benefits, however: isolationism among central countries can lead to advantages for other competitive nations. For example, the number of graduate-student applicants to Canada has risen since the change in the US administration (see go.nature.com/2fjc4i). However, if adequate scientific capacity does not exist in these other countries, global talent will not be cultivated to the extent it is today. With good bibliometric standards to measure the impact of mobility, we can test the effects of these political changes in the decades to come.

One thing is already clear. Internationally mobile scholars are in the minority, yet show the highest impact across the globe. Limiting the circulation of scholars will damage the entire scientific system.

Journal name:
Nature
Volume:
550,
Pages:
29–31
Date published:
(05 October 2017)
DOI:
doi:10.1038/550029a

Supplementary information

PDF files

1. Supplementary information (1.6M)

Comments

Comments

There are currently no comments.

Open countries have strong science

04 October 2017

Caroline S. Wagner and Koen Jonkers find a clear correlation between a nation's scientific influence and the links it fosters with foreign researchers.

Spencer Platt/Getty

Nations that welcome international researchers and encourage cross-border collaboration tend to produce papers with high scientific impact.

International projects account for at least 20% of national government spending on scientific research. Some countries spend as much as 50% of these funds on international collaborations[1, 2]. The number of internationally co-authored papers is growing rapidly[2]. For countries at the forefront of

research, the fraction of papers that are entirely 'home grown' is falling[3].

Is there a connection? We analysed publication and citation data for 36 nations, along with government expenditures on science. We found that although government spending on research and development (R&D;) does correlate with the number of publications produced, it does not correlate with scientific impact — at least as assessed by citations, one of the few practical metrics available. What does correlate with impact is a country's openness, which we approximated by combining metrics of international co-authorship and the mobility of each nation's research workforce.

In 2016, we partnered with Jeroen Baas, head data scientist at Elsevier, the publication house that also runs the citation database Scopus, to examine nearly 2.5 million publications that were published in 2013 across all scholarly fields and that had three years' worth of citation data available. Publications and a field-weighted citation index were apportioned to countries according to authors' locations. (So if two-thirds of the authors on a publication were in the United Kingdom and one-third in Singapore, those fractions were applied to determine the publication count and citations assigned to those countries for that paper.)

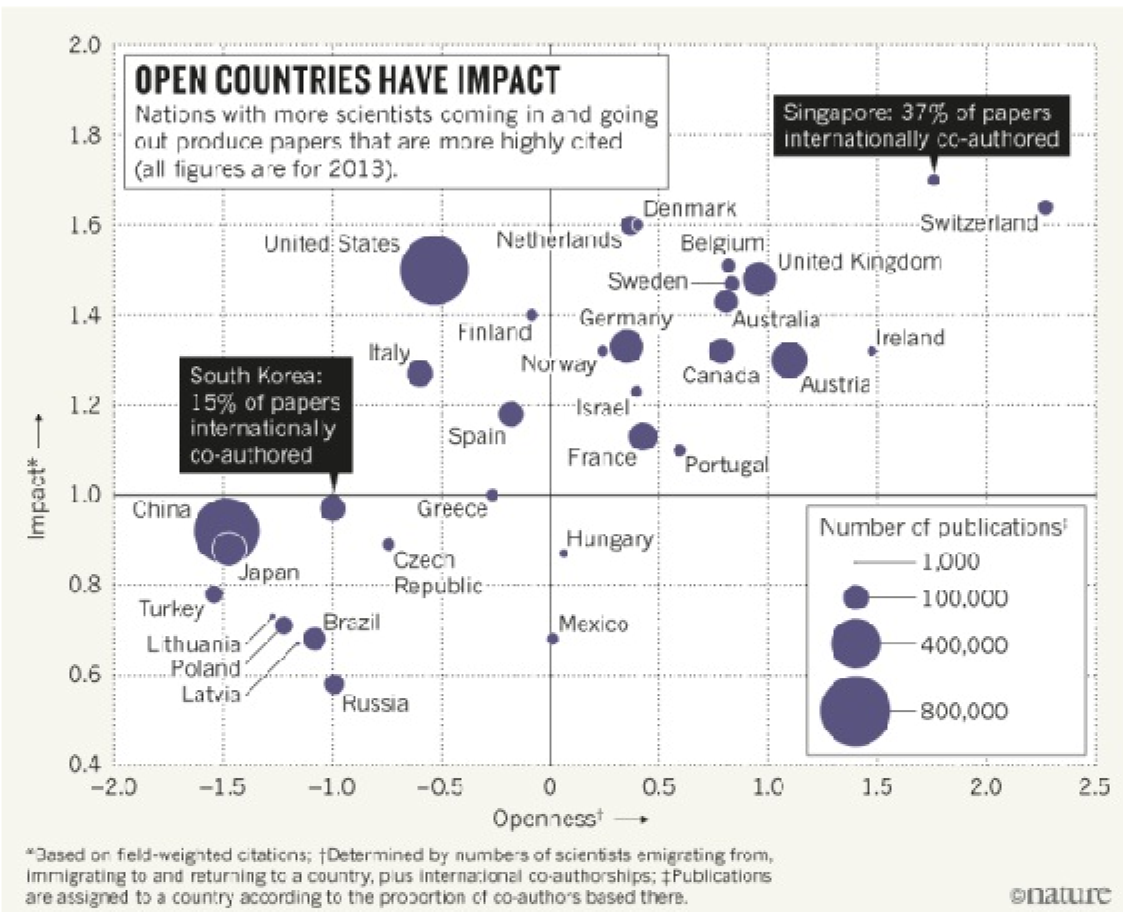
In terms of papers published, the United States and China dominate. For 'international papers' (those with authors from more than one country), the United States still leads, followed by the United Kingdom, China, Germany, France and Canada. When international papers are considered as a percentage of all of a country's papers, Switzerland (42%) appears as the most connected country, followed by Belgium (38%), Singapore (37%), Austria (36%) and Denmark, the Netherlands and Sweden (all 34%). In terms of impact for international papers, Singapore tops our list, followed by the United States, and then Sweden, Belgium, Switzerland and the Netherlands.

We looked for factors that could explain this. In addition to international collaboration, scientific mobility was expected to contribute to impact[4]. So we also considered new researchers coming in, returnees and emigrating researchers, all of which are tracked by the Organisation for Economic Co-operation and Development (OECD). These variables, together with collaboration, proved to be highly correlated as measures of international

engagement; so we used them to create an index of openness and were able to assign values to 33 of the countries that we looked at (data available at go.nature.com/2fzrnt3).

To assess whether government R&D; spending (as tracked by the OECD and Eurostat, the statistical office of the European Union) and our openness measure explained the relatively higher impact for smaller countries, we used a Pearson correlation analysis, which allows comparisons to be made across a large quantitative range, such as the publication output of the United States versus that of Singapore.

Public R&D; funding is tied to publication output: the more money spent, the more articles produced (counting sole-authored, co-authored and internationally co-authored). But we found only a weak correlation between spending and impact. In other words, more government funds spent does not necessarily result in more citations.



Countries that are highly 'open' and that produce high-impact research seem to benefit from participating in international collaboration. This is seen in the higher impact of smaller nations, which cluster in the top-right quadrant of the graphic (see 'Open countries have impact'). Singapore, the United Kingdom, the Netherlands, Switzerland, Sweden and Denmark all scored highly on this measure as well as on citations. The correlation between openness and citation impact was tight ($r^2 = 0.7$ according to a regression analysis) regardless of R&D; spending or numbers of articles published.

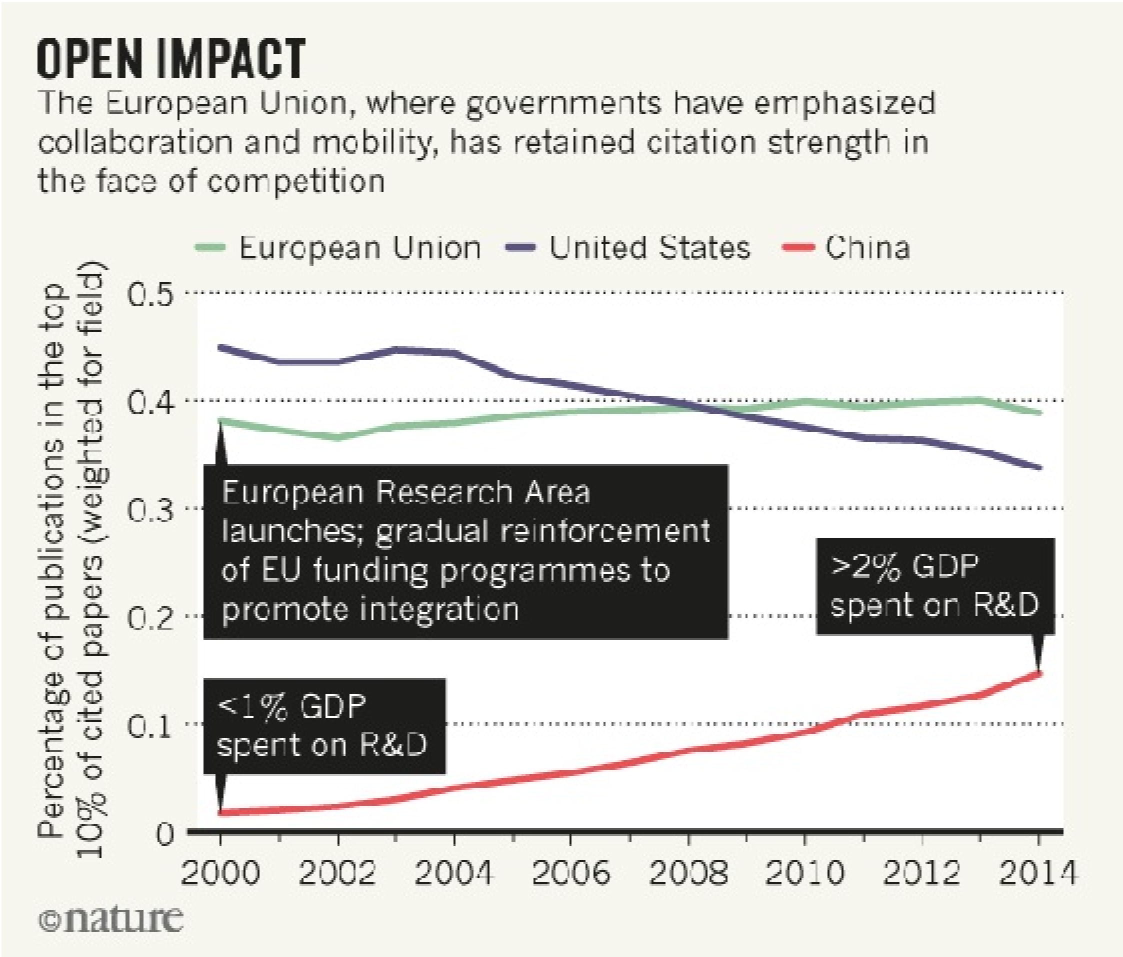
Countries with low openness and low impact include Russia, Turkey and Poland, China, Japan, Latvia, Lithuania, the Czech Republic and, against expectations, South Korea (which spends a higher percentage of its GDP on R&D; than almost every country, including the United States) These countries are shown in the lower-left quadrant.

The United States scores highly on impact, but less so on openness — perhaps because of the magnitude of its scientific enterprise and its geographic distance from possible collaborators. Of our 33 countries, only 4 (the United States, Italy, Spain and Finland) have low openness and high impact, and only 2 (Hungary and Mexico) have high openness and low impact.

Our analysis suggests that openness is related to impact, although we recognize that correlation is not causation. Nevertheless, we note that many of the countries whose scholarship has high impact, and whose policies encourage international engagement, are from Europe. The EU has established the European Research Area (ERA). Its governments have been implementing measures to strengthen domestic research systems while also promoting both international collaboration and mobility. The EU's Framework programmes have similar aims — one of the current stated objectives of EU research policy is to be more “open to the world”.

Analysis of citation strength for countries in Europe shows that they have greatly enhanced their impact compared with the United States (see 'Open impact'). As a bloc, the EU now outperforms the United States. Both far exceed China in impact, although China's share of high-impact papers is growing rapidly[5]. Other countries that promote openness also perform well in

terms of impact: examples include Singapore and Australia.



EU Joint Research Centre Tools for Innovation Monitoring, based on Scopus data release August 2016

Some will argue that citation is not synonymous with quality or importance, but it does signal engagement and recognition. Studies dating as far back as 1992 show that international papers are, on average, more highly cited[6]. The countries that are engaging internationally are seeing a dividend in terms of attention to their research.

It may be that the exchange of ideas encourages greater creativity, or that a virtuous cycle of quality work attracts others to work with those in higher-impact countries. In fact, we had very similar results when we considered each component in our openness metric separately, although most of the

effect of the mobility variables is mediated by international collaboration. Analytically, it makes sense to combine these into a single variable. However, other factors — such as the ease of obtaining visas or support to study in a country — are not explicitly incorporated.

In Japan, especially, output and citation impacts have remained flat since 2000. Japan is also among the least internationalized of leading nations, and this could be dragging on its performance. Lack of professional mobility, as well as language barriers, may be hindering engagement.

Our analysis suggests that national funding programmes should, whenever possible, move away from policies that fund only national researchers. In the longer term, countries could benefit more by funding the best science, wherever it is, and ensuring that domestically based scientists are linked with it. Restricting the movement of researchers — by limiting exchange opportunities or imposing visa restrictions, for example — could be counterproductive.

Just as industries make 'build or buy' decisions, so governments must make 'link or sink' decisions about research investment. Our data add to a growing body of work about the changing science system, indicating that science policymakers who seek to enhance impact should prioritize international exchange.

Journal name:
Nature
Volume:
550,
Pages:
32–33
Date published:
(05 October 2017)
DOI:
doi:10.1038/550032a

Comments

Commenting is currently unavailable.

Nature News

周四, 19 10月 2017

Nature News

[周四, 19 10月 2017]

- **Nature News**

Nature News

Nature is a weekly international journal publishing the finest peer-reviewed research in all fields of science and technology on the basis of its originality, importance, interdisciplinary interest, timeliness, accessibility, elegance and surprising conclusions. Nature also provides rapid, authoritative, insightful and arresting news and interpretation of topical and coming trends affecting science, scientists and the wider public.

- **The Human Cell Atlas: from vision to reality** [周三, 18 10月 08:00]
  As an ambitious project to map all the cells in the human body gets officially under way, Aviv Regev, Sarah Teichmann and colleagues outline some key challenges.
- **Top Chinese university to consider social-media posts in researcher evaluations** [周三, 18 10月 08:00]
  Controversial policy means mainstream media are starting to rival rigorous academic publications in some universities in China.
- **Mysterious particles spotted in Saturn’s atmosphere** [周三, 18 10月 08:00]
  Source may be dust shed by planet’s iconic rings, according to data from NASA's doomed Cassini probe.
- **Efforts to save leading Hungarian university hit hurdle** [周三, 18 10月 08:00]
  US-registered Central European University faces another year of uncertainty over whether it can continue to operate in Hungary.
- **Sleeping sickness can now be cured with pills** [周三, 18 10月 08:00]
  Researchers seek approval from regulators for this quicker, easier treatment.
- **Self-taught AI is best yet at strategy game Go** [周三, 18 10月 08:00]
  Artificial-intelligence program AlphaGo Zero trained in just days, without any human input.
- **Science must examine the future of work** [周三, 18 10月 08:00]
  As automation changes employment, researchers should gather the evidence to help map the implications.
- **Blue is in the eye of the bee-holder** [周三, 18 10月 08:00]
  Flowers have evolved an ingenious way to attract pollinators.
- **Epic star collision, asteroid fly-by and journal resignations** [周三, 18 10月 08:00]
  The week in science: 13–19 October 2017.
- **New definitions of scientific units are on the horizon** [周三, 18 10月 08:00]
  Metrologists are poised to change how scientists measure the Universe.
- **The future of work** [周三, 18 10月 08:00]

Digital technologies are upending the workforce. The right research can tell us how.

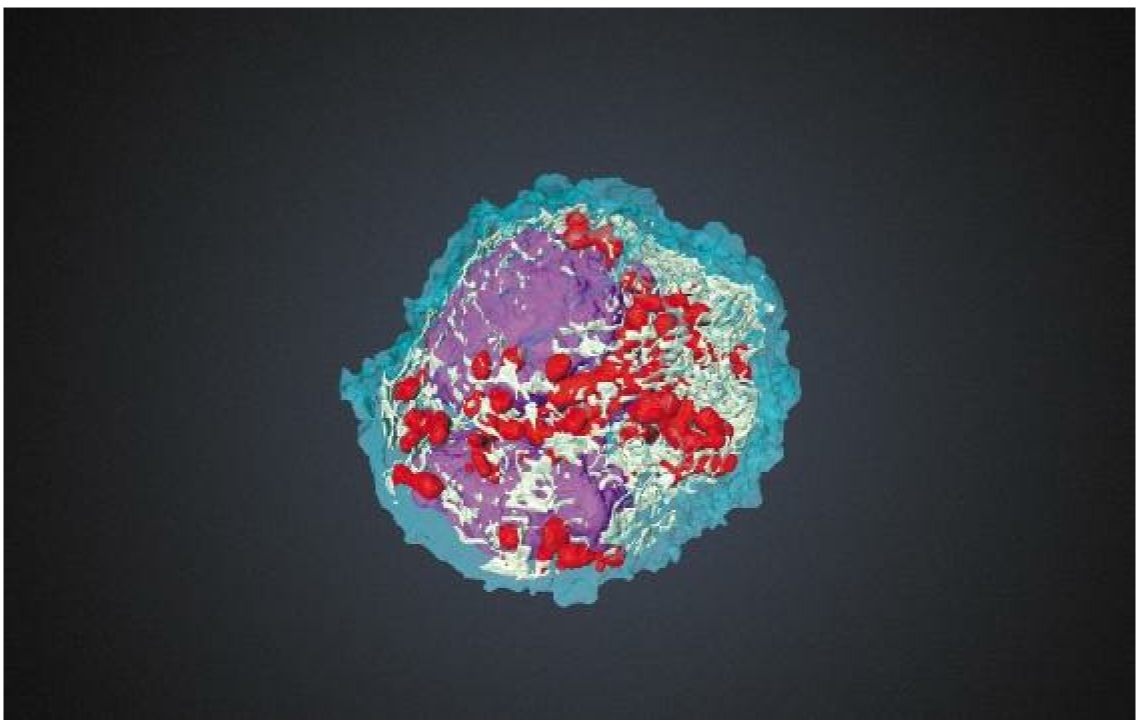
- ## The shape of work to come [周三, 18 10月 08:00]
  Three ways that the digital revolution is reshaping workforces around the world.
- ## Lessons from history for the future of work [周三, 18 10月 08:00]
  Global comparisons of previous social and economic upheavals suggest that what is to come depends on where you are now, argues Robert C. Allen.
- ## The second Renaissance [周三, 18 10月 08:00]
  Ian Goldin calls on scientists to help society to weather the disruptive transformations afoot.
- ## Archaeology: The wonder of the pyramids [周三, 18 10月 08:00]
  Andrew Robinson enjoys a volume rounding up research on the complex at Giza, Egypt.
- ## Books in brief [周三, 18 10月 08:00]
  Barbara Kiser reviews five of the week's best science picks.
- ## History: Five millennia of Indian science [周三, 18 10月 08:00]
  James Poskett applauds a show celebrating discovery on the subcontinent, from zero to the boson.
- ## Federal funding: Stifled by budgets, not irrelevance [周三, 18 10月 08:00]
- ## Ornithology: Danish dairy farmer delivers data coup [周三, 18 10月 08:00]
- ## Open data: Spot data glitches before publication [周三, 18 10月 08:00]
- ## PhD students: living wage key to diversity [周三, 18 10月 08:00]
- ## PhD students: side jobs are no solution [周三, 18 10月 08:00]
- ## Breaking and entering [周三, 18 10月 08:00]
  Escape is not an option.
- ## Brazilian Amazon still plagued by illegal use of natural resources [周二, 17 10月 08:00]
  Practices such as poaching and illegal logging are concentrated near inhabited areas and along rivers, study finds.
- ## Give researchers a lifetime word limit [周二, 17 10月 08:00]
  Brian C. Martinson imagines how rationing the number of publications a scientist could put out might improve the scientific literature.
- ## Japanese research leaders warn about national science decline [周二, 17 10月 08:00]
  Concern mounts over budget cuts and other changes that undermine basic science.
- ## Reboot for the AI revolution [周二, 17 10月 08:00]
  As artificial intelligence puts many out of work, we must forge new economic, social and educational systems, argues Yuval Noah Harari.

- **[Eye in the sky offers clearest vision of Earth]** [周一, 16 10月 08:00]
  The world’s latest carbon-monitoring satellite has advanced our understanding of how the planet functions. US politicians should take note.
- **[Colliding stars spark rush to solve cosmic mysteries]** [周一, 16 10月 08:00]
  Stellar collision confirms theoretical predictions about the periodic table.
- **[Prepare for larger, longer wildfires]** [周五, 13 10月 08:00]
  Climate change makes land management more urgent than ever, says Kathie Dello.
- **[Global networks of small telescopes will chase companion signals of gravitational waves]** [周五, 13 10月 08:00]
  Seeing cosmic events is one thing, but what if you could hear them and taste them, too?
- **[Weather-company chief is Trump's pick to lead climate agency]** [周四, 12 10月 08:00]
  Barry Myers would bring private weather-forecasting experience to the National Oceanic and Atmospheric Administration.
- **[European drug regulation at risk of stalling as agency prepares to leave London]** [周四, 12 10月 08:00]
  Post-Brexit plans to relocate the European Medicines Agency could trigger severe staff losses, its head has warned.
- **[European Medicines Agency chief raises alarm at forced relocation]** [周四, 12 10月 08:00]
  Guido Rasi says that ensuring the safety of drugs could be compromised.
- **[Male scientists share more — but only with other men]** [周四, 12 10月 08:00]
  Evolutionary differences blamed for squeezing out female researchers.
- **[FDA advisers back gene therapy for rare form of blindness]** [周四, 12 10月 08:00]
  Therapy that targets disease-causing mutations could become the first of its kind approved for use in the United States.

The Human Cell Atlas: from vision to reality

18 October 2017

As an ambitious project to map all the cells in the human body gets officially under way, Aviv Regev, Sarah Teichmann and colleagues outline some key challenges.



Villani, A.-C. ET AL. SCIENCE 356, EAAH453 (2017); image Kathryn White; reconstruction James Fletcher

A new type of human dendritic cell recently discovered using single-cell RNA sequencing.

Our knowledge of the cells that make up the human body, and how they vary

from person to person, or throughout development and in health or disease, is still very limited. This week, a year after project planning began, more than 130 biologists, computational scientists, technologists and clinicians are reconvening in Rehovot, Israel, to kick the Human Cell Atlas initiative[1] into full gear. This international collaboration between hundreds of scientists from dozens of universities and institutes — including the UK Wellcome Trust Sanger Institute, RIKEN in Japan, the Karolinska Institute in Stockholm and the Broad Institute of MIT and Harvard in Cambridge, Massachusetts — aims to create comprehensive reference maps of all human cells as a basis for research, diagnosis, monitoring and treatment.

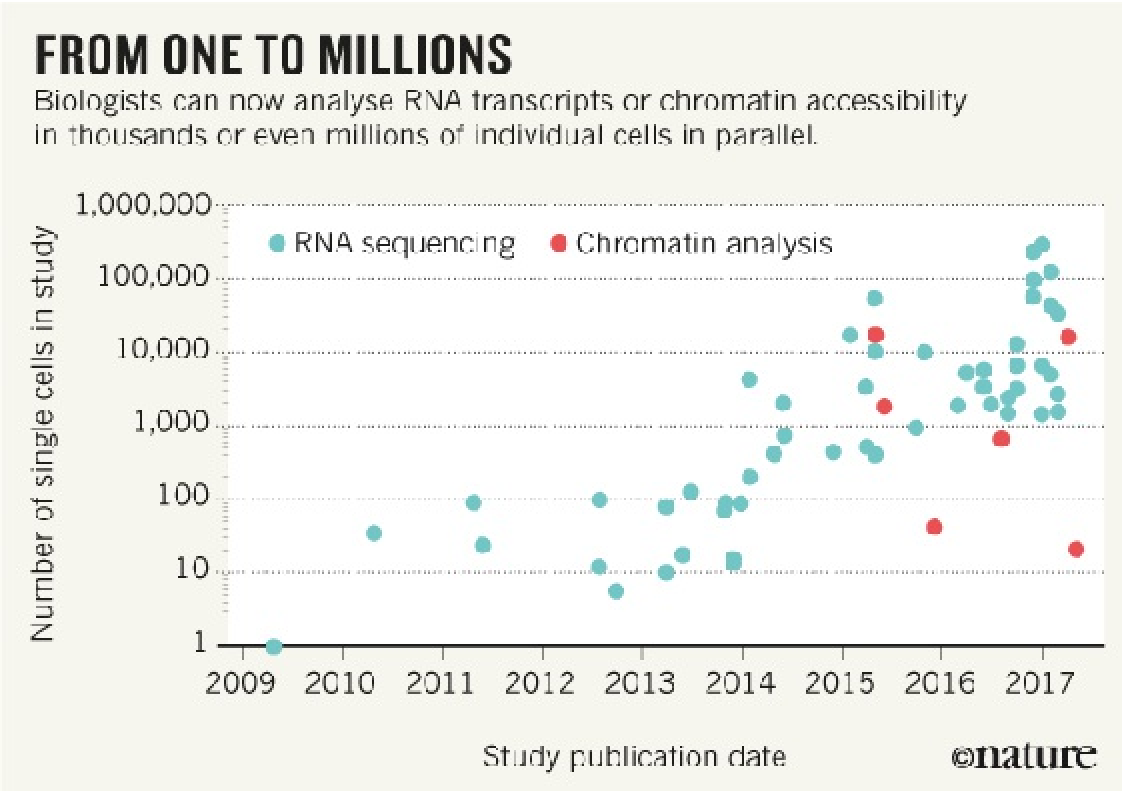
On behalf of the Human Cell Atlas organizing committee, we outline here some of the key challenges faced in building such an atlas — and our proposed strategies. For more details on how the atlas will be built as an open global resource, see the white paper[2] posted on the Human Cell Atlas website.

Cells have been characterized and classified with increasing precision since Robert Hooke first identified them under the microscope in the seventeenth century. But biologists have not yet determined all the molecular constituents of cells, nor have they established how all these constituents are associated with each other in tissues, systems and organs. As a result, there are many cell types we don't know about. We also don't know how all the cells in the body change from one state to another, which other cells they interact with or how they are altered during development.

Technology revolution

New technologies offer an opportunity to build a systematic atlas at unprecedented resolution. These tools range from single-cell RNA sequencing to techniques for assessing a cell's protein molecules and profiling the accessibility of the chromatin. For example, we can now determine the RNA profiles for millions of individual cells in parallel (see 'From one to millions'). Protein composition and chromatin features can be studied in hundreds or thousands of individual cells, and mutations or other markers tracked to reconstruct cell lineages. We can also profile multiple

variants of RNA and proteins *in situ* to map cells and their molecules to their locations in tissues.



Source: Svensson, V., Vento-Tormo, R. & Teichmann, S. A. Preprint at https://arxiv.org/abs/1704.01379 (2017)

We anticipate that the atlas will help researchers to answer key questions in diverse biological fields. In cellular taxonomy, it might enable the discovery and identification of cell types and molecular markers or signatures (a collection of genes, say, that characterize a specific cell type). In histology, it should enable researchers to relate tissue structure to the position of cells and molecules. Developmental biologists will be able to use it to track cell fate and lineage. Physiologists could characterize dynamic states, such as the cell cycle, and transient responses such as a T cell's reaction to a pathogen.

The atlas could also facilitate research on the molecular mechanisms of communication within and between cells. And it should allow biologists to compare cell types across species to better understand human evolution, and

to determine to what extent animal model systems and organoids reflect human biology.

Crucially, the atlas should help researchers to compare healthy reference cells to diseased ones in the relevant tissues — and so facilitate the development of better drugs and more accurate predictions of unintended toxicity. The atlas could also aid regenerative medicine — the process of replacing, engineering or regenerating human cells, tissues or organs to establish normal function. Key diagnostic tests, such as the complete blood count — a routine blood screen that provides crude counts of white blood cells, red blood cells and so on — would become vastly more informative if cell types and states could be identified with much finer granularity. Such information could, for example, help to diagnose blood cancer, autoimmunity or infection before clinical symptoms appear.

Early studies are already showing tremendous potential in all these areas. New cell types have been found in the brain[3–7], gut[8], retina[9] and immune system[10], and these discoveries have yielded new insight — into how the immune system[11] functions, for example, and into the dynamics of tumour ecosystems[12]. Yet, to take the next step — to build a human cell atlas that is truly useful — requires taking the long view and addressing various systemic and organizational challenges, as well as technical and scientific ones.

The challenges

Agree on scope. In light of the enormous complexity of the human body, and the rapid evolution of technologies for probing cells and tissues, and for analysing the data, we plan to build this resource in phases and generate reference maps at increasing resolution as the project progresses.

The first draft of the atlas will profile cells' molecular and spatial characteristics, capturing only those cell types that occur above a pre-specified rarity — ones that make up more than 1% of a sample, say. These cells will be obtained from major tissues from healthy donors, taking into account the genetic diversity, geographical location and person's age. Although disease will not be a focus of the first draft of the atlas, we plan to

look at some disease samples to compare them with healthy cell types.

The first draft will focus on tissues, not whole organs. Extremely rare cells may be missed, and sample sizes may be too small to fully reveal the links between cellular characteristics and human diversity. In later phases, the atlas could take on entire organs, include small cohorts of people (say, 50–60) with diseases of interest, gather bigger sample sizes and provide greater power to associate molecular variation with the underlying genetic diversity. A similar step-wise strategy was deployed in the Human Genome Project; even a partially assembled genome proved immediately useful to researchers, and human genetic variation in health and disease was tackled over several years after the full genome was sequenced.

The atlas will provide an important starting point for functional studies — for instance, those aimed at establishing the mechanistic links between cell states and disease. But such studies are themselves beyond its scope. Again, this parallels what happened with the Human Genome Project: studies of functional elements in the genome, which are ongoing, have relied on the reference sequence obtained through the project.

The atlas will aim to provide a detailed representation of molecules, cells, tissues, organs and systems, allowing researchers to zoom in and out to identify patterns and interactions at various levels of resolution. To this end, those compiling the atlas must establish how many cells to sample, which types of molecular features to analyse, how to assign cells to different categories and how to subdivide those categories. At the spatial level, they must decide how to sample complex anatomies and histologies. Lastly, they need to establish ways of connecting the various layers of cellular and spatial information from different samples to a single anatomical reference by developing what is termed a common coordinate framework.

To ensure the best use of resources, those involved in the initiative must agree on the desired resolution for each phase of the atlas. Researchers could, of course, try to pursue ever-rarer cell types, but potentially at ever-greater expense. In this respect, the Human Cell Atlas will pursue similar approaches to those used in human genetic studies that focus on variants present at a certain frequency. Here, geneticists have begun to tackle increasingly rare variants as technologies have advanced.

Be open and fair. To have maximum impact, the Human Cell Atlas must be an open resource, on many levels.

The project is already open to all interested participants who are committed to its values. Discussions about particular organs, tissues, technologies or computational approaches are running on more than a dozen Slack channels that anyone can join.

Wherever consent agreements allow, atlas data will be made publicly available in an open-source data-coordination platform as soon as possible, after they have been collected and have passed quality-control checks. All standards established to ensure the production of high-quality data, and any updates to those standards, will also be shared. The same goes for new technologies and computational methods resulting from the project.

Atlas data and analysis products will exist in multiple public clouds (currently, those hosted by Google, Amazon and Microsoft) to ensure that people with different preferred cloud environments can access them. Because computation will happen in the cloud, individual researchers will not need to download and store all the data or have access to their own high-performance computing power. Finally, in addition to the continual release of data and periodic formal data releases, publications interpreting the data will help to establish standardized approaches and disseminate the insights and value that can be gained from them.

As much as possible, the atlas must reflect the diversity of humans and human experience. The broad distribution of participating researchers, institutions and countries involved in the initiative will, in itself, help to ensure tissue diversity. The initiative currently includes members from 5 continents and more than 18 countries, including Japan, Israel, South Africa, China, India, Singapore, Canada and Australia.

Getting appropriate consent agreements and fostering public trust from the outset will also help efforts to obtain sufficient geographical, gender, age and genetic diversity in sampling. As part of the global initiative, an ethics working group will establish how best to obtain informed consent from sample donors, how the terms of that consent can be adhered to and how to protect the privacy of participants and donors appropriately. Various existing

projects involving human samples, such as the public-research project ENCODE (the Encyclopedia of DNA Elements), which aims to identify all the functional elements of the human genome, can provide guidance on this.

Procure samples appropriately. Obtaining tissue samples using standardized procedures, with appropriate consent and in a way that enables other researchers to know exactly where the sample came from is a complex endeavour. To access the diversity of human tissues needed, researchers will work with both fresh tissue from live donors and specimens obtained postmortem or from transplant organ donors.

We plan to learn from, and build on, pre-existing reliable procurement processes. Examples include those used in the Genotype-Tissue Expression Project (GTEx, a database and tissue bank designed to help researchers to gain insight into the mechanisms of gene regulation in humans) and the Cambridge Biorepository for Translational Medicine, a resource for multidisciplinary research projects for which fresh tissue is required.

Organize effectively. The Human Cell Atlas consortium is built on four distinct and interconnected pillars. Collaborative biological networks involve experts in biological systems or organs as well as in genomics, computation and engineering, working together to build maps of each tissue, system or organ. Several biological-network pilot projects have been formulated through grass-roots efforts in the Human Cell Atlas community. As well as revealing new biology and helping to build a collaborative international network, these activities are informing the community about how to structure sampling and conduct analyses for a full-scale cell atlas.

A technical forum involving genomics experts, imaging specialists and biotechnologists, is developing new technologies, and testing, comparing and disseminating existing ones. A data-coordination platform is being designed to bring researchers to the data by developing the software to upload, store, process and serve data. The platform also provides an open environment in which computational methods and algorithms developed by any interested group can be shared. Finally, an analysis garden involves computational biologists working together to develop sophisticated techniques for data mining and interpretation.

Activities across all areas are currently governed by a scientific steering group, the Human Cell Atlas organizing committee. Co-chaired by two of us (A. R. and S. A. T.), this includes 27 scientists from 10 countries and diverse areas of expertise. The committee establishes working groups (about 5 so far, consisting of about 5 to 15 members each) that tackle specific key areas. For instance, an analysis working group is crafting best practices for computational analysis through a community-wide process, including workshops and jamborees. The committee governs the data-coordination platform, including making all policy decisions and approving its overall plan.

Join the effort

Having a catalogue of genes at our fingertips has transformed research in human biology and disease. Similarly, we believe that the Human Cell Atlas will catalyse progress in biology and medicine. Descriptors such as ‘cell type’ and ‘cell state’ can be difficult to define at the moment. An integrative, systematic effort by many teams of scientists working together and bringing different expertise to the problem could dramatically sharpen our terminology, and revolutionize the way we see our cells, tissues and organs. We invite you to join the effort.

Journal name:
Nature
DOI:
doi:10.1038/550451a

Supplementary information

PDF files

1. HCA organizing committee (61K)

Comments

Comments

There are currently no comments.

Top Chinese university to consider social-media posts in researcher evaluations

Controversial policy means mainstream media are starting to rival rigorous academic publications in some universities in China.

18 October 2017

Wang Zhao/AFP/Getty

News articles written by researchers at some Chinese universities will now be considered in evaluations.

One of China’s most prestigious universities plans to give some articles in

newspapers and posts on major social-media outlets the same weight as peer-reviewed publications when it evaluates researchers.

The policy has sparked a vigorous debate among Chinese academics. Proponents say it will encourage researchers to engage with the public, but many are concerned that it will promote those who toe the party line established by China’s strictly censored media and social media, at the expense of more highly qualified researchers. Critics also say the system could be manipulated to inflate a researcher’s impact, for example by artificially boosting page views.

Zhejiang University in Hangzhou announced the policy on its WeChat page on 15 September, saying that it would mainly apply to the humanities and social sciences. But Chinese researchers say the move could influence science as well, by giving a hiring and promotion advantage to politically minded scientists.

“You do not need to be good scientist, you do not need to publish good science papers,” says one biologist at a prominent Beijing-based university who requested anonymity. He is concerned that the policy could alter evaluations at China’s main grant agency, the National Natural Science Foundation of China (NSFC). “If they open the Pandora’s box, the NSFC might change its policy as well,” he says. The agency's head, Yang Wei, says it will do no such thing. NSFC grants are given solely “according to the judgement of peer reviewers”, he says.

Viewing figures

The Zhejiang policy sets specific criteria: articles have to be original, written by the researcher and at least 1,000 words long; they need to be picked up by major news outlets and widely disseminated through social media; and they need to have been seen by a large number of people. The policy requires an article to be viewed more than 100,000 times on WeChat, China’s most popular instant-messaging service, or 400,000 times on news aggregators such as Toutiao. Articles that meet the criteria will be considered publications, alongside papers in peer-reviewed journals.

The university has also established a publication hierarchy, with official media outlets such as the *People's Daily* considered most important, regional newspapers and magazines occupying a second tier, and online news sites such as Sina, NetEase or Sohu ranking third.

Ping Fu, who researches library science at Central Washington University in Ellensburg, is concerned that the policy will blur the distinction between peer-reviewed academic publications and popular writing. This could affect the top levels of scholarship in China, he says. Liu Jin-ping, a biologist at Hainan University in Haikou, also worries that the policy will give prominence to stories that "flatter the government". Some academics will aim to "become Internet stars" so they can be promoted, he wrote on his blog.

Full credit

Lin Boqiang, an energy-policy and climate-change researcher at Xiamen University who has published some 800 media commentaries, thinks researchers should get credit for this work. He "criticizes government policy all the time" and would never write something incorrect to please political powers, he says: "Our reputation is on the line."

But both Liu and Lin are concerned the system could be gamed, either for self-interest or with political motivation. Lin says these articles should not be considered equal to academic publications. "Other universities will do this," he says. "I hope they do it in a more sophisticated way."

Zhejiang University refused to answer *Nature*'s questions about the policy, but it posted a statement on its homepage in response to the controversy, saying that the commentaries in the mainstream media will supplement and not replace peer-reviewed journals: "This policy is to explore more forms of exposure of research, especially for humanities and social sciences, and the assessment will be made by a strict panel review, which will not lower the academic standard."

Grant committees in other countries encourage researchers to do public outreach, but the Zhejiang policy is rare in how it ranks such efforts for

researcher evaluation. Jilin University in Changchun announced a similar policy in August.

Balancing act

Glen Peters, a climate-policy researcher at the Center for International Climate Research in Oslo, agrees that researchers should be acknowledged for important contributions to public understanding, but he says the challenge in giving scientists credit for public outreach is how to measure its quality and impact against those of conventional journal publications. “If you don’t get the weighting right, then incentives could be perverted and lead to bad outcomes, such as poor quality and political bias,” he says. “The potential is high, but so are the risks.”

One journalist at China’s *Legal Daily* has questioned whether such a policy is legal. It was drafted by the university’s propaganda department, part of the Communist Party of China. According to the laws that govern universities, evaluation decisions are supposed to be made by university administrative departments or faculty committees, writes the journalist.

Some scientists contacted by *Nature* are confident that this initiative will not affect science. But others see it as part of the government’s attempts to control information. There is already concern about Chinese President Xi Jinping’s efforts to align education with communist values and to control what is written by journalists or on social media. Scientists say that bans on Google, Google Scholar and other Internet-based technologies hamper their ability to stay in touch with international peers. “There are certainly many layers of concern,” says one environmental scientist who did not want to be named for fear of damaging relationships with Chinese colleagues.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22822

Comments

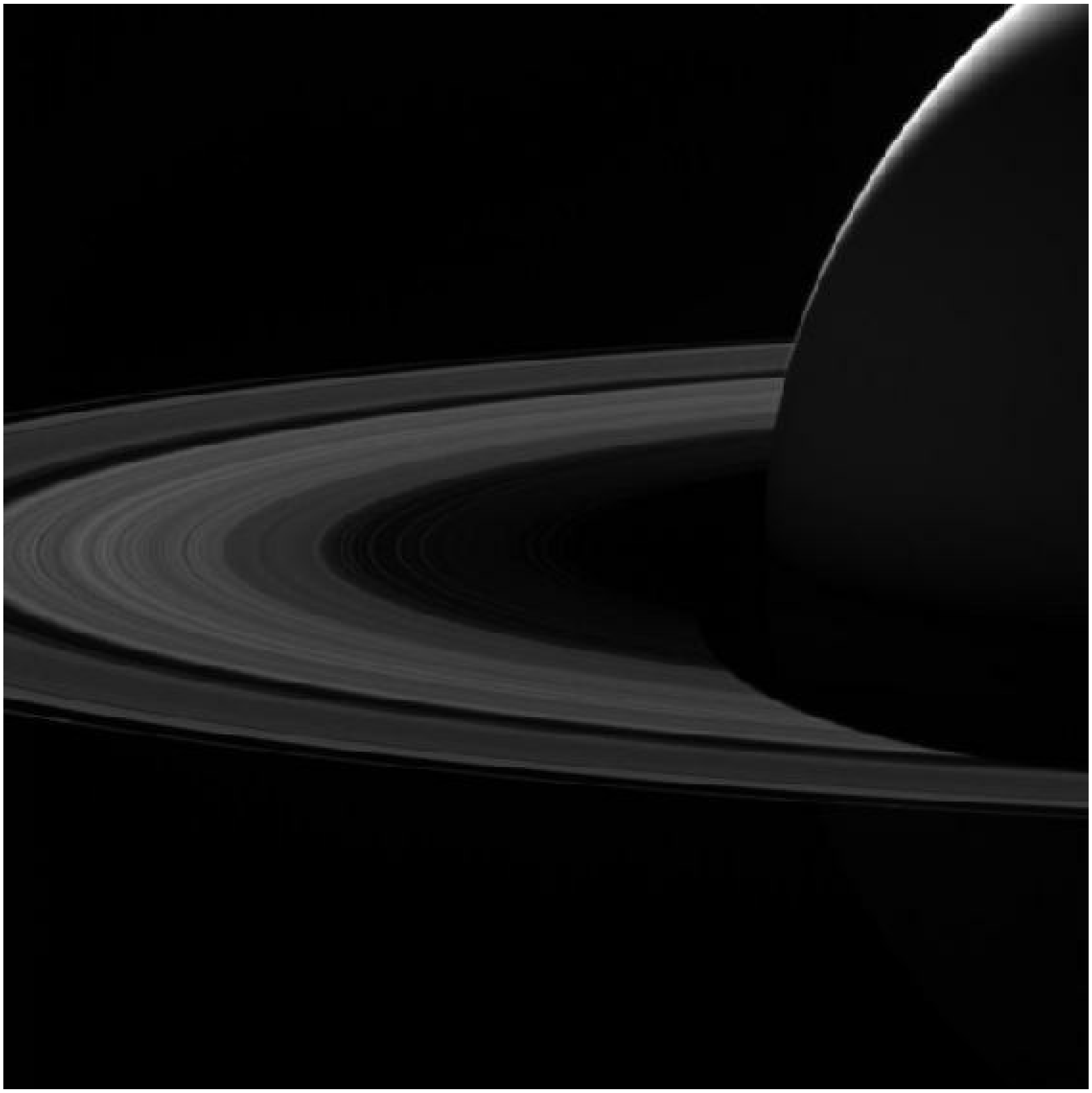
Commenting is currently unavailable.

Mysterious particles spotted in Saturn’s atmosphere

Source may be dust shed by planet’s iconic rings, according to data from NASA's doomed Cassini probe.

18 October 2017

Provo, Utah



NASA/JPL-Caltech/SSI

Saturn's rings are made of whirling bands of ice and dust.

NASA's Cassini spacecraft continues to yield surprising discoveries, more than a month after it burned up on its mission-ending dive into Saturn. New data from the probe suggest that Saturn's majestic rings are showering tiny dust particles into the planet's upper atmosphere, where they form a complicated and unexpected chemical mix.

A mass spectrometer aboard Cassini detected the strange chemistry as the

probe spent its final five months looping between Saturn and its rings.

“We really hit the jackpot,” said Mark Perry, a planetary scientist at the Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland. He reported the findings on 17 October at a meeting of the American Astronomical Society’s Division for Planetary Sciences in Provo, Utah.

Mission scientists had expected Cassini's mass spectrometer to spot the signature of water molecules as the spacecraft slipped between the planet and its rings. In the 1970s and 1980s, NASA's Pioneer and Voyager missions found fewer charged particles than expected in Saturn’s uppermost atmosphere. On the basis of those data, researchers proposed in 1984 that water molecules coming off the rings — mostly in the form of ice — act as catalysts to strip charged particles from the atmosphere[1]. Cassini's final months gave scientists their first opportunity to test this idea directly.

Chemical surprise

But it wasn't evidence of water that jumped out at Cassini's science team. Data from the mass spectrometer revealed a witch’s brew of chemicals, including methane, a molecule that could be carbon monoxide and more-complex molecules. The concentrations of these chemicals are greatest around Saturn’s equator and at high altitudes, which suggests that the material is shedding off the planet’s rings.

The deeper the probe went into the atmosphere, the stranger the measurements became. Cassini’s closest swings past Saturn's surface revealed a panopoly of heavy molecules, Perry told conference attendees. The scientists have not yet pinpointed each type of molecule, but clearly, there is much more than just water around.

By analysing the types of material that could be coming off the rings, Perry’s team concluded that the debris must be fragments of tiny dust particles, which measure just 1 to 10 nanometres across but are relatively heavy. When these particles spiralled off the rings and slammed into Cassini’s mass spectrometer, they shattered into smaller pieces.

Exactly how those particles make the journey from the rings to the atmosphere remains to be seen. “We have a lot of work to do to understand how they are getting in there,” Perry said. “None of the models predict this.”

On these final plunges, pulled along by Saturn’s gravity, Cassini was zooming along at more than 30 kilometres per second — a speed more than four times greater than the mass spectrometer was designed to withstand. “These are higher speeds than anything it has ever seen,” noted Linda Spilker, a planetary scientist at the Jet Propulsion Laboratory in Pasadena, California, and Cassini’s project scientist.

At such enormous speeds, anything that Cassini rammed into would have splintered into bits.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22838

Comments

Comments

There are currently no comments.

Efforts to save leading Hungarian university hit hurdle

US-registered Central European University faces another year of uncertainty over whether it can continue to operate in Hungary.

18 October 2017

Ferenc Isza/AFP/Getty Images

A sudden change to Hungarian higher-education law in April led to widespread protests.

The threatened Central European University (CEU) in Budapest has been dealt a blow in its efforts to avert possible closure in Hungary.

The country’s parliament voted on 17 October to postpone for a year a

decision that would allow the university to keep operating there. At a press conference held by the university shortly after the vote, CEU rector Michael Ignatieff called the delay “unacceptable” and “unnecessary”.

In April, the Hungarian government unexpectedly amended its higher-education law to require that all foreign-accredited universities there had to operate as higher-education institutes in their countries of origin by 1 January 2018.

The change drew protests and was widely believed to be politically motivated. Critics saw it as an attack on billionaire philanthropist George Soros who founded the university in 1991 and has openly criticized Hungary’s strict refugee policies.

The CEU took steps to comply with the new requirements and on 3 October sealed an agreement with Bard College in Annandale-on-Hudson, New York, to provide educational activities there. Accredited courses run jointly by the universities would be launched next year, the CEU said. The agreement still requires government signature and parliamentary ratification.

But on 16 October the government proposed delaying the implementation of the amendment until 1 January 2019, and the parliament approved the delay the next day.

A government spokesperson told *Nature* that the delay was to give other foreign higher-education institutions time to comply with the new requirements, adding that three institutions, including the CEU, are still in negotiation.

Hungary's Minister for Human Capacity Zoltan Balogh suggested on 16 October that government sign-off of the CEU's agreement might have to wait for the new deadline.

“We are being deliberately kept in legal limbo,” said Ignatieff, who fears the uncertainty will make it hard to retain faculty and recruit students. “We are being slowly strangled in this battle for academic freedom.”

Journal name:

Nature
DOI:
doi:10.1038/nature.2017.22855

Comments

Comments

There are currently no comments.

Sleeping sickness can now be cured with pills

Researchers seek approval from regulators for this quicker, easier treatment.

18 October 2017

Neil Brandvold

Health workers screen people in a remote village in the Democratic Repulic of the Congo for sleeping sickness.

For the first time, researchers have cured the deadly neurological disease sleeping sickness using pills instead of a combination of intravenous infusions and pills. The investigators presented the results from final clinical trials on 17 October at the European Congress on Tropical Medicine and

International Health in Antwerp, Belgium, providing hope that the treatment will help to eliminate the malady within a decade.

The oral therapy — called fexinidazole — cured 91% of people with severe sleeping sickness, compared with 98% who were treated with the combination therapy. It also cured 99% of people in an early stage of the disease who would typically undergo a spinal tap, to determine whether they needed infusions. The relative ease of the treatment with fexinidazole means that if approved, it might save more lives than the current option, say the investigators leading the phase 3 trial, the final phase of testing before the drug goes to regulators for approval.

Sleeping sickness is endemic to Africa and generally infects extremely poor people who live in remote regions. The sick often suffer from the disease for years before seeking treatment, causing them and those caring for them to miss work and spend their savings on traditional medicines. Trekking to a hospital and remaining there for intravenous infusions is costly as well.

“It’s not just the person with sleeping sickness, it’s the family that takes care of them during years of this neurological, very serious disease,” says Philippe Büscher, a sleeping-sickness specialist at the Institute of Tropical Medicine in Antwerp, Belgium, who was not involved in the study. “Whatever money they have, they’ll spend on this instead of anything else.”

Büscher commends the team for conducting a quality clinical trial under extraordinary circumstances in countries hit hardest by the disease, the Democratic Republic of the Congo and the Central African Republic. Investigators had to carry equipment to remote clinics over rugged terrain; one study site was repeatedly robbed; and early on in the trial, some participants fled armed conflict. “I need to congratulate them for beautiful work,” Büscher says.

Neil Brandvold

The hospital where Pablo Loela was being treated for sleeping sickness canno
afford to provide food for their patients: families must provide meals for their loved ones.

A better way

Sleeping sickness — also known as human African trypanosomiasis — is spread through the bite of tsetse flies carrying parasites, most commonly *Trypanosoma brucei gambiense*. The organism infects the central nervous system, and patients can experience confusion, daytime sleepiness, night-time insomnia and various psychiatric symptoms, including manic episodes and aggression. If left untreated, they enter a coma and die. For decades, the only treatment was a toxic arsenic-based drug that killed one in 20 patients.

In 2009, researchers introduced a safer option: nifurtimox–eflornithine combination therapy, or NECT, which consists of pills and 14 intravenous

infusions. For the first time in 50 years, the incidence of sleeping sickness slipped below 10,000 new cases per year; it’s currently around 2,200, according to the World Health Organization. But the need for infusions, along with the spinal tap required to qualify a patient for the treatment, still present obstacles in regions where sterile equipment, electricity and doctors are in short supply.

The group that developed NECT — a non-profit research organization based in Geneva, Switzerland, called the Drugs for Neglected Diseases initiative (DNDi) — continued searching for a better therapy. In 2007, it discovered fexinidazole, a compound that had been shelved by Paris-based pharmaceutical company Sanofi. With the firm's agreement, the DNDi took the drug through clinical trials. It estimates that developing the therapy through to approval will cost a total of around US$50 million — a fraction of what pharmaceutical companies often spend on new drugs.

Just the beginning

Sanofi will soon submit an application for drug approval through the European Medicines Agency, whose sign-off could pave the way for regulators in the Democratic Republic of the Congo. The drug might get a green light by the end of next year, says Nathalie Strub Wourgraft, the DNDi’s medical director. Because it is a simple oral treatment, she suggests that patients might even be treated at home, which would save them and their families the expense of hospital stays.

However, Büscher argues that home treatments could be dangerous because people who don’t respond to fexinidazole could die of the disease if not seen immediately by medical staff. It’s imperative that patients follow up with health workers, he says, and he suggests offering people incentives to return to the clinic, such as money or staples including salt or sorghum. “This is a success,” he says, “but it is not the end.”

DNDi researchers and their colleagues are currently working on what they hope will be an even better oral treatment to cure the disease in a single dose, and more reliably than fexinidazole.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22856

Comments

Comments

There are currently no comments.

Self-taught AI is best yet at strategy game Go

Artificial-intelligence program AlphaGo Zero trained in just days, without any human input.

18 October 2017

Xavierarnau/Getty

AlphaGo Zero came up with Go strategies that human players haven't invented in thousands of years.

An artificial intelligence (AI) program from Google-owned company DeepMind has reached superhuman level at the strategy game Go — without learning from any human moves.

This ability to self-train without human input is a crucial step towards the dream of creating a general AI that can tackle any task. In the nearer-term, though, it could enable programs to take on scientific challenges such as protein folding or materials research, said DeepMind chief executive Demis Hassabis at a press briefing. “We’re quite excited because we think this is now good enough to make some real progress on some real problems.”

Previous Go-playing computers developed by DeepMind, which is based in London, began by training on more than 100,000 human games played by experts. The latest program, known as AlphaGo Zero, instead starts from scratch using random moves, and learns by playing against itself. After 40 days of training and 30 million games, the AI was able to beat the world's previous best 'player' — another DeepMind AI known as AlphaGo Master. The results are published today in *Nature*[1], with an accompanying commentary[2].

Getting this technique, known as reinforcement learning, to work well is difficult and resource-intensive, says Oren Etzioni, chief executive of the Allen Institute for Artificial Intelligence in Seattle, Washington. That the team could build such an algorithm that surpassed previous versions using less training time and computer power “is nothing short of amazing”, he adds.

Strategy supremo

The ancient Chinese game of Go involves placing black and white stones on a board to control territory. Like its predecessors, AlphaGo Zero uses a deep neural network — a type of AI inspired by the structure of the brain — to learn abstract concepts from the boards. Told only the rules of the game, it learns by trial and error, feeding back information on what worked to improve itself after each game.

At first, AlphaGo Zero’s learning mirrored that of human players. It started off trying greedily to capture stones, as beginners often do, but after three days it had mastered complex tactics used by human experts. “You see it rediscovering the thousands of years of human knowledge,” said Hassabis.

After 40 days, the program had found plays unknown to humans (see 'Discovering new knowledge').

Discovering New Knowledge

Deepmind

Approaches using purely reinforcement learning have struggled in AI because ability does not always progress consistently, said David Silver, a scientist at DeepMind who has been leading the development of AlphaGo, at the briefing. Bots often beat their predecessor, but forget how to beat earlier versions of themselves. This is the project's first "really stable, solid version of reinforcement learning, that’s able to learn completely from scratch," he said.

AlphaGo Zero’s predecessors used two separate neural networks: one to predict the probable best moves, and one to evaluate, out of those moves, which was most likely to win. To do the latter, they used ‘roll outs’ — playing multiple fast and randomized games to test possible outcomes. AlphaGo Zero, however, uses a single neural network. Instead of exploring possible outcomes from each position, it simply asks the network to predict a winner. This is like asking an expert to make a prediction, rather than relying on the games of 100 weak players, said Silver. “We’d much rather trust the predictions of that one strong expert.”

Merging these functions into a single neural network made the algorithm both stronger and much more efficient, said Silver. It still required a huge amount of computing power — four of the specialized chips called tensor processing units, which Hassabis estimated to be US$25 million of hardware. But its predecessors used ten times that number. It also trained itself in days, rather than months. The implication is that “algorithms matter much more than either computing or data available”, said Silver.

Think outside the board

Several DeepMind researchers have already moved from working on AlphaGo to applying similar techniques to practical applications, said Hassabis. One promising area, he suggested, is understanding how proteins fold, an essential tool for drug discovery.

Generating examples of protein folding can involve years of painstaking crystallography, so there are few data to learn from, and there are too many possible solutions to predict structures from amino-acid sequences using a brute-force search. The puzzle shares some key features with Go, however. Both involve well-known rules and have a well-described goal. In the longer term, such algorithms might be applied to similar tasks in quantum chemistry, materials design and robotics.

Silver acknowledged that to apply its approach to real-world tasks more generally, the AI will need the ability to learn from smaller amounts of data and experience. Another essential step will be learning the rules of a game for itself, as another DeepMind bot did in 2015 for arcade games. Hassabis reckons this is something AlphaGo Zero could eventually do: “We’re pretty sure it would work, it would just extend the learning time a lot,” he said.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22858

Comments

Comments

There are currently no comments.

Science must examine the future of work

As automation changes employment, researchers should gather the evidence to help map the implications.

18 October 2017

VCG/Getty

Automation will take away jobs, but a bigger question is how many it will generate.

In 2014, the *Los Angeles Times* began beating its rivals to report earthquakes, using an algorithm to convert announcements from the US Geological Survey

(USGS) to breaking news within a few minutes. This June, it announced that a magnitude-6.8 quake had shaken Santa Barbara, California. That was certainly news to the distinctly unshaken residents of Santa Barbara; the earthquake the newspaper was reporting on had actually happened in 1925. The paper's Quakebot had misinterpreted an update to the USGS seismic database and published its story online without anyone checking. The story was deleted and Santa Barbarans (and human journalists everywhere) could breathe a sigh of relief.

The tale encapsulates many of the issues that surround the intensifying debate about the roles of computers and humans in the workplace of the future — both the very near and the very far. Much of that debate places people and algorithms in direct competition. From lorry drivers threatened by self-driving vehicles to doctors who could be replaced by know-it-all diagnostic devices, many jobs as we know them could be done by artificial intelligence (AI) systems.

In an Editorial last year on the likely role and risks of AI in future society, *Nature* noted that even academic debate on the topic is polarized between sceptics and fanciful futurists (see *Nature* **532,** 413; 2016). In a special issue this week, we try to find and explore some middle ground, by bringing together and assessing the evidence on how automation will affect the future of work.

In a sense, this debate is nothing new. Technology and automation have been putting people out of jobs for hundreds of years, as historian Robert Allen discusses in a Comment. So have other factors — chiefly economic trends and globalization. But the spread of technology has also created new roles. In broad terms, as manufacturing jobs in the West have been transferred to low-wage economies elsewhere, politicians and economists have looked to tech to help fill the gap. These new industries, they argue, both need direct labour to develop them and create employment indirectly through the need for service and support. But will this trend continue? The true debate over the future of work is not whether computers will replace people in many jobs — they surely will — but whether they are team players. For how long will Quakebot and its descendants need a human supervisor?

Both sceptics and fanciful futurists will find something to agree and disagree

with in the articles that follow. In a Comment, Yuval Noah Harari, historian and best-selling author of *Sapiens* (Harper, 2014) and *Homo Deus* (Harvill Secker, 2015), argues: “The challenges posed in the twenty-first century by the merger of infotech and biotech are arguably bigger than those thrown up by steam engines, railways, electricity and fossil fuels.” He also offers reassurance about job prospects for some people, from a perhaps unlikely source. Each US military drone flying over Syria keeps 110 people in a job, he writes — 30 operators and 80 analysts to process the information it sends back. This is not an argument for more drones, the use of which is controversial. But, as Harari writes: “A careful study of the military job market might tell us a lot about potential future developments in the civilian economy.”

Careful study, *Nature* naturally argues, is something that (human) scientists and other academics excel at. As the 2016 editorial put it, “it is crucial that progress in technology is matched by solid, well-funded research to anticipate the scenarios it could bring about”, such as impacts on mental health and management, and how humans interact with robots. It’s important, too, to study possible political and economic reforms that will allow those usurped by machinery to contribute to society.

The Oxford Martin Programme on Technology and Employment at the University of Oxford, UK, is doing just this (see go.nature.com/2xxauvm). Oxford economist Ian Goldin offers his own thoughts.

Among the topics worthy of examination is the future fate of science and scientists. So far, the application of technology and automation to research has fuelled, and not felled, the need for human support. Indeed, fields such as bioinformatics exist only because of the work that computers generate for scientists. But as explored in a Careers Feature, science is not immune from the gig economy — short-term employment on specialist tasks such as writing a literature review or managing a database. The trend towards parcelling off and even publishing science as a series of steps rather than full papers could see demand for freelance services rise. (The breakdown of complex tasks into a series of simpler steps is, of course, also a proven path to automation.)

Still, browse ‘help needed’ adverts for scientific gigs and the future looks less

rosy. As little as US$80 to perform a detailed meta-analysis of published studies? It’s hardly worth even plugging in for that.

Journal name:
Nature
Volume:
550,
Pages:
301–302
Date published:
(19 October 2017)
DOI:
doi:10.1038/550301b

Comments

Comments

There are currently no comments.

Blue is in the eye of the bee-holder

Flowers have evolved an ingenious way to attract pollinators.

18 October 2017

Ron Reznick/VW Pics/UIG via Getty Images

Nanostructures on flowers generate a blue halo that attracts bees.

The car maker Lexus announced a new paint job for its LC coupé this month, which it says will appeal to drivers who value the interaction of science and craftsmanship. The car is blue and the science it leans on is the optics of iridescence. Lexus says that it uses several layers of pigment to increase the amount of incoming light that reflects as blue. The finish, it claims, is “more blue” than anything seen before — and more time-consuming to apply. People who buy the model are unlikely to suffer that common psychological

bias experienced by owners of a new car who suddenly notice other vehicles everywhere the same colour as theirs: at present, the company can make just two a day.

Lexus says that its new blue is based on the famous wings of the morpho butterfly. These contain no pigment, but look blue because of how the wing structure physically separates the various components of white light and reflects only certain wavelengths. The company could also have borrowed the idea from the (less PR friendly) tarantula spider, many species of which use the hairs on their legs and body to show off the same blue effect. In fact, such iridescence is fairly common in plants and animals — sometimes deliberate (the shimmer of the peacock tail) and sometimes less so (the same effect from a fresh cut of meat). It's why a blue-cooked steak really does look blue. blue pigments are rare), and this week a paper online in *Nature* explores its role in flowering plants (E. Moyroud *et al. Nature* http://dx.doi.org/10.1038/nature24285; 2017).

Fewer than 10% of the 280,000 species of flowering plant naturally produce blue petals. This presents a problem, because the bees on which many flowers rely for pollination struggle to see any colour other than blue. So how do these flowers attract the insects they need?

The new study shows that they use structural-colour techniques to generate an iridescent blue halo. From the tulip to the golden perennial sweet pea, a dozen different flowering plants of varying colours were found to have surface nanostructures that produced the optical effect. It's visible to the human eye, too, and best seen against dark-coloured petals.

In a series of tests with bumblebees (*Bombus terrestris*), the researchers demonstrate that the insects avoid artificial flowers made to have smooth surfaces that don't produce the blue ring. And they show how the insects see the halo more easily than we do, because bee vision can better distinguish the ultraviolet frequencies into which the structural-colour effect spreads. The findings are discussed in an accompanying News & Views article (D. D. Deheyn *Nature* http://dx.doi.org/10.1038/nature24155; 2017).

Lexus boasts that it took more than a decade to develop its new blue paint. It took the flowers a lot longer: their ability to generate the halo effect has

evolved over millions of years, and perhaps emerged in each species independently. In both cases, the colour is best appreciated at first hand. Photographs do not do it justice. Take a stroll in the garden. And keep one eye on the road.

Journal name:
: Nature

Volume:
: 550,

Pages:
: 302

Date published:
: (19 October 2017)

DOI:
: doi:10.1038/550302a

Comments

Comments

There are currently no comments.

Epic star collision, asteroid fly-by and journal resignations

The week in science: 13–19 October 2017.

18 October 2017

Events | People | Research | Facilities | Policy | Awards | Funding | Trend watch

EVENTS

Flames devastate northern California Wildfires have scorched about 890 square kilometres in Northern California, leaving at least 41 people dead as of 17 October, making them the deadliest fires in the state's history. Nearly 100,000 residents of Napa and Sonoma Counties had been evacuated from their homes, although this week officials have started to let people return. At least 88 of the many hundreds of people who were reported missing are still unaccounted for. The exact cause of the flames is unknown, but the area was primed for a conflagration. Vegetation flourished in the region after record rainfall last winter, and heatwaves this summer dried everything out, turning it into kindling. Winds gusting at more than 100 kilometres per hour hindered the efforts of firefighters to bring the blazes under control.

Justin Sullivan/Getty

Journal editors quit Five German scientists said on 12 October that they have resigned their editorial positions at journals published by Elsevier, after negotiations over a national licensing agreement for German institutes ground to a halt. For more than a year, a consortium of German science organizations called Projekt DEAL has been pushing for a new type of nationwide licence with Elsevier that would include open-access options and replace the need for individual institutional subscriptions. About 200 German universities and research institutes have cancelled their individual contracts with the Dutch publisher.

Asteroid buzz A house-sized asteroid whizzed by Earth on 12 October, passing within 44,000 kilometres of the planet — just above the orbits of geostationary satellites — and providing a test of international planetary defences. Telescopes around the globe swivelled to track the body, which is estimated to be 15–30 metres wide and is known as 2012 TC4. NASA, the European Space Agency and other asteroid-hunting groups gathered data to fine-tune orbital calculations and establish its future path. The asteroid's next

close pass will be in 2050, when it will safely fly by Earth. Future Earth impacts after that date have not been ruled out.

PEOPLE

Trump nominations Barry Myers, the chief executive of weather-forecasting firm AccuWeather, is US President Donald Trump's pick to lead the National Oceanic and Atmospheric Administration (NOAA), the White House said on 11 October. Myers, an attorney by training, has led AccuWeather — based in State College, Pennsylvania — since 2007. Some scientists worry that his ties to the company could lead to conflicts of interest, and note that he has no direct experience with NOAA's broader research portfolio, which includes the climate, oceans and fisheries. Two days later, the White House announced that Trump had nominated Kathleen Hartnett White, a former Texas environmental regulator and prominent climate sceptic, for its top environmental post. If confirmed as chair of the Council on Environmental Quality, White would advise the president and coordinate federal policies on energy and the environment. White is a fellow at the Texas Public Policy Foundation, a conservative think tank based in Austin. She has called efforts to shift away from fossil fuels "environmental lunacy".

New Pasteur chief Stewart Cole was appointed on 13 October as the next president of the Pasteur Institute in Paris, replacing Christian Bréchot, who had reached the institute's mandated retirement age. Many of the Pasteur's researchers had wanted Bréchot to stay on, but a campaign to change the age-limit rule was unsuccessful. Cole, a microbial-pathogenesis specialist, has held several posts at the biomedical research institute and will begin his four-year term in January. Last month, Bréchot was appointed president of the Global Virus Network, an international coalition of virologists based in Baltimore, Maryland.

RESEARCH

Epic stellar clash Researchers announced on 16 October that they had for the first time witnessed the collision of two neutron stars — and perhaps the

subsequent formation of a black hole. The event was first spotted on 17 August by gravitational-wave detectors in the United States and Italy and by a NASA γ-ray probe. More than 70 observatories rushed to observe the collision's aftermath; their discoveries are detailed in dozens of papers and solve several cosmic mysteries.

FACILITIES

FAST's first pulsars The world's largest single-dish telescope has observed its first two pulsars. The Five-hundred-meter Aperture Spherical Telescope (FAST) in southern China's Guizhou province detected the neutron stars in August. Researchers at the National Astronomical Observatories of China reported the results on 10 October after they were confirmed by an Australian telescope. The observations suggest FAST is working well, despite its radical design: the dish consists of thousands of panels that move to track radio signals, requiring elaborate coordination. Signals from the two pulsars were captured a year into an estimated three-year debugging phase. FAST, which is expected to find hundreds, possibly thousands, of pulsars, is looking for clues to how the Universe formed, as well as for signs of extraterrestrial life.

China Daily/Reuters

POLICY

Climate-rule repeal On 10 October, the US Environmental Protection Agency moved to repeal former president Barack Obama's landmark regulations to reduce greenhouse-gas emissions from power plants. Agency administrator Scott Pruitt signed a measure to begin the process of rescinding the Obama policy, a move that is expected to spark lawsuits by environmental groups and some states. The power-plant rule would reduce greenhouse-gas emissions to 32% below 2005 levels by 2030. In 2016, the Supreme Court blocked the policy from taking effect; legal challenges from 27 state governments are still pending, although a federal appeals court has put the case on hold while the administration of President Donald Trump reviews the rule.

Measuring impact UK science minister Jo Johnson has announced plans to

assess universities on their economic impact and engagement with wider society. Higher-education bodies will consult on creating a Knowledge Exchange Framework, an evaluation system designed to incentivize activities such as transferring technology into industry, spinning off companies and conducting contract research, training and consultancy, Johnson said on 12 October. If implemented, the framework would become a third strand of UK university assessment, alongside the Teaching Excellence Framework and Research Excellence Framework.

AWARDS

MacArthur grants The philanthropic MacArthur Foundation in Chicago, Illinois, announced its 2017 award recipients on 11 October. Six of the 24 winners — often referred to as MacArthur geniuses — are scientists. They include anthropologist Jason De León of the University of Michigan in Ann Arbor, who uses methods including archaeology and forensic science to study undocumented migrants on the US–Mexican border; computational linguist Regina Barzilay of the Massachusetts Institute of Technology in Cambridge, who deciphers ancient languages using machine learning; and immunologist Gabriel Victora of the Rockefeller University in New York City, who observes how antibodies evolve in the immune system in real time. Each winner gets US$625,000 over 5 years, with no restrictions on how they can spend the money.

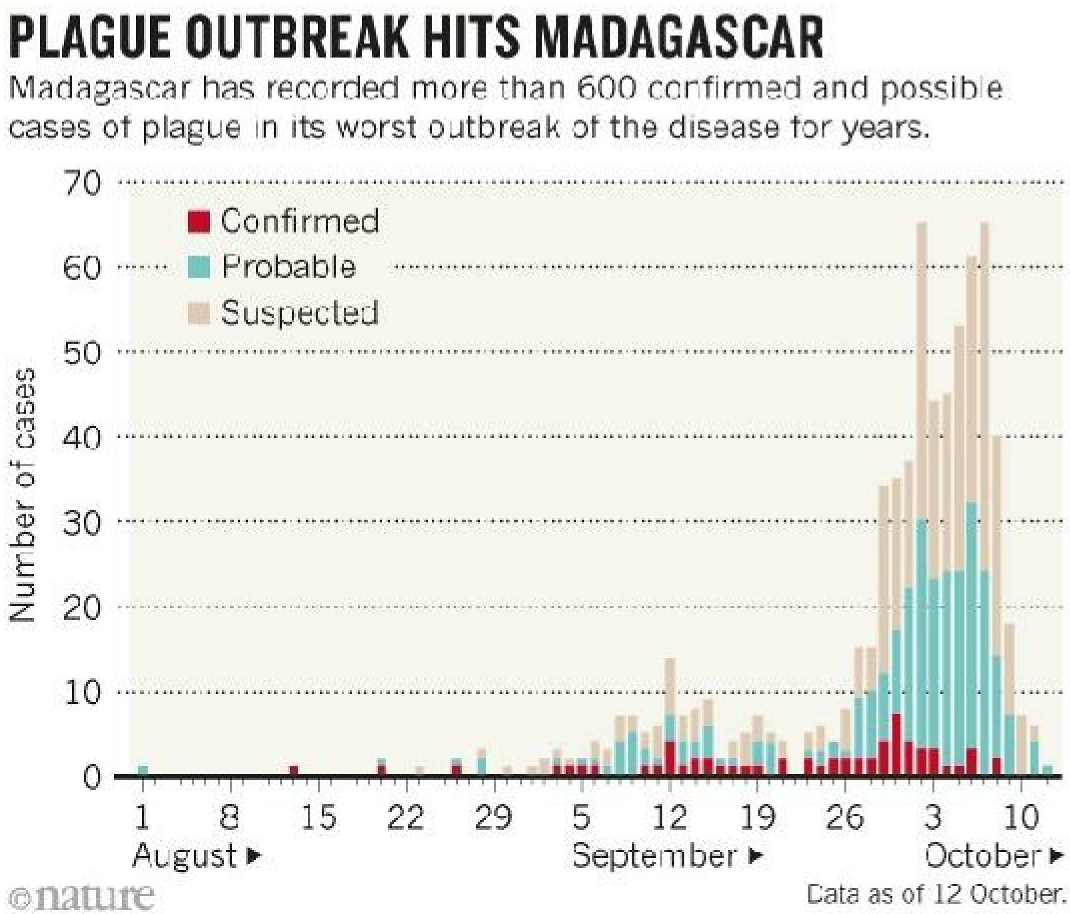
FUNDING

Research boost Online shopping giant Alibaba will set up seven international research laboratories as part of its plan to spend US$15 billion on research and development over the next three years. The company, based in Hangzhou, China, announced the Alibaba DAMO Academy on 11 October. The seven labs will be established in China, the United States, Russia, Israel and Singapore. Research topics will include data intelligence, the ‘Internet of things’, quantum computing and human–machine interfaces. Recruitment of the first 100 researchers is under way. The advisory board of the academy includes prominent scientists from outside China, including

geneticist George Church of Harvard University in Cambridge, Massachusetts.

TREND WATCH

Madagascar is battling an outbreak of plague, with more than 600 cases and at least 57 deaths since 1 August. Plague is endemic to the island and surfaces almost annually. But the current outbreak is unusually large, and cases are mostly of pneumonic plague, which is deadlier and more transmissible than the more usual bubonic form. Untreated, pneumonic plague can kill within 24 hours. On 10 October, the World Health Organization reported a linked case of plague in the Seychelles.



Source: WHO

Journal name:
Nature
Volume:
550,
Pages:
306–307
Date published:
(19 October 2017)
DOI:
doi:10.1038/550306a

Comments

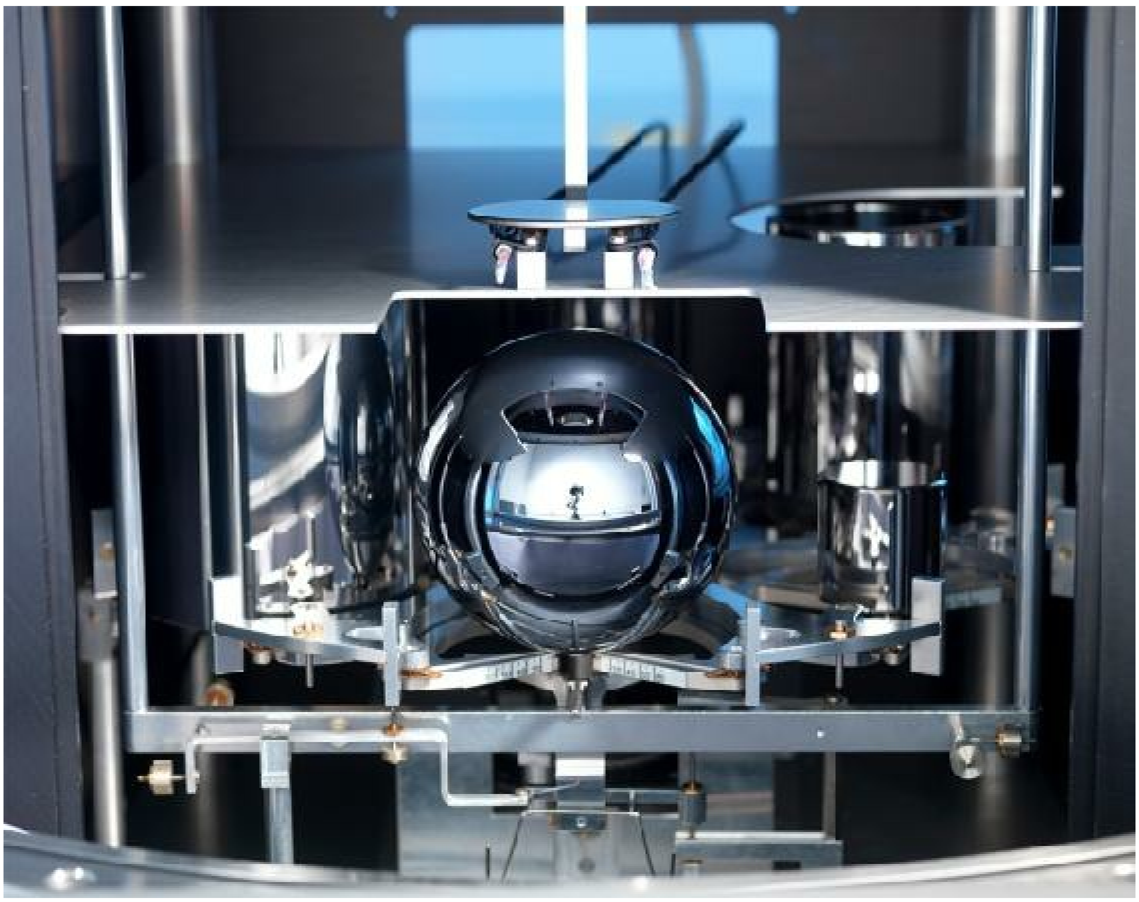
Comments

There are currently no comments.

New definitions of scientific units are on the horizon

Metrologists are poised to change how scientists measure the Universe.

18 October 2017



Natl. Phys. Lab., UK

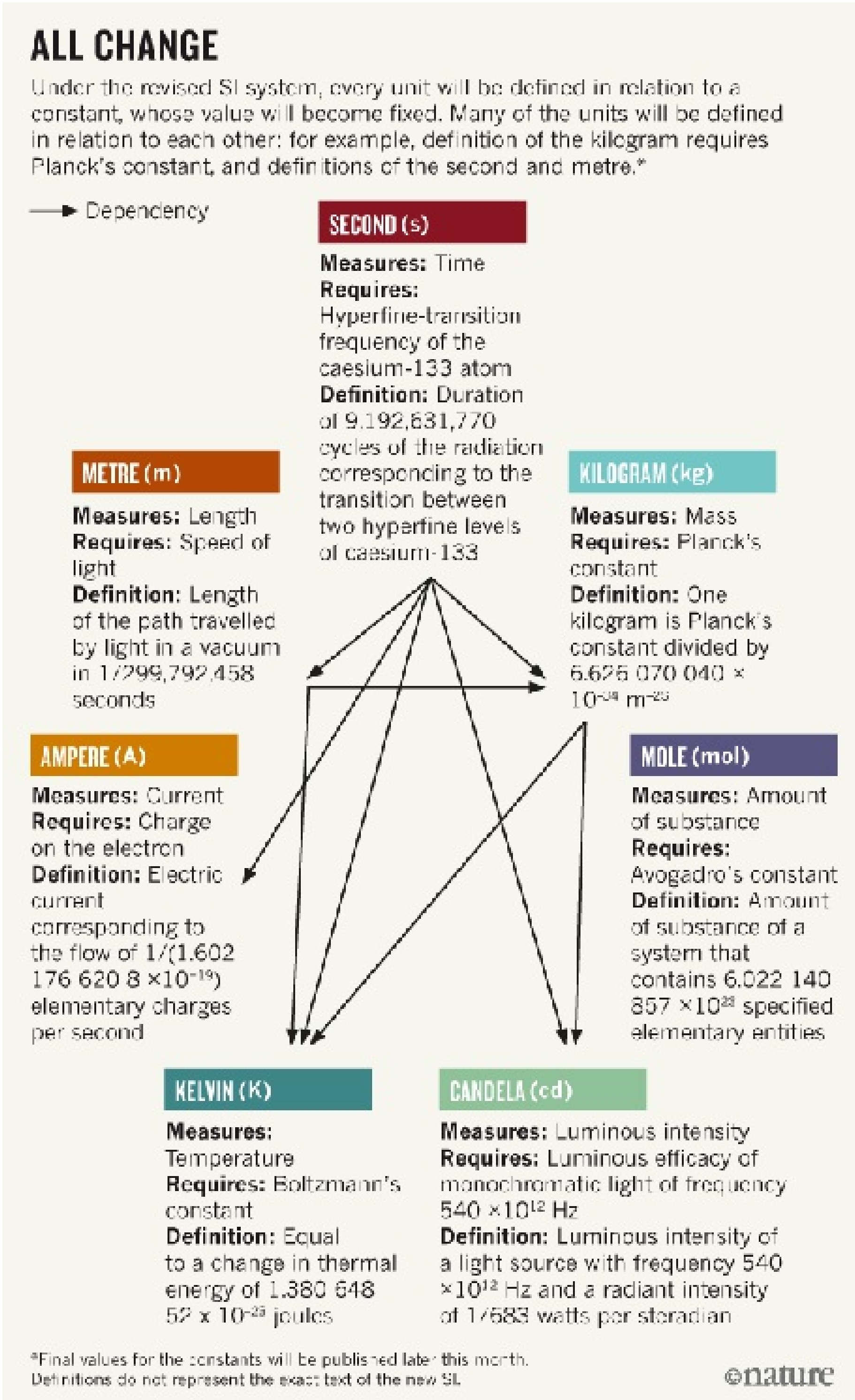
A sphere of pure silicon can be used to define a unit of measurement known as a mole.

Revamped definitions of scientific units are on their way. In the biggest

overhaul of the international system of units (SI) since its inception in 1960, a committee is set to redefine four basic units — the ampere, the kilogram, the kelvin and the mole — using relationships to fundamental constants, rather than abstract or arbitrary definitions. The International Bureau of Weights and Measures is reviewing the plans at a meeting near Paris from 16 to 20 October. Its recommendations will then go before the General Conference on Weights and Measures, which oversees the SI system, in November 2018. The changes would take effect in May 2019.

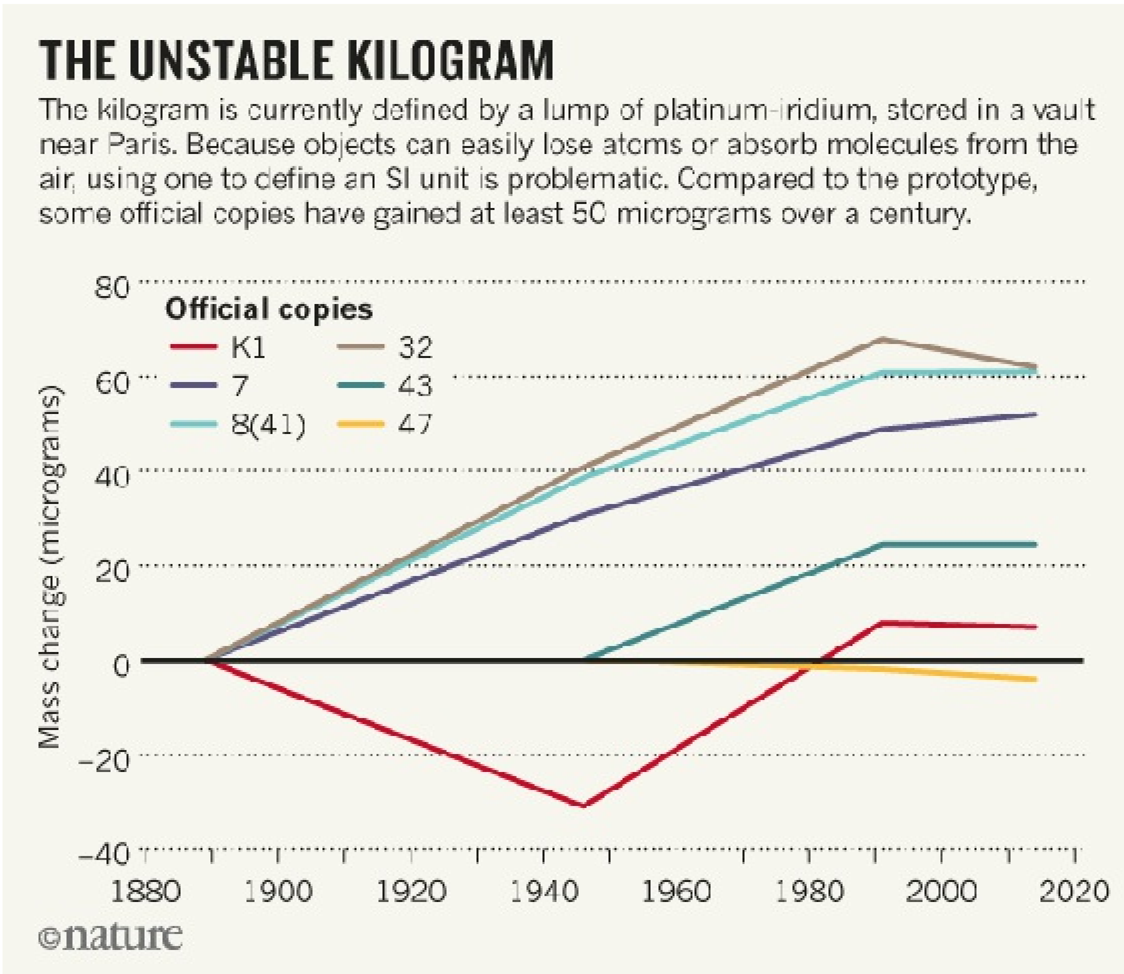
The kilogram is currently defined as the mass of a chunk of metal in a vault in Paris. And an imaginary experiment involving the force between two infinite wires defines the ampere, the unit of electrical current. The mole, meanwhile, is the amount of substance in a system with as many elementary entities as there are atoms in 0.012 kilograms of carbon-12, while the kelvin relates to the temperature and pressure at which water, ice and water vapour co-exist in equilibrium, known as the triple point of water. In the future, these units will be calculated in relation to constants — for example, the ampere will be based on the charge of an electron.

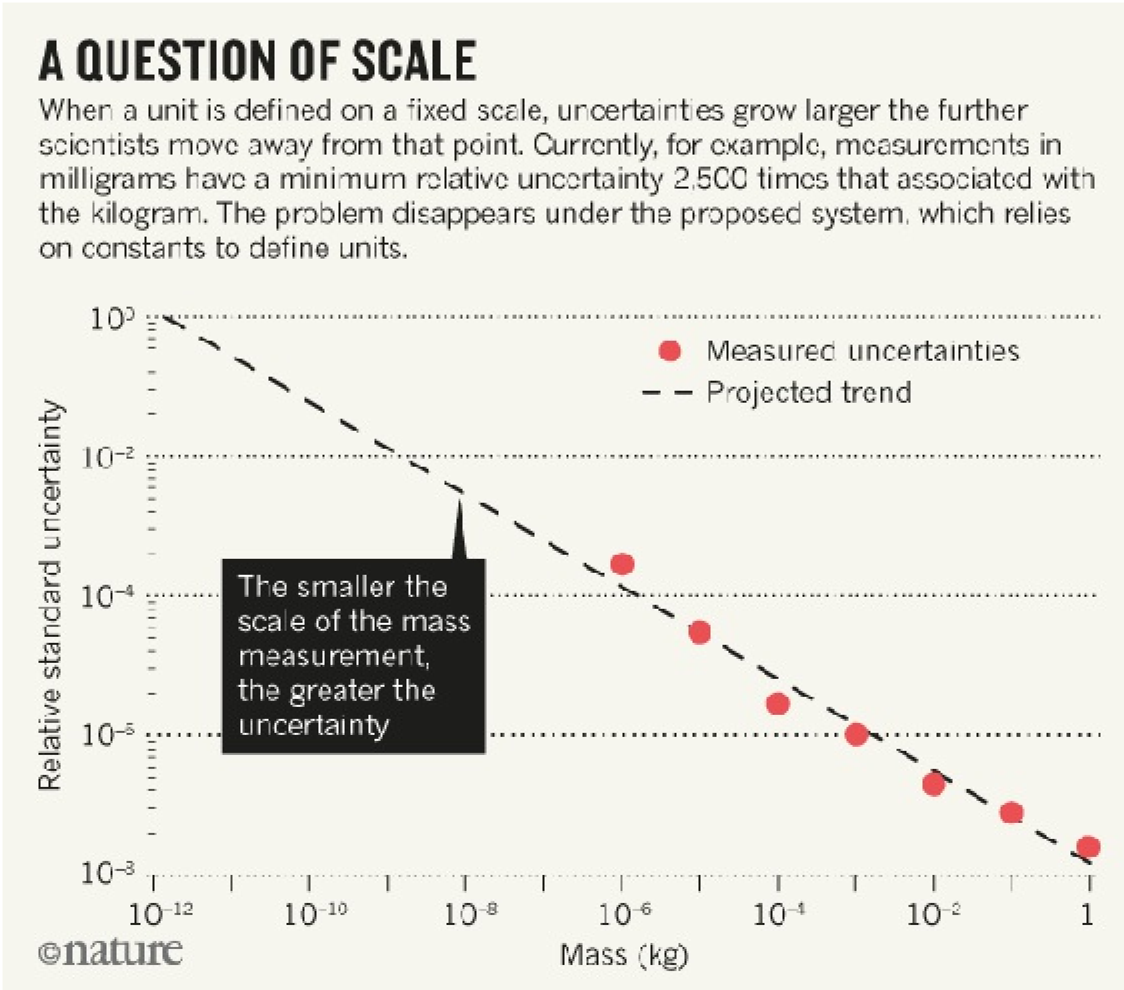
Redefinition might not affect everyday measurements, but it will enable scientists working at the highest level of precision to do so in multiple ways, at any place or time and on any scale, without losing accuracy.


ALL CHANGE
Under the revised SI system, every unit will be defined in relation to a constant, whose value will become fixed. Many of the units will be defined in relation to each other: for example, definition of the kilogram requires Planck's constant, and definitions of the second and metre.*
Dependency
SECOND (s)
Measures: Time
Requires: Hyperfine-transition frequency of the caesium-133 atom
Definition: Duration of 9,192,631,770 cycles of the radiation corresponding to the transition between two hyperfine levels of caesium-133
METRE (m)
Measures: Length
Requires: Speed of light
Definition: Length of the path travelled by light in a vacuum in 1/299,792,458 seconds
KILOGRAM (kg)
Measures: Mass
Requires: Planck's constant
Definition: One kilogram is Planck's constant divided by 6.626 070 040 × 10^{-34} $m^{-2}s$
AMPERE (A)
Measures: Current
Requires: Charge on the electron
Definition: Electric current corresponding to the flow of 1/(1.602 176 620 8 ×10^{-19}) elementary charges per second
MOLE (mol)
Measures: Amount of substance
Requires: Avogadro's constant
Definition: Amount of substance of a system that contains 6.022 140 857 ×10^{23} specified elementary entities
KELVIN (K)
Measures: Temperature
Requires: Boltzmann's constant
Definition: Equal to a change in thermal energy of 1.380 648 52 x 10^{-23} joules
CANDELA (cd)
Measures: Luminous intensity
Requires: Luminous efficacy of monochromatic light of frequency 540 ×10^{12} Hz
Definition: Luminous intensity of a light source with frequency 540 ×10^{12} Hz and a radiant intensity of 1/683 watts per steradian
*Final values for the constants will be published later this month.
Definitions do not represent the exact text of the new SI.
©nature

The problem

For measurements on conventional scales, existing definitions of SI units suffice. But they are poor tools for modern science at the extremes. And basing units on specific points or materials can be troublesome and inelegant, say metrologists.





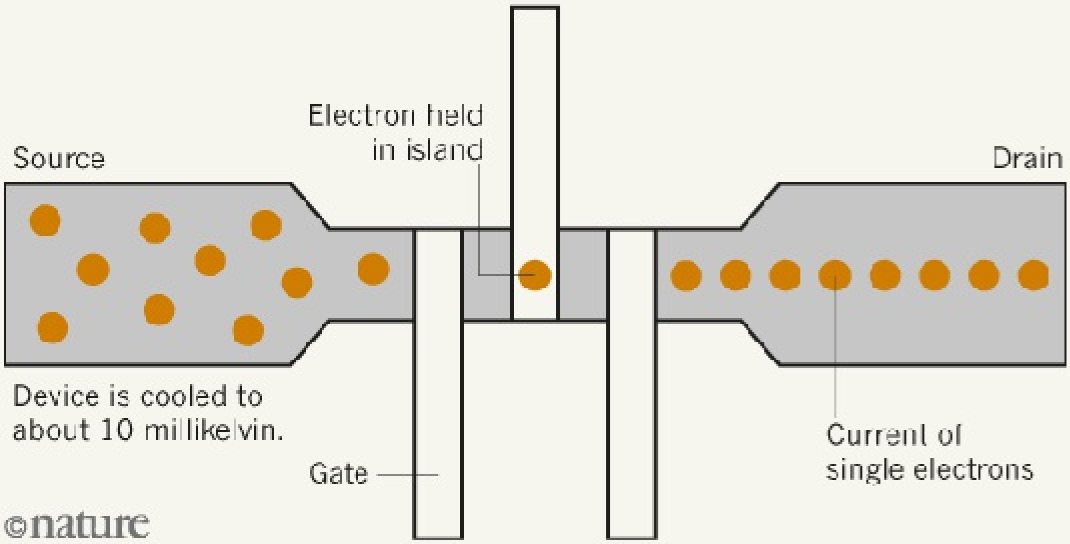
Source: Shaw, G. et al. Metrologia 53, A86–A94 (2016).

The techniques

Under the revamped SI system, researchers will be able to use various experiments to relate constants to each of the units measured.

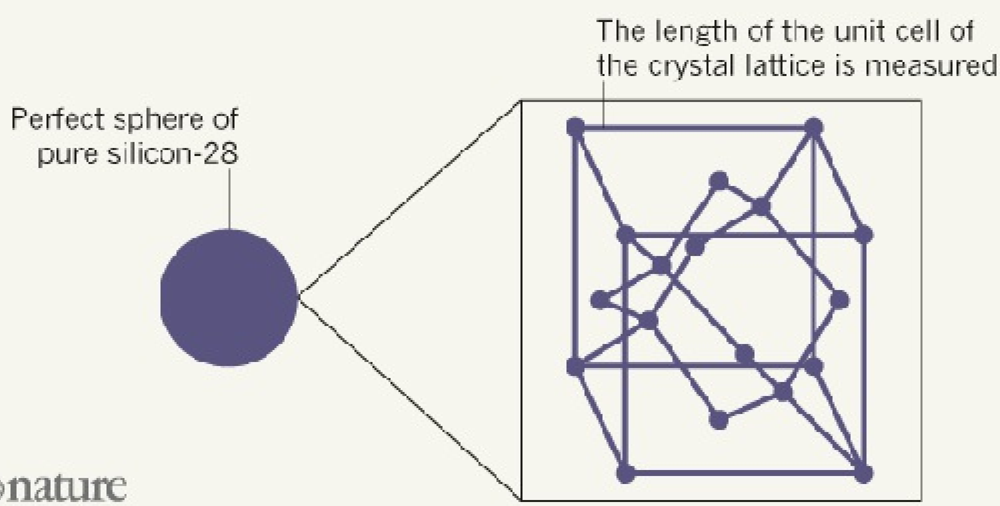
AMPERE: THE SINGLE-ELECTRON PUMP

Used to measure the charge of an electron, an electron pump could become one tool for determining the ampere. By trapping individual electrons as they travel rapidly across a conductor, the pump can generate a measureable current by counting single electrons.



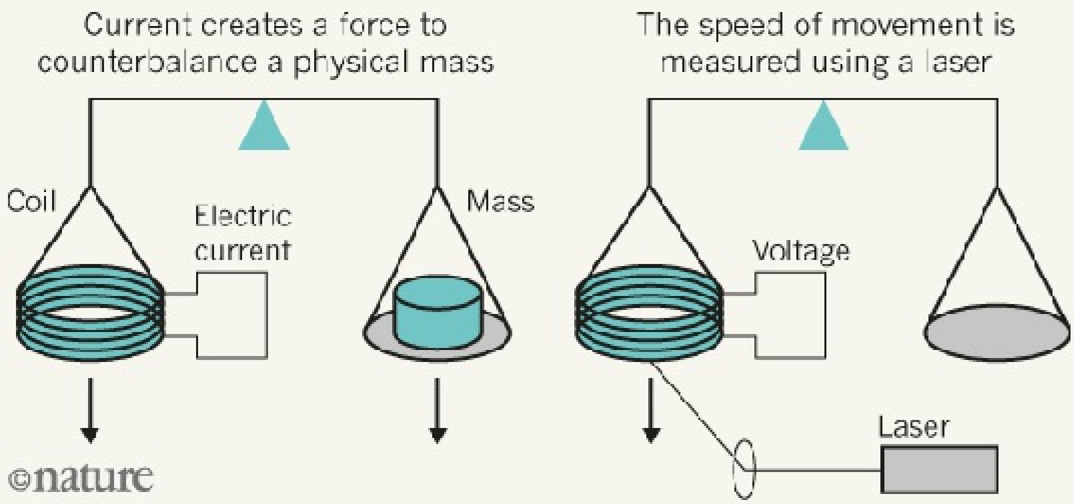
MOLE: THE SILICON SPHERE

As the device that gives scientists Avogadro's constant, this silicon sphere offers a state-of-the-art way to measure a mole. It would determine the precise number of atoms in a perfect sphere of pure silicon-28. Researchers do this by using lasers to measure the length of a unit of the sphere's crystal lattice, and its mean diameter.



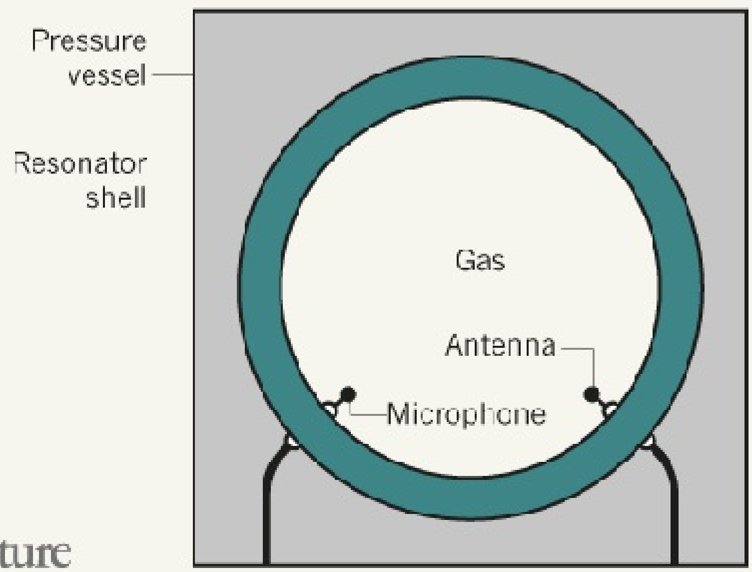
KILOGRAM: THE WATT BALANCE

The Watt balance compares mechanical power with electromagnetic power using two separate experiments. First, a current is run through a coil in a magnetic field to create a force that counterbalances a known physical mass. Then, the coil is moved through the field to create a voltage. By measuring the speed as well as experimental values that relate the voltage and current to Planck's constant, scientists can precisely determine the weight of a mass in kilograms.



KELVIN: ACOUSTIC THERMOMETRY

This technique could be used to derive precise temperature measurements. The speed of sound in a gas-filled sphere (which is proportional to the average speed of the atoms in it) can be determined at a fixed temperature, by analysing the frequency of sound waves that resonate within in it and measuring the sphere's volume.

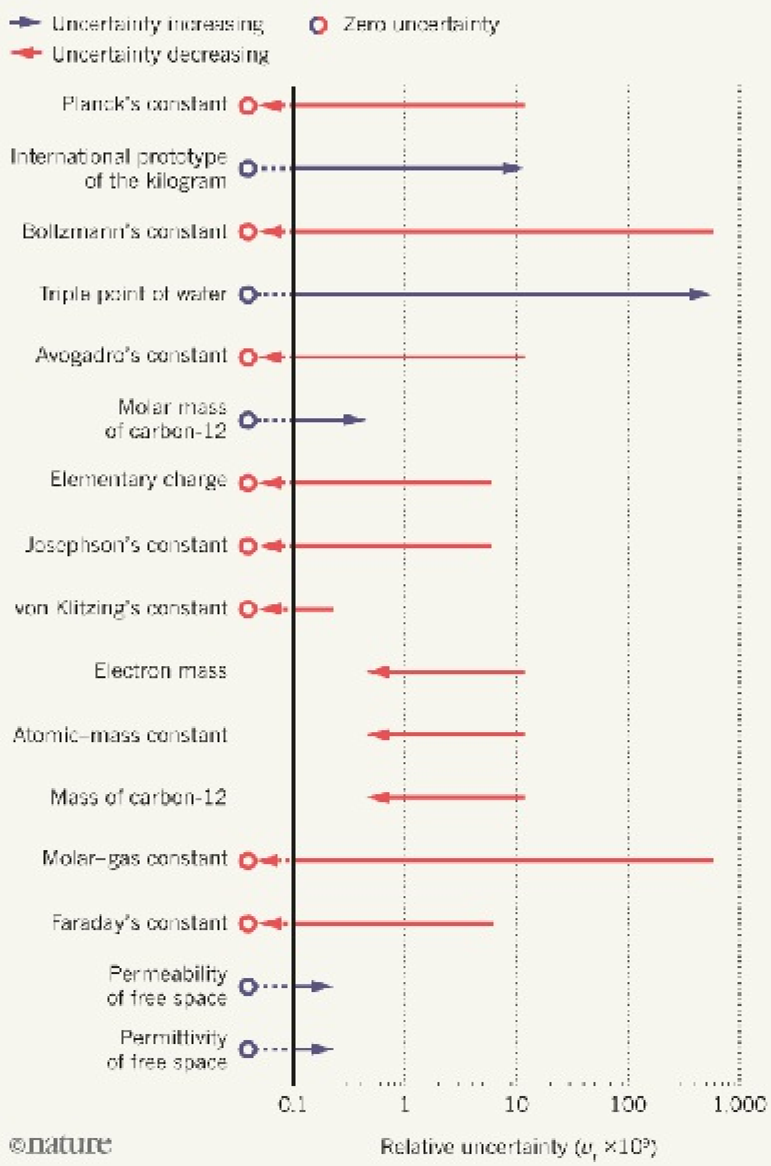


©nature

THE FUTURE

Experimental teams have been working for decades to agree on values for the constants on which the definitions will soon hinge. They had to meet strict conditions, which the kilogram teams fulfilled only in 2015. All groups submitted final figures by 1 July. Under the new system, these constants will be stripped of their uncertainties and fixed as exact numbers in May 2019. Their former uncertainties will then be transferred to measurements that use the units defined by the constants. As a consequence, other, related constants, once expressed in the new units, will see their uncertainties reduced as well.

The loser will be the mass of the prototype kilogram in Paris. It currently has an uncertainty of zero but that will soon rise to at least ten parts per billion.



Journal name:

Nature

Volume:

550,
Pages:
312–313
Date published:
(19 October 2017)
DOI:
doi:10.1038/550312a

Comments

Comments

There are currently no comments.

The future of work

Digital technologies are upending the workforce. The right research can tell us how.

18 October 2017

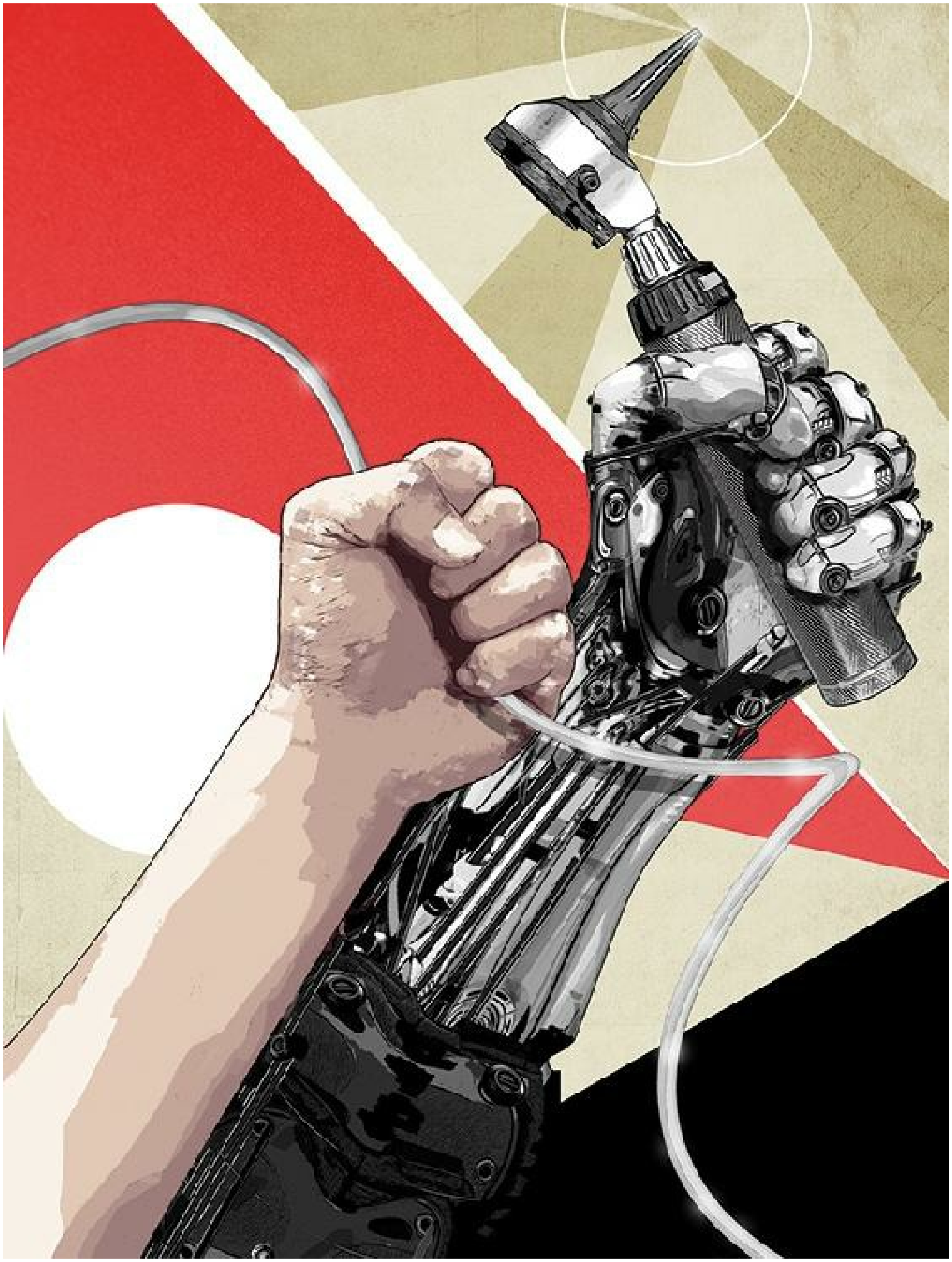


Illustration by Chris Malbon

Robots did not write this sentence, or any other part of *Nature*. But that could

change. Dramatic shifts in labour are reshaping society, the environment and the political landscape. Consider this disorienting estimate from the World Economic Forum: 65% of children entering primary schools now will grow up to work in jobs that do not yet exist. This week, *Nature* asks: what light is research shedding on the future of work, and how will the changes affect scientists' working world?

A News Feature explores which jobs are most at risk of being replaced by artificial intelligence and machine learning; whether a decentralized 'gig economy' will democratize work; and what programmes will best prepare workers. “There's a huge need, a huge opportunity, to study the changes,” says economist Erik Brynjolfsson. And the scientific workforce is feeling these shifts. A Careers Feature reports on people doing research outside the traditional career path. “I love the freedom,” says Cecile Menard, an independent land-surface modeller in Edinburgh, UK, “but for other people, it may be too stressful.”

Important lessons can be drawn from the past. Economic historian Robert Allen synthesizes three centuries of data to see when and where the relationship between wages and productivity was most like today's — and finds that some regions are in uncharted waters. These changes call for new socio-economic models and a revolution in education, concludes historian Yuval Noah Harari. And economist Ian Goldin argues that our era has more parallels with the Renaissance than the Industrial Revolution. This time, he urges, “knowledge and enquiry must find a way to conquer prejudice and ignorance”.

Journal name:
Nature
Volume:
550,
Pages:
315
Date published:
(19 October 2017)
DOI:
doi:10.1038/550315a

Comments

There are currently no comments.

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The shape of work to come

Three ways that the digital revolution is reshaping workforces around the world.

18 October 2017

Illustration by Chris Malbon

Last year, entrepreneur Sebastian Thrun set out to augment his sales force with artificial intelligence. Thrun is the founder and president of Udacity, an education company that provides online courses and employs an armada of salespeople who answer questions from potential students through online chats. Thrun, who also runs a computer-science lab at Stanford University in California, worked with one of his students to collect the transcripts of these chats, noting which resulted in students signing up for a course. The pair fed

the chats into a machine-learning system, which was able to glean the most effective responses to a variety of common questions.

Next, they put this digital sales assistant to work alongside human colleagues. When a query came in, the program would suggest an appropriate response, which a salesperson could tailor if necessary. It was an instantaneously reactive sales script with reams of data supporting every part of the pitch. And it worked; the team was able to handle twice as many prospects at once and convert a higher percentage of them into sales. The system, Thrun says, essentially packaged the skills of the company's best salespeople and bequeathed them to the entire team — a process that he views as potentially revolutionary. “Just as much as the steam engine and the car have amplified our muscle power, this could amplify our brainpower and turn us into superhumans intellectually,” he says.

The past decade has seen remarkable advances in digital technologies, including artificial intelligence (AI), robotics, cloud computing, data analytics and mobile communications. Over the coming decades, these technologies will transform nearly every industry — from agriculture, medicine and manufacturing to sales, finance and transportation — and reshape the nature of work. “Millions of jobs will be eliminated, millions of new jobs will be created and needed, and far more jobs will be transformed,” says Erik Brynjolfsson, who directs the Initiative on the Digital Economy at the Massachusetts Institute of Technology in Cambridge.

But making firm predictions is difficult. “The technology is rushing ahead, which in a way is a good thing, but we have a huge gap in understanding its implications,” Brynjolfsson says. “There's a huge need, a huge opportunity, to study the changes.” Researchers are beginning to do just that, and the emerging evidence resists simple storylines. Advances in digital technologies are likely to change work in complex and nuanced ways, creating both opportunities and risks for workers (see 'More research needed').

More research needed

Illustration by Chris Malbon

Scientists are grappling with how technology could alter workplaces.

The changing world of work presents an almost endless number of topics for

scientists to explore. Here are two other workplace trends and the research questions — as yet mostly unanswered — that they raise.

How will workers respond to new forms of tracking and surveillance?

Although employers have long monitored the performance of their staff, workplace surveillance is entering a new era.

Companies can now log workers' keystrokes and remotely take screenshots of their computers, for example, or use motion sensors, biometrics, radio-frequency identification (RFID) chips and the Global Positioning System to track their movements, even after hours.

But it's not yet clear whether workers will show widespread resistance to the increasing use of surveillance technology, or where they might draw the line. And could new forms of surveillance backfire in less obvious ways, undermining trust, morale or innovation?

How will human-enhancement technologies affect worker health and safety?

Technologies for improving human performance — from cognition-boosting drugs to bionic 'exoskeletons' that are designed to make physical labour safer and easier — are beginning to make their way into the workplace.

In some cases, these technologies could help to protect the health and safety of workers. An alertness-enhancing drug, such as modafinil, might help long-haul drivers avoid accidents, and exoskeletons could reduce joint stress and muscle fatigue. But researchers don't know whether the long-term use of these technologies could harm workers, either directly or indirectly, perhaps by encouraging overwork or increased risk-taking.

Here are three pressing questions about the future of work in a digital world and how researchers are beginning to answer them.

Will machine learning displace skilled workers?

In previous waves of automation, technological advances have allowed machines to take over tasks that were simple, repetitive and routine. Machine learning opens up the possibility of automating more complex, non-routine cognitive tasks. “For most of the last 40 or 50 years, it was impossible to automate a task before we understood it extremely well,” Brynjolfsson says. “That's not true anymore. Now machines can learn on their own.”

Machine-learning systems can translate speech, label images, pick stocks, detect fraud and diagnose disease — rivalling human performance in some new and surprising domains. “A machine can actually look at many, many, many more data samples than a human can handle,” says Thrun. Earlier this year, he led a team that demonstrated that some 129,000 images of skin lesions could be used to train a machine to diagnose skin cancer with a level of accuracy that matches that of qualified dermatologists[1].

LISTEN

Reporter Benjamin Thompson finds out how lessons from the past can help explore the future of work.

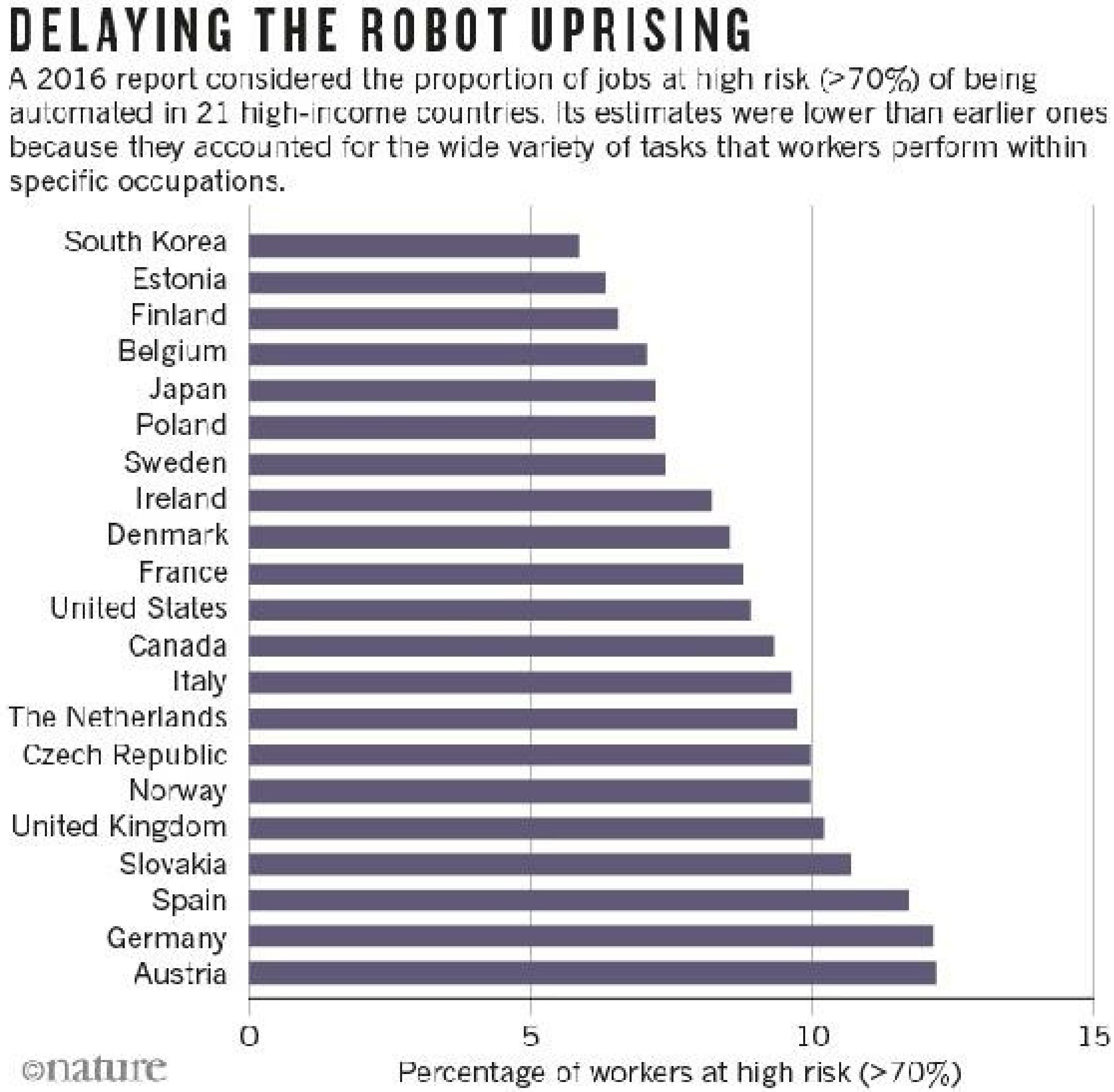
You may need a more recent browser or to install the latest version of the Adobe Flash Plugin.

These advances have raised concerns that such systems could replace human workers in fields that once seemed too complex to be automated. Early estimates seemed dire. In 2013, researchers at the Oxford Martin Programme on Technology and Employment at the University of Oxford, UK, reviewed the advances and lingering challenges in machine learning and mobile robotics to estimate how susceptible 702 different occupations were to automation[2]. Their startling conclusion was that 47% of jobs in the United States were at high risk of computerization, with jobs in transportation, logistics, production and administrative support particularly vulnerable. That spelt trouble for workers such as taxi drivers, legal secretaries and file clerks.

Since then, however, other researchers have argued that the 47% figure is much too high, given the variety of tasks that workers in many occupations

tend to perform. “Once you go deeper, once you look into the task structure of what people really do at work, then you find that the estimates get much lower,” says Ulrich Zierahn, a senior researcher at the Centre for European Economic Research in Mannheim, Germany.

For instance, the Oxford study reported that clerks in bookkeeping, accounting and auditing face an automation risk of 98%. But when Zierahn and his colleagues analysed survey data on what people in those professions actually do, the team found that 76% of them had jobs that required group work or face-to-face interaction. For now at least, such tasks are not easily automated[3]. When the authors extended their approach to other professions, they found less-alarming figures for the number of at-risk jobs in the 21 countries surveyed. In the United States, the share of workers at high risk of automation was just 9%, and the figure ranged from a low of 6% in South Korea and Estonia to a high of 12% in Germany and Austria (see 'Delaying the robot uprising').



Sources: OECD/Ref. [3] (http://go.nature.com/2KK4D4Y)

Brynjolfsson is now working with Tom Mitchell, a computer scientist at Carnegie Mellon University in Pittsburgh, Pennsylvania, to drill deeper into the impact of machine learning. They have developed a rubric outlining the characteristics that make certain tasks especially amenable to this approach. For instance, machine-learning systems are adept at tasks that involve translating one set of inputs — say, images of skin lesions — into another set of outputs, such as cancer diagnoses. They're also most likely to be used for tasks in which the large digital data sets required for training the system are readily available. Brynjolfsson and Mitchell are now going through several

large occupational databases to determine how well a variety of workplace tasks match up with these and other criteria.

Even with these kinds of analysis in hand, determining the consequences for the labour market is complex. Just because a task can be automated doesn't mean that it will be; new technologies often require costly and time-consuming organizational changes. Legal, ethical and societal barriers can also delay or derail their deployment. “AI is not yet an off-the-shelf product,” says Federico Cabitza, who studies health-care informatics at the University of Milano-Bicocca in Italy. Implementing medical machine-learning systems, for instance, requires both technological readiness and willingness to devote the thousands of person-hours necessary to make these systems operational, he says — not to mention buy-in from caregivers and patients.

Research suggests that the workforce is flexible in adapting to new technologies. In the second half of the twentieth century, increasing automation prompted shifts within occupations as employees began performing more complex and non-routine tasks. In some future cases, these shifts could be positive; if automated systems start making routine medical diagnoses, it could free doctors to spend more time interacting with patients and working on complex cases. “The fact that computers are becoming good at medical diagnosis doesn't mean that doctors will disappear as a job category,” Mitchell says. “Maybe it means we'll have better doctors.”

Indeed, many people might find themselves working alongside AI systems, as the Udacity salespeople did, rather than being replaced by them. Self-driving cars, for instance, are not yet able to navigate all situations on their own, so car manufacturer Nissan is developing a human-powered solution. If one of its autonomous cars encounters a situation it doesn't understand, such as roadworks or a traffic accident, it will contact a remote command centre where a human 'mobility manager' can take control until the car has passed the trouble spot. “Machines think in a very different way, fundamentally, than humans do, and each has its strengths,” says Pietro Michelucci, executive director of the Human Computation Institute in Fairfax, Virginia. “So there's a real natural marriage between machines and humans.”

Will the gig economy increase worker

exploitation?

Flexibility, variety and autonomy: these are the promises of the burgeoning gig economy, in which workers use online platforms to find small, short-term jobs. This sort of on-demand, digitally mediated gig work can take a variety of forms, from driving for the taxi service Uber to completing microtasks — including taking surveys, translating a few sentences of text or labelling an image — on a massive crowd-working platform such as Amazon Mechanical Turk.

These digital platforms allow workers to complete tasks from anywhere, meaning they could remove some geographical barriers to getting good jobs. “Someone in Nairobi is no longer constrained by the local labour market,” says digital geographer Mark Graham of the University of Oxford.

Graham and his colleagues have spent several years studying the digital, on-demand economy in southeast Asia and sub-Saharan Africa. They have conducted face-to-face interviews with more than 150 gig workers in these regions, surveyed more than 500 people and analysed hundreds of thousands of transactions on online labour platforms.

Their preliminary results show that these jobs do pay off for some gig workers; 68% of the survey respondents said that the work makes up an important part of their household income. And digital platforms provided jobs to a variety of people — including women who were primary caregivers and migrants without work permits — who said that their employment opportunities were otherwise limited. “There are some people who really thrive in this system,” Graham says. “But it's not like that for everyone.”

There is a pronounced oversupply of labour in the gig economy, leading some workers to drop their rates below what they consider fair. Many also work long hours at high speeds and to tight deadlines. “They tend to have a very precarious existence, so they're worried about saying no to jobs that they do get,” Graham says. “We talked to quite a few people who have done things like stay up for 48 hours straight, just working solidly in order to get their contracts done on time.”

Considerable geographical inequities remain. In a 2014 study[4], Graham and several colleagues analysed more than 60,000 transactions on one major platform in March 2013. Most jobs, they found, were listed by employers in high-income countries and completed by workers in low- or middle-income countries (see 'The gigs are up').

Source: Ilabour (http://go.nature.com/2GZE5TZ)

But those who live close to where the jobs are still seem to have an advantage. They win a disproportionate share of jobs and earn significantly more — US$24.13 per hour, on average — than foreign workers, who earned $11.66 per hour for comparable work. And some low- and middle-income nations attracted many more jobs than others; India and the Philippines are the top two recipients in Graham's analysis.

Practical concerns could explain some of these disparities. Language and time-zone differences might make some employers reluctant to hire foreign workers, and the history of outsourcing labour to India and the Philippines may have helped make workers there more attractive to employers. But discrimination, both conscious and unconscious, could play a part, too; Graham's team found task listings explicitly stating that people from certain countries need not apply. “Even though these technologies have been able to connect different parts of the world, they have not been able to bridge these kinds of differences as much as we hoped,” says Mohammad Amir Anwar, a researcher who works with Graham.

Another large ethnographic study of gig workers is beginning to reveal more about how this work gets done. It also provides some clues about what workers need to succeed. Between 2013 and 2015, two senior researchers at Microsoft Research — anthropologist Mary Gray in Cambridge, Massachusetts, and computational social scientist Siddharth Suri in New York City — surveyed roughly 2,000 gig workers in the United States and India and conducted longer interviews with nearly 200 of them.

One of the first things they discovered was that, although gig workers are often portrayed as independent, autonomous labourers, many of them were in fact communicating and collaborating with each other[5]. Workers helped each other to set up accounts and profiles, shared information about good employers and newly posted jobs, and provided technical and social support. Workers are making a deliberate effort to add human connections back into the system, Suri says, and they're doing it on their own time. “So they clearly must value it.”

In a more quantitative follow-up study[6], in which they mapped the social connections among more than 10,000 Amazon Mechanical Turk workers, Gray, Suri and their colleagues found that this kind of collaboration can have real pay-offs. Workers who had connections to at least one other person on the platform had higher approval rates, were more likely to gain elite 'master' status, and found out about a new task more quickly than unconnected workers. For people to be productive, says Gray, “it turns out that they really need to collaborate. They need each other.”

Can the digital skills gap be closed?

For years, experts have been sounding the alarm about a looming shortage of digital skills. They have warned that there are too few trained workers to fill high-tech jobs, and that a lack of basic digital literacy could prevent workers in certain geographical regions or demographic groups from thriving in the digital economy. In response, various innovative programmes for boosting digital literacy and skills have sprung up worldwide. Research is now starting to provide some clues about what does and doesn't work — and about where skills training might fall short.

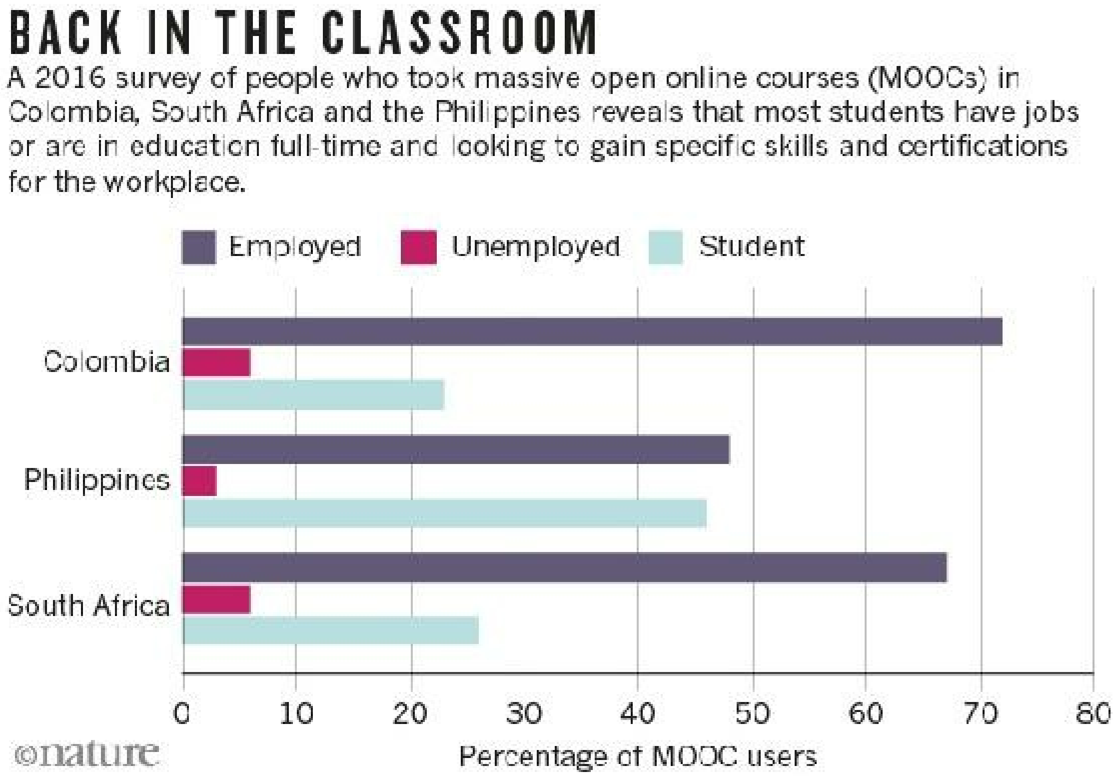
There have been some documented successes. More than a decade ago, the US Defense Advanced Research Projects Agency began developing a personalized, interactive and adaptive 'digital tutor' system to train new recruits to the US Navy for jobs as information-systems technology (IT) technicians. Students would work with the tutor one-to-one, completing lessons on different topics and solving related problems. The system prioritized conceptual learning and reflection, regularly prompting students to review what they'd learnt. When the tutoring system judged that a student had mastered the material, it would move on to the next subject.

In a 2014 review[7] of the programme, researchers at the Institute for Defense Analyses in Alexandria, Virginia, found that 12 recruits who completed the 16-week course outperformed graduates of conventional, classroom-based US Navy IT training that lasted more than twice as long. The 12 even did better than a group of senior naval IT technicians — who each had an average of nearly ten years' experience — on almost every measure. “If we can do that, why not do more of it?” says Dexter Fletcher, who co-authored the review. “Why not begin to apply this seriously to workforce training?”

In a follow-up study[8], Fletcher found that a slightly modified version of the digital tutor yielded similar results when it was used to train 100 military veterans for civilian jobs in IT. Within six months of completing the programme, 97% of the veterans who wanted IT jobs had landed them, earning an average annual salary roughly equal to that of someone with 3–5 years of experience in the field.

Numerous other strategies have been promoted to improve digital skills and employment, including massive open online courses (MOOCs) — university-level classes that are delivered over the Internet — and coding bootcamps, which are intensive, short-term training courses that teach the basics of computer programming.

In a 2016 analysis[9] of 1,400 MOOC users in Colombia, the Philippines and South Africa, researchers determined that 80% of students were from low- or middle-income backgrounds and that 41% had only basic computer skills. More than half of the students (56%) were female, and computer science was the most popular MOOC topic. “Women are actually engaging in MOOCs in areas where they are underrepresented,” says Maria Garrido, a co-author of the report at the University of Washington's Information School (see 'Back in the classroom').



Source: Ref. [9] (http://go.nature.com/2YFAPWC)

But the quality of these programmes can vary enormously, and few have been rigorously evaluated. Coding bootcamps can be expensive, require a significant time investment and are located primarily in technology corridors and urban settings. And achievement gaps remain; in a 2015 study[10] of more than 67,000 MOOC students, two Stanford researchers found that female students and students of both genders from Africa, Asia and Latin America were less likely to reach certain course milestones — such as watching more than 50% of the lectures — and earned lower grades than male students and MOOC students from North America, Europe and Oceania.

Even those who complete digital-skills courses can still face a variety of barriers to employment. When researchers interviewed students in a Kenyan IT programme at Strathmore University in Nairobi in 2004, some of the students said that they were worried about graduating into a local economy that didn't appreciate their expertise or have jobs in which they could put it to use[11]. “And this was especially true for the women,” says Lynette Yarger, an information scientist at Pennsylvania State University in University Park, who was involved in the research. As one student put it: “Because I am a woman, employers may not think that they should give me a job working in IT, so I may never fully get to use all that I have learned to do, work that I want to do.”

One thing the research is already making clear is that even well-designed training programmes might not be sufficient to ensure success in the world of digital work. “The fact that you have better skills and know how to use a computer doesn't necessarily mean that you automatically can get a good job,” Garrido says. “Digital skills are an important piece of the puzzle, but they're not enough.”

Journal name:
Nature
Volume:
550,
Pages:
316–319
Date published:
(19 October 2017)
DOI:
doi:10.1038/550316a

Comments

Comments

There are currently no comments.

Lessons from history for the future of work

18 October 2017

Global comparisons of previous social and economic upheavals suggest that what is to come depends on where you are now, argues Robert C. Allen.

Lewis Hine/Pictorial Press Ltd/Alamy

Children working in a cotton mill in Macon, Georgia, in January 1909.

Today is not the first time that people have worried that machines will render

human labour obsolete, making a few very rich and the majority very poor.

Since the Industrial Revolution, mechanization has been controversial. Machines pushed up productivity, raising incomes per capita. But they threatened to put people out of work, to lower their wages and to divert all the gains from growth to the owners of businesses. The stocking-frame operators of Nottingham, UK (the Luddites), wrecked improved knitting machines that threatened their jobs. Mobs burnt down the first mills housing spinning and weaving equipment in the 1760s and 1790s.

Now, it is robots that threaten work, wages and equality[1]. Are the gains of technological progress destined to benefit only the top 1% of earners?

Economists' stock answer to this question is 'no'[2]. Technical progress in the past three centuries has led to incomes in the West (that is, the developed nations of today) that are much higher than they were in 1700 in real terms, and the fraction of the adult population employed in these countries is at record levels. Despite mechanization, automation and computerization, people have found jobs. Somehow the economy has always adjusted; somehow in the future it always will.

I think this answer is too simplistic.

Phase shift

There have been long periods of economic history in which things did not work out well, and we must wonder whether we are in another. Also, the 'future of work' depends very much on where you are in the world. Most discussions in the West focus on how technological evolution in the West affects jobs in the West. This frame is too narrow for the twenty-first century: we must investigate the effect of technological change on work everywhere. For the past three centuries, the global economy has been sufficiently integrated that new technology in one place affects work in others.

LISTEN

Reporter Benjamin Thompson finds out how lessons from the past can help explore the future of work.

You may need a more recent browser or to install the latest version of the Adobe Flash Plugin.

Rather than ask (unanswerable) questions about how machines will affect work over the next centuries, we can ask what the invention of the textile mill meant for a girl growing up in Manchester, UK, in 1800 or the wife of a subsistence rice farmer in China's Yangtze Delta at the same time. Technological change affected their futures of work very differently and often detrimentally. Similar things are happening now.

We need to divide the past into periods defined by trends. The periods I suggest here reflect Western history, which is not as limiting as it sounds: globalization means that developments in one region affect others.

The three phases are: the Industrial Revolution (1750–1830); the Western ascent to affluence (1830–1970); and the problem-ridden present (since 1970). Each holds lessons and pressing research questions for today.

The industrial revolution

The Industrial Revolution was Britain's creative response to the globalization of the world economy that occurred after Columbus's voyage to America in 1492 and Vasco da Gama's sail around Africa to India in 1498. Britain's colonies in North America, the Caribbean and India formed a large market for Britain's handicraft industries. Exports boomed, and by the mid-eighteenth century about one-third of Britain's workforce was employed in making metal goods and cloth.

Large data sets of wages and prices over this period[3] have been assembled since the 1980s and show that real wages rose as a consequence of this export boom[4]. Inventors designed machines to save expensive labour. Mechanization paid in Britain rather than elsewhere because labour was more expensive relative to capital; that is why the Industrial Revolution was

primarily a British affair.

Textiles were the world's most important manufactured product in terms of employment before the Industrial Revolution, and the first to be mechanized. Indian cotton cloth was imported to Europe, where it was a smash hit. English manufacturers struggled to compete because English wages were so high. The invention in the 1760s and 1770s of spinning machines to speed up cloth-making, including Hargreave's spinning jenny, Arkwright's water frame and Crompton's spinning mule, solved the problem. The first victims of technological unemployment were the British women spinning cotton by hand and, later, the much-larger number spinning wool, once machinery was adapted to that fibre.

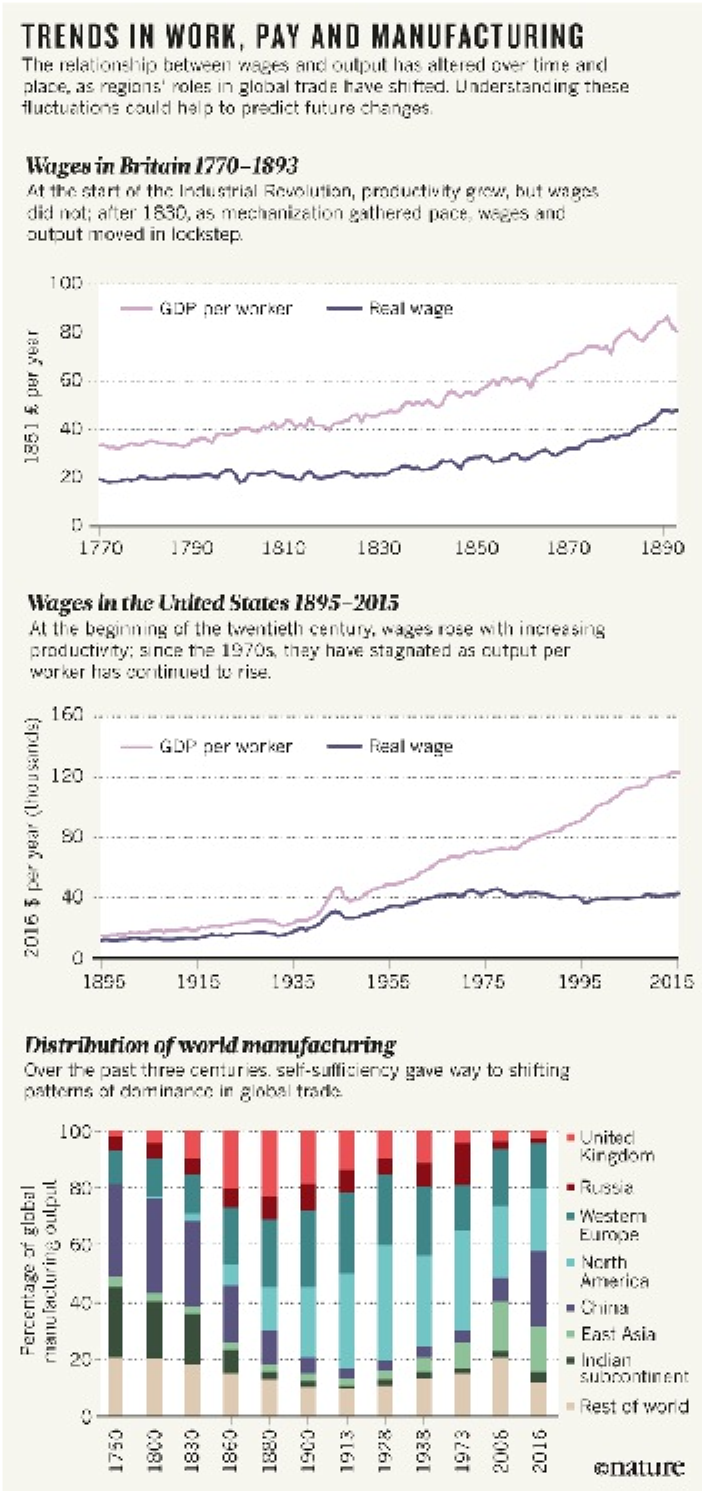
Soon jobs were lost from Casablanca to Canton. Investing in spinning machines made sense only in the high-wage economy of eighteenth-century England, thus they greatly increased English competitiveness without benefiting other nations. As jobs proliferated in the British cotton mills, massive technological unemployment spread across Africa and Asia[5]. The collapse of the Indian cotton trade around the 1830s led the British governor general to remark[6]: “The bones of the cotton-weavers are bleaching the plains of India.”

In 1820, the future of work for the wife of a farm labourer in England was an unhappy one. She had lost the opportunity to increase her family's income by spinning part-time, as her mother had done. The same impoverished fate befell a farmer's wife in the Ganges or Yangtze deltas. Some British women found work in the cotton mills (but a smaller number than had been employed to spin cotton by hand). By contrast, the future of work was auspicious for railway engineers, bricklayers and metal workers, to say nothing of the vast number of middle-class entrepreneurs and professionals who directed and serviced the industrial economy.

Machines were invented to save labour in most sectors of the economy in the first half of the nineteenth century. As one trade after another was eliminated in Britain, earnings collapsed in the affected trade, and that, in itself, lowered average national earnings. The displaced workers shifted into other trades, pushing down those wages. The Luddites and other opponents of

mechanization are often portrayed as irrational enemies of progress, but they were not the people set to benefit from the new machinery, so their opposition makes sense.

The implications were stark (see 'Trends in work, pay and manufacturing'). Although output per worker grew from 1770 to 1890, there was little growth in the real wage from 1770 to about 1830. During the Industrial Revolution (phase one) the 'normal' relationship was booming productivity and constant average wages — rather like the past 40 years.



Sources: See Supplementary Information

The western ascent to affluence

The average real wage only began to rise in the middle of the nineteenth century, when higher-productivity factory work replaced the hand trades. By 1850 Britain was the 'workshop of the world'. Comprising only around 3% of the world's population, the United Kingdom produced about half of the world's iron, for instance.

Industrial pre-eminence saw in the next phase of history. The new normal in the West was productivity and wages advancing together, as the Industrial Revolution spread across Europe and North America. Although there were shocks along the way owing to the depression of the 1930s and the Second World War, the period from the mid-nineteenth century to 1970 was one in which the working class benefited from the growth in productivity. Incomes became more equal. This is the economic performance that many have come to regard as normal.

How this favourable situation arose is a fundamental question. It seems that a positive-feedback system was in operation. Rising incomes led to the demand for fancier manufactured goods (for example, bicycles then cars) and more services (such as travel, retail trade and medical care). These created markets that encouraged technological change and led to jobs that were performed more effectively by educated people[7].

The need for educated workers led to the expansion of state provision of education. The increasing number of educated people prompted the invention of technologies that took advantage of education[8]. Those technologies led to further demand for education. At the same time, the public provision of infrastructure — roads and airports, for instance — was crucial for the development of industries involving cars and aircraft. Public support for research in medicine, agriculture and technologies with military applications, such as electronics and aircraft, underlaid many advances. The welfare state helped to spread the benefits of this economic development across the population.

The upshot was a pattern of economic growth in which technical progress benefited most people in the West.

The same was not true in Asia and Africa. Before the Industrial Revolution, China and India had the largest manufacturing sectors in the world because they had the largest populations, and nations were mostly self-sufficient in the pre-globalization era. As the Industrial Revolution gathered pace, Britain's share of goods manufactured worldwide increased, reaching a peak of about one-quarter in the late nineteenth century. Western Europe's share and that of North America also increased. In the same period, the shares of India and China collapsed. This drop represented absolute de-industrialization and not simply shifting percentages.

The technological revolution that spread prosperity in the West created modern 'underdeveloped countries' in the East (that is, Asia, Africa and South America). It converted them into economies that exported solely primary products — wheat, rice, bauxite, oil — rather than secondary ones such as cloth and porcelain.

By the 1830s, technological progress in the West meant a bleak future of work elsewhere.

The problem-ridden present

The past four decades have seen many job losses in the manufacturing sector in Western countries, static or falling real wages, and rising inequality as the gains from growth accrue to the top 1%. Did the 'new normal' end in 1970, or are the recent trends just a blip? Might what was 'normal' in 1850–1970 return soon — that is, the concurrent advance of productivity and wages?

Some people believe that the feedback loops between education and technology will kick in again, generating new knowledge-based, high-income jobs in the West to replace lost manufacturing jobs. Computers and robots will save us.

I am more pessimistic. The rise in real wages that began in the mid-nineteenth century and tracked the rise in output per worker ended in the 1970s (see 'Trends in work, pay and manufacturing'). Real wages rose at a slower rate than productivity in the 1980s and 1990s — or stagnated

altogether, as in the United States. In some cases (for example, the United Kingdom) wages have actually been falling in real terms over the past decade. A deviation of this magnitude from the trend suggests that the new pattern may not be transitory.

Similarly, the rebound in overall inequality in mature economies, such as the United States, over the past 40 years is unprecedented. Inequality rose in many countries as they industrialized and fell thereafter — this trend is called a Kuznets curve (after the Nobel laureate Simon Kuznets)[9]. The rise in inequality since 1970 has shown that this is a reversible feature of economic history.

Inequality is an area that has seen much recent research, with large data sets assembled and interrogated. Some scholars have focused on the share of total income going to the top 1% or 5%[10]. Others use indices that incorporate information from every level of the income distribution[11]. How we interpret the results depends on our breadth of vision. A common pattern in many countries is a fall in inequality from the early twentieth century to the 1970s and then a rise. This is true of the United States, the United Kingdom and China, for instance. At the global level, inequality increased steadily from 1820 to 1990 and then declined slightly. This pattern takes into account inequality between countries as well as within. Rising per capita incomes in the West in phase two increased global inequality. In phase three, global inequality fell even though inequality increased in many rich and poor countries[12].

Why are the feedback loops that led to general prosperity in the West between 1850 and 1970 seemingly inoperative now[13, 14, 15]? A big change is the industrialization of Asia — first Japan starting in the 1870s, then South Korea and Taiwan since the Second World War, and now China (see 'Trends in work, pay and manufacturing'). These countries have supplanted Western nations as the low-cost producers of manufactured goods. Trade flows have reversed, with Asia shipping textiles and steel to Europe rather than the other way around. Technological progress in Asia has raised incomes and levels of employment dramatically in the region.

The future of work to someone born in China in 1990 is bright indeed —

provided that the country can avoid environmental crises and resource depletion.

Globalization means that Asia's bright future causes havoc elsewhere. Imports of cheap Japanese steel and vehicles caused the collapse of the rust belt in the United States and its counterparts in Western Europe (with Germany as something of an exception). Western de-industrialization was the flip side of the East Asian miracles. And cheap Chinese imports may benefit Africans as consumers, but could blight their employment prospects as African industries struggle to compete. Indeed, China is now purchasing large areas of land in Africa to guarantee access to food and minerals. It is hard to believe that manufacturing or information technology will ever recover in the West, no matter how many robots are installed, visas rescinded, trade agreements ripped up or walls built.

We cannot forecast the future without an understanding of the relationships between science, technology and the economy, because technical change is such an important determinant of the future. I have studied these questions for the Industrial Revolution using business accounts and histories of inventions. The steam engine, for instance, was an application of seventeenth-century science (the discoveries that the atmosphere has weight and that condensing steam creates a vacuum). By contrast, the cotton mills owed little to science and much to attempts to cut costs of relatively expensive employment[16].

How has the balance between knowledge and incentives evolved? The more technology advances in response to economic incentives rather than 'random' scientific discoveries, the more feasible it is to direct the course of technical progress to benefit more people. Furthermore, the cotton mills of the Industrial Revolution increased the demand for workers without education, whereas more-recent technology requires more education. Why the difference? Will the recent trend of needing educated workers persist? If not, then the hope that a knowledge-based future will make everyone better off is doomed.

Journal name:
Nature
Volume:

550,
Pages:
321–324
Date published:
(19 October 2017)
DOI:
doi:10.1038/550321a

Supplementary information

PDF files

1. Supplementary Information 550321a (49K)

Comments

Comments

There are currently no comments.

The second Renaissance

18 October 2017

Ian Goldin calls on scientists to help society to weather the disruptive transformations afoot.

Jay Shaw Baker/NurPhoto/Getty

Workers protest in London in February.

The Renaissance that began in Europe in the mid-1400s and ended in the early 1500s brought a radical transformation of the sciences, the humanities and politics. Building on the invention of the printing press and cheap paper, information was democratized, there was a hunger for literacy and the Catholic Church's near-monopoly on knowledge was challenged. The

resulting breakthroughs took Europe from being one of the more backward regions of the world to being the most advanced by far, within just 80 years.

But it ended in tears. Extremists, pointing to growing inequalities and the corruption of the elite, called for a return to spiritual values. In Italy, thousands of artworks and books were burned, branded as irreverent. Across Europe, rising intolerance of scientists, intellectuals, foreigners and ethnic minorities became the norm, with religious wars and inquisitions playing out over the following centuries.

In my view, many parts of the world are now in the middle of a second Renaissance. This one is seeing even faster change than the last, and across the entire globe. History tells us that it will be disruptive. It will bring immense benefits and it will be highly destabilizing. We should expect more extremism and the rise of potentially catastrophic risks.

Innovation today is happening faster than ever, driven by the unlocking of individual and collective abilities in a booming population. On average, literacy levels, life expectancy and incomes have soared. Flows of goods, services, money, people and, most importantly, ideas across national borders — globalization — has unleashed unprecedented progress and a scientific and broader renaissance. They have also brought growing interdependence and new risks[1, 2].

The Internet helps to harness the global capacity for connectivity and innovation, but also brings us malware, cybercrime and the sacrifice of privacy. Airports are crucial to international integration of science and commerce, but they can also be super-spreaders of pandemics — just as explorers to the new world brought with them fatal diseases. Financial hubs create fresh opportunities for economies to prosper, but they simultaneously allow a financial crisis in one country to destroy jobs and pensions in distant parts of the world[3].

The tension between individual success and collective collapse is growing. As more people escape poverty and climb the energy curve, climate change and biodiversity loss accelerate. As more people benefit from better nutrition, ocean fisheries are at risk of collapse and forests are destroyed for cattle. Improvements in global health could soon be threatened by rapidly rising

antibiotic resistance.

Accelerating technological change will provide solutions for many challenges, from cancer to cleaner sources of energy. But our politics and our institutions are locked in past models that are increasingly unfit for purpose. Deep ethical issues arising from genomics research and the potential dangers of biological pathogens are not being adequately addressed. Improvements in computing and artificial intelligence will kill off many jobs. Breakthroughs in nanotechnology and materials science, augmented and virtual reality, 3D printing and other applications will also radically disrupt society. All are barely understood by politicians and most citizens.

Growing gap

Inequality is rising in almost all countries that are experiencing rapid change. The faster the pace of change, the more rapidly people are being left behind. The share of wealth enjoyed by the top 1% of citizens in the advanced economies has risen from an average of 17% in the late 1980s to more than 23% today (it is 39% in the United States). Countries starting from a more equal distribution of wealth, such as China and the nations of the former Soviet Union, have seen the most rapid rise in inequality[4].

John MacDougall/AFP/Getty

A robot sweeps food towards two dairy cows at an 'automated farm' exhibit at a food and agriculture fair.

Far from levelling the playing field and making the world more 'flat', as is alleged, globalization is making it more mountainous. Place matters more than ever. Cities hold a growing share of wealth and job opportunities, but it is increasingly difficult to afford to live in them. In dynamic ones, such as London, San Francisco, Paris, Berlin, Shanghai and Mumbai, house prices relative to average incomes are at an all-time high.

Technological change is already a key contributor to the growing inequality[5]. This is likely to be exacerbated as machine intelligence and automation take over a growing share of routine tasks in manufacturing and services, including retail, administration and call centres. Over the next 20 years, up to half of US jobs, one-third of jobs in the United Kingdom and the European Union and two-thirds of jobs in China and Mexico may be replaced by computers and robotics[6].

The future will bring new jobs, but their number will be small relative to those lost. And the quality of many of these new jobs will be inferior, in terms of the conditions of work and pay. Although it is tempting to imagine a world in which machines do dangerous and routine jobs, leaving more creative, stimulating and well-paid jobs for humans, this may not come to pass. The pace and scale of technological disruption, which far exceeds that of any previous industrial revolution, raises doubts about our capacity to keep up. We may not be able to redistribute enough funds from the wealthy, or come up with sufficiently creative changes to our systems of work and social safety, to prevent a further rise in inequality[6, 7]. Although this is a major issue for advanced economies, it is even more so for developing countries, because automation may remove key rungs of semi-skilled tasks from the development ladder.

Growing interdependence and complexity also mean that our politicians are increasingly unable to protect or shape our futures. Rather than pursue more cooperative politics, which enhance the benefits of connectivity and mitigate the risks, politicians increasingly blame foreigners and immigrants for the ills. This is profoundly misguided. Immigrants contribute disproportionately to the dynamism of our societies, as can be seen in the talent pool of leading universities, Silicon Valley firms, Nobel prizewinners and patent holders[8].

Those living in the fast-changing cosmopolitan cities of the world are embracing globalization and change: most Londoners did not support Britain's decision to exit from the European Union; people living in dynamic cities tended not to support US President Trump. The populist call for protectionism is driven by those in the United States who fear being left behind. This is not an irrational fear: as is evident from inequality, unemployment and health data, some people are being left behind. There is a correlation, for example, between those who voted for Trump and those whose jobs are vulnerable to having machines take over their jobs[9].

Alongside their anxieties about being left behind by globalization comes a deep mistrust of the 'experts' in charge of the global systems, and a rejection of evidence. Paradoxically, although we know more than ever, rising complexity and speed of change mean that experts are likely to be wrong more often. The financial system, for example, is home to numerous highly

qualified experts, housed in a formidable array of powerful institutions, who are handsomely paid to secure economic stability. Yet, as the 2008 financial crisis demonstrated, they have proved dismally unequal to the task. Similarly, experts in the European Commission seem to have failed to control reporting of emissions from leading car manufacturers. Little wonder that trust in authority has been severely eroded. When the evidence threatens entrenched elites, scepticism regarding expertise becomes particularly poisonous. Trump's dismissal of the science of climate change is an egregious example of this trend.

The flourishing of science was contested in the original Renaissance, too. Printing presses provided the means for experts and intellects to share knowledge, but also allowed fake news to flourish. In Medici Florence, fundamentalist Italian preacher Girolamo Savonarola circumvented the authority of popes and princes with the mass production of one-page pamphlets — the equivalent of today's tweets. Both Savonarola and the clergy denied that Earth went around the Sun, and that the heart was a pump.

Although history does not repeat itself, it does rhyme. In the United Kingdom, campaigners successfully used social media to convince people to support Brexit even when it was against their interests, as in the case of farmers who receive subsidies from the European Union. In the United States, social media that propagated fears rather than facts played a key part in shaping the outcome of the 2016 presidential election[10].

Rapid response

As societies change more rapidly, flexibility becomes more important. For individuals, it becomes more necessary to move to where the jobs are and to reskill. For governments, it is crucial to renew infrastructure and social safety nets. Regulatory frameworks also need to evolve rapidly, to address a widening range of risks — from the genetic enhancement of humans to geoengineering.

Unfortunately, at a time when the need to renew and invest in the future is rising, the ability of governments to keep pace with change is being

undermined. The use of off-shore tax havens — notably by companies at the frontier of technological change — as well as competition by governments to attract increasingly mobile individuals and companies by reducing taxes, together with austerity policies, have reduced the capacity of governments to invest in health, education, infrastructure, social security, research and other expenditures[11]. Lower investment leads to lower growth and political gridlock, as politicians fight over the allocation of fixed or diminishing resources.

Stronger safety nets are necessary to prevent poor and vulnerable individuals and families from being undermined by technological and other changes. If not, social cohesion will be eroded, fanning the flames of populist push-back against change and all things foreign.

Some Silicon Valley billionaires, fearing revolt against the growing wage gap, along with some social activists, have called for the introduction of a Universal Basic Income (UBI) for people working and not. But a UBI is not a panacea. The Organisation for Economic Co-operation and Development has shown that the policy could, perversely, increase inequality and poverty. And, because jobs are so important to our status and self-worth, having money alone does not protect against the increases in morbidity, criminal activity, opioid and alcohol abuse that have been associated with unemployment[12].

Instead, we need a broader change in attitudes towards work. We need to remove the stigmas associated with part-time employment, retirement and volunteer work. We should nurture a greater respect and pay for creative, caring and home-based activities.

There are reasons for optimism. There are more scientists alive today than all those who previously lived; citizen science adds millions more. As well as more minds at work, there are more-diverse collaborations, thanks to greater gender equality and the participation of more nations and peoples. The probability of unlocking mysteries and finding solutions to great challenges is rising, as is the global dissemination of the benefits. Cross-border collaborative projects, from the CERN particle-physics laboratory near Geneva, Switzerland, to the Human Genome Project, highlight the benefits of

cooperative activity, in stark contrast to isolationist politics.

Now, more than ever, scientists must engage and communicate, to ensure that science is not overrun by politics. Renaissance moments are associated with an intensifying battle of ideas. Scientists need to engage in this struggle over the development and application of their expertise and inventions.

In the first Renaissance, extremists won; reason and evidence did not prevail. In our second Renaissance, knowledge and enquiry must find a way to conquer prejudice and ignorance. Scientists know that they can never progress through isolationism or ignorance. Nor can our societies.

Journal name:
Nature
Volume:
550,
Pages:
327–329
Date published:
(19 October 2017)
DOI:
doi:10.1038/550327a

Comments

2 comments

1. *Pentcho Valev* • 2017-10-18 04:30 PM
   Fundamental physics is paralyzed, even killed, by blind faith in false principles. The falsehood of Einstein's constant-speed-of-light postulate is easy to prove but I'm not going to do this here. Let me just call the attention, by quoting Joao Magueijo, to the validity of the following conditional: If Einstein's constant-speed-of-light postulate is false, fundamental physics is dead. "The speaker Joao Magueijo, is a Reader in Theoretical Physics at Imperial College, London and author of Faster Than the Speed of Light: The Story of a Scientific Speculation. He opened by explaining how Einstein's

theory of relativity is the foundation of every other theory in modern physics and that the assumption that the speed of light is constant is the foundation of that theory. Thus a constant speed of light is embedded in all of modern physics and to propose a varying speed of light (VSL) is worse than swearing! It is like proposing a language without vowels." http://www.thegreatdebate.org.uk/VSLRevPrnt.html "...Dr. Magueijo said. "We need to drop a postulate, perhaps the constancy of the speed of light." http://www.nytimes.com/2002/12/31/science/e-and-mc2-equality-it-seems-is-relative.html "But the researchers said they spent a lot of time working on a theory that wouldn't destabilise our understanding of physics. "The whole of physics is predicated on the constancy of the speed of light," Joao Magueijo told Motherboard. "So we had to find ways to change the speed of light without wrecking the whole thing too much." http://www.telegraph.co.uk/technology/2016/12/06/speed-light-discovered/ Joao Magueijo, Faster Than the Speed of Light, p. 250: "Lee [Smolin] and I discussed these paradoxes at great length for many months, starting in January 2001. We would meet in cafés in South Kensington or Holland Park to mull over the problem. THE ROOT OF ALL THE EVIL WAS CLEARLY SPECIAL RELATIVITY. All these paradoxes resulted from well known effects such as length contraction, time dilation, or E=mc^2, all basic predictions of special relativity. And all denied the possibility of establishing a well-defined border, common to all observers, capable of containing new quantum gravitational effects." http://www.amazon.com/Faster-Than-Speed-Light-Speculation/dp/0738205257 Pentcho Valev

2. *Pentcho Valev* • 2017-10-18 05:19 PM

   Another science killer is the false second law of thermodynamics. Systems violating the second law are commonplace but scientists always turn the blind spot of the eye to them. Here is vigorous motion of water in an electric field, obviously able to produce work - e.g. by rotating a waterwheel: "The Formation of the Floating Water Bridge including electric breakdowns" https://www.youtube.com/watch?v=17UD1goTFhQ "The water movement is bidirectional, i.e., it simultaneously flows in both directions." https://www.wetsus.nl/home/wetsus-news/more-than-just-a-party-trick-the-floating-water-bridge-holds-insight-into-nature-and-human-innovation/1 The work (rotating a waterwheel) will be done at the expense of what energy? The first hypothesis that comes to mind is: At the expense of electric energy. The system is, essentially, an electric motor. However close inspection would suggest that the hypothesis is untenable. Scientists use triply distilled water to reduce the conductivity and the electric current passing through the system to minimum. If, for some reason, the current is increased, the motion stops - such system cannot be an electric motor. If the system is not an electric motor, then it is a heat engine violating the second law of thermodynamics. Here arguments describing such heat engines as impossible, idiotic, etc. are irrelevant - the following conditional is valid: IF THE SYSTEM IS NOT AN ELECTRIC MOTOR, then it is a a heat engine violating the second law of thermodynamics. In other words, if the work is not done at the expense of electric energy, it is done at the expense of ambient heat. No third source of energy is conceivable. In the electric field between the plates of a capacitor, the same turbulent motion can be seen: " Liquid Dielectric Capacitor" http://www.youtube.com/watch?v=T6KAH1JpdPg In the capacitor system the rising water can repeatedly do work, e.g. by lifting floating weights. The crucial question is: The work (lifting floating weights) will be done at the expense of what energy? Obviously "electric energy" is not the correct answer - the capacitor is not an electric motor. Then the only possible answer remains "ambient heat". The system is a heat engine violating the second law of thermodynamics! Pentcho Valev

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Brazilian Amazon still plagued by illegal use of natural resources

Practices such as poaching and illegal logging are concentrated near inhabited areas and along rivers, study finds.

17 October 2017

Jeff Hutchens/Getty

An official with Brazil's environmental enforcement agency arrests poachers caught near Manaus.

Despite Brazil’s efforts to safeguard the Amazon rainforest by establishing protected areas and boosting law enforcement, illegal use of the region’s natural resources is still widespread, according to a study[1] published on 10

October in *PeerJ*.

The researchers looked at 4,243 law-enforcement records from between 2010 and 2015, across 118 federally protected areas of the Brazilian Amazon. Although the overall number of citations decreased over those five years, illegal activities still occurred in nearly every protected area. The analysis highlighted the need for improved monitoring and enforcement, says study co-author Érico Kauano, a conservation biologist at the Chico Mendes Institute for Biodiversity Conservation (ICMBio), the Brazilian agency responsible for the management of the federal protected areas.

Kauano and his colleagues grouped illegal activities into ten categories, and found that 37% of the infractions fell into the “suppression and degradation of vegetation” group, which included deforestation, logging of endangered tree species and the unauthorized use of fire. Illegal fishing was the next most common citation at 27%, followed by hunting at 18%. Most of the illegal activity occured in more accessible and densely populated areas.

Roads have a major role in opening up the tropics to colonization and exploitation[2]. Deforestation of the Brazilian Amazon increased after the construction of the Belém–Brasília Highway in the 1960s, and continued with the opening of the Trans-Amazonian Highway in 1970s. A 2014 study[2] using satellite images found that around 95% of the deforestation in Brazil’s Amazon occurred within 5.5 kilometres of a road and within 1 kilometre of a navigable river.

Caught in the act

The availability and use of government data are what sets this study apart from others, says Emilio Bruna, a tropical ecologist at the University of Florida in Gainesville, who was not involved in the study. Past studies, including a paper[3] published last month in *Biotropica* (where Bruna is editor-in-chief), struggled to obtain even the most basic information, such as how many staff members were employed by the agency that manages protected areas, and how much they were paid, Bruna says.

Data from efforts on the ground are important because, although remote-sensing instruments such as satellites can detect deforestation, for example, they fail to identify threats present beneath the forest canopy. Law-enforcement records, when available, can complement remote-sensing data sets, the study authors say.

“You can actually tell what it is they’re writing infractions for, and that’s valuable,” says Bruna. But he points out that, without knowing where law-enforcement efforts are being allocated, it’s only a partial picture. “It could be that the reason certain protected areas have the most infractions is because those are the places that are under the greatest threat,” he says. “Or it could be because that’s where the greatest enforcement is being focused.”

Greater enforcement

“We are still far from having adequate staff in the protected areas,” Kauano says. In 2014, a local news outlet reported that the Brazilian Institute of Environment and Renewable Natural Resources had only 47 agents to monitor environmental crimes in Amazonas, the country’s largest state in the Amazon region, which covers an area of about 1.6 million square kilometres.

Hiring more enforcement officials looks unlikely in the short term, however, owing to Brazil’s ongoing political and economic crisis, says Kauano. “What ICMBio seeks to do to overcome this is to prioritize some regions with greater problems.”

Bruna cautions against jumping to conclusions from the study’s results, however. “Not all infractions are created equal,” he says. It’s important to differentiate between a resident fishing out of season and a fishing charter operator. Bruna worries that some may look at this study and think that the people living near protected areas are the problem. But they aren’t the only ones breaking the law, he says. And the demand for the fruits of this illegal labour comes from all over the world.

Local people can, in fact, be part of the solution. There is some evidence that people living in or near protected areas are helping with conservation, says

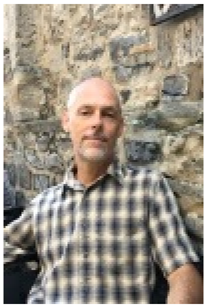
Kauano. But he adds that the government needs to make a greater effort to work with local communities.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22830

Comments

Comments

There are currently no comments.



Ellie R. Martinson

Give researchers a lifetime word limit

Brian C. Martinson[1] imagines how rationing the number of publications a scientist could put out might improve the scientific literature.

17 October 2017

A dirty truth pervades academic publishing: we write papers to gain credit in an academic marketplace. Almost a quarter of a century ago, academic worthies lamented that scholarly publications had become “the coins academics must use to get through the tollgates on their way to academic promotion” (D. Rennie and A. Flanagin *J. Am. Med. Assoc.* **271**, 469–471; 1994). In some cases, papers in flashy journals truly do bring in hard cash — reportedly more than US$40,000 at some universities in China. And plenty of people reading this will have felt they’d better squeeze a paper or two out soon to have any chance of getting their next grant proposal funded.

The purpose of authorship has shifted. Once, its primary role was to share knowledge. Now it is to get a publication — ‘pubcoin’ if you will. Authorship has become a valuable commodity. And as with all valuable commodities, it is bought, sold, traded and stolen. Marketplaces allow

unscrupulous researchers to purchase authorship on a paper they had nothing to do with, or even to commission a paper on the topic of their choice. ‘Predatory publishers’ strive to collect fees without ensuring quality.

I have spent much of my career studying how academic and clinical workplaces influence how carefully researchers conduct their studies. The commodification of authorship encourages all manner of corner-cutting, sloppiness in research, and other degradations in the quality of publications, not to mention an obvious motive for plagiarism. A quest for high-profile papers leads researchers to favour a spectacular result, even if it is specious. Authors cite themselves to boost the impact of publications, and cite colleagues to curry favour.

At this point, it is hard even to envisage a world in which the communication of knowledge could return to its rightful place as the focus of academic authorship. But if we cannot imagine something, we cannot attain it. So let me try. Imagine a world in which each scientist is allotted a fixed number of words that they can publish over her or his career. I’m not the first person to suggest this: the Australian writer Michael McGirr has proposed a word limit for every person.

What would happen? Might authorship regain its original purpose?

Lifetime limits would create a natural incentive to do research that matters. Researchers would have to ask themselves, “Is this project I’m pursuing worth the words it will cost me?” I see several articles in my own CV that did not contribute much knowledge to the world. I cannot help but think that I might have pursued better questions had a word limit been in place.

Ideally, limits would encourage researchers to ensure that research is conducted with the utmost care. (Imagine losing part of your allotment of words to a paper that is discredited or even retracted.) This would provide a counterweight to the pressure to publish quickly for priority. It would also lead to increased value being placed on concision and clarity, improving readability and efficiency. Honorary authorship would become much less attractive.

With less time needing to be spent on papers of low quality or containing

little new information, readers and editors would be able to give the smaller number of articles more attention. Editorial workload would be reduced by virtue of the lower volume and the higher quality of material. This might reduce editorial costs, enhance quality, and quite possibly enhance the job satisfaction and quality of life of editors and readers. Predatory publishers would vanish.

With a boost in the quality of scientific papers, the communal work of peer review would get easier. Individual researchers would be asked to carry out fewer reviews. Reviewing invitations would be for work of higher quality, making the job more enjoyable and less aggravating. And knowing the stakes for the authors in expending their precious words, reviewers themselves might be inclined to put more time and effort into their reviews, further improving quality.

The task of evaluating candidates for jobs, advancement and prizes would become less scattershot. With fewer publications per candidate, promotion and tenure committees could become less reliant on tallying counts of first-authored publications, and devote time to reading and critiquing the published work. This, in turn, should reduce their use of journal impact factors as proxies for quality.

Limits would of course bring a new set of problems: if we don’t also address our own cognitive biases and penchant for compelling narratives, word limits could exacerbate tendencies to publish only positive findings, leading researchers to explore blind alleys that others’ negative results could have illuminated. Researchers might skimp on a full description of caveats, previous work and methods. Some subjects and pursuits might be inherently wordier than others. Exceptions might have to be made for experts such as statisticians and bioinformaticians whose skills are required on many papers — but perhaps this would boost the quality of collaborations. Perhaps researchers could apply for word bonuses for careful reproductions, cautious interpretations and meticulously described methods.

Would these drawbacks be worse than the current incentives to publish as much as you can? We have lost sight of information sharing as the primary reason for publishing. Perhaps my flight of fancy is a rose-tinted remembrance of times past. Or perhaps it can serve as a guide to restore the

exchange of ideas to its rightful, pithy, place.

Journal name:
Nature
Volume:
550,
Pages:
303
Date published:
(19 October 2017)
DOI:
doi:10.1038/550303a

Comments

Commenting is currently unavailable.

Japanese research leaders warn about national science decline

Concern mounts over budget cuts and other changes that undermine basic science.

17 October 2017

Toru Hanai/Reuters

People gather for a rally in Fukushima, Japan, for Prime Minister Shinzo Abe and the Liberal Democratic Party.

As Japan heads towards a national election on 22 October, scientific leaders worry that the outcome will do little to address long-standing concerns about

the country’s deteriorating research landscape. They say that a decline in funding and a shift away from basic research has undermined Japan’s capacity to compete against both established scientific powerhouses and emerging ones such as China.

Since 25 September, when Prime Minister Shinzo Abe called for a snap election, science has barely featured in the campaign. Debate has focused on the government’s plan to amend the constitution and increase taxes. The latest polls suggest that Abe’s conservative Liberal Democratic Party could lose some seats, but will retain enough to lead a coalition government.

If Abe is re-elected, he says, his government will pursue an innovation agenda. At a meeting of global science leaders in Kyoto on 1 October, Abe reaffirmed his pledge to turn Japan into “a cradle of innovation” by cutting regulations that impede new technologies.

Despite Abe’s lofty ambitions, the ruling party coalition has decreased the science and technology budget by more than 5% overall since it came to power in 2012. And the budget for universities has dropped by about 1% a year for a decade. “This has been pointed out as the major cause of the deterioration of research performance and, eventually, the global rank of Japanese universities,” says Takashi Onishi, president of Toyohashi University of Technology and a former president of the Science Council of Japan, which advises the government. In the past two decades, the country’s share of highly cited papers has stagnated, whereas those of many other leading nations are rising, according to publisher Elsevier’s Scopus database.

In an attempt to elevate Japan’s top research universities, the government has introduced reforms that categorize institutions according to their research or teaching focus, and that allocate funding on the basis of performance. The government wants leading research institutions to compete globally for the best students and faculty.

Atsushi Sunami, a science-policy specialist at the National Graduate Institute for Policy Studies (GRIPS) in Tokyo, agrees with this aim, but says that to succeed, the government will need to increase its research funding. And money alone will not be enough, says Hiroshi Nagano, also a science-policy specialist at GRIPS. For universities to become world class, they need

autonomy to decide their research and teaching focus, he says. “The current policy is oriented in the opposite direction.”

Basic research left behind

Changes to the university system implemented by Abe’s government are designed to make academia more responsive to the needs of society and industry, in the hope that it will boost low private-sector investment in research. Although scientists broadly encourage this increased collaboration, some say that it has compromised support for basic research. “The government should focus on the development of basic research to supply seeds or ideas to applied sciences,” says Onishi.

Science leaders point to other big concerns about the future of Japanese research. Minicharini Hamaguchi, head of the Japan Science and Technology Agency in Kawaguchi, says that the domestic workforce will be insufficient to keep up with changes in science, technology and innovation, given the country’s rapidly ageing population. He says that policies are urgently needed to encourage more women and foreigners into science and to boost the number of students in doctoral courses, which has dropped by 18% since 2003.

Students who pursue research careers are finding it harder to get jobs. Budget cuts have depleted permanent research positions at universities, and fewer younger researchers are securing permanent posts: the number of research associates on short-term contracts more than doubled from 2007 to 2013.

Biologist and 2016 Nobel prizewinner Yoshinori Ohsumi has warned that the situation for young researchers will jeopardize the country’s chances of winning future Nobel prizes. Japan has the second-highest number of science laureates in the twenty-first century after the United States — but, Ohsumi says, that record is unlikely to hold.

Journal name:
Nature
Volume:

550,
Pages:
310–311
Date published:
(19 October 2017)
DOI:
doi:10.1038/550310a

Comments

Comments

There are currently no comments.

Reboot for the AI revolution

17 October 2017

As artificial intelligence puts many out of work, we must forge new economic, social and educational systems, argues Yuval Noah Harari.

Laura Lezza/Getty

A robot conducts the Orchestra Filarmonica di Lucca at Teatro Verdi in Pisa, Italy, this September.

The ongoing artificial-intelligence revolution will change almost every line of work, creating enormous social and economic opportunities — and challenges. Some believe that intelligent computers will push humans out of the job market and create a new 'useless class'; others maintain that

automation will generate a wide range of new human jobs and greater prosperity for all. Almost everybody agrees that we should take action to prevent the worst-case scenarios.

The automation revolution is emerging from the confluence of two scientific tidal waves. Computer scientists are developing artificial intelligence (AI) algorithms that can learn, analyse massive amounts of data and recognize patterns with superhuman efficiency. At the same time, biologists and social scientists are deciphering human emotions, desires and intuitions. The merger of infotech and biotech is giving rise to algorithms that can successfully analyse us and communicate with us, and that may soon outperform human doctors, drivers, soldiers and bankers in such tasks. These algorithms could eventually push hundreds of millions out of the job market.

Governments might decide to deliberately slow down the pace of automation, to lessen the resulting shocks and allow time for readjustments. But it will probably be both impossible and undesirable to prevent automation and job loss completely. That would mean giving up the immense positive potential of AI and robotics. If self-driving vehicles drive more safely and cheaply than humans, it would be counterproductive to ban them just to protect the jobs of taxi and lorry drivers.

A more sensible strategy is to create new jobs. In particular, as routine jobs are automated, opportunities for new non-routine jobs will mushroom. For example, general physicians who focus on diagnosing known diseases and administering familiar treatments will probably be replaced by AI doctors. Precisely because of that, there will be more money to pay human experts to do groundbreaking medical research, develop new medications and pioneer innovative surgical techniques.

This calls for economic entrepreneurship and legal dexterity. Above all, it necessitates a revolution in education.

Lifelong learning

To make use of the new opportunities, people will need radical, lifelong

retraining. The AI revolution won't be a single event after which the job market and the educational system will settle into a new equilibrium. Rather, it will be a cascade of ever-bigger disruptions. Even today, few employees expect to work in the same job for their entire life (see go.nature.com/2ymdvjs). By 2050, not just the idea of 'a job for life', but even the idea of 'a profession for life' might seem antediluvian. It will become increasingly difficult to know what to teach schoolchildren and university students.

Predicting the future was never easy. If you lived in China 1,000 years ago, there were many things you didn't know: the empire might collapse in 50 years; the Khitans might invade, or a new plague might kill millions. Nevertheless, you did know that most people would still work as farmers and weavers, rulers would still need men to fight in their armies and administer their taxes, women would still have few opportunities beyond marriage and life expectancy would still be about 40 years.

LISTEN

Reporter Benjamin Thompson finds out how lessons from the past can help explore the future of work.

You may need a more recent browser or to install the latest version of the Adobe Flash Plugin.

Hence, in 1017, poor Chinese parents taught their children how to plant rice or weave silk, and wealthier parents taught their boys how to read and write, or to fight on horseback, and their girls to be modest and obedient housewives. It was obvious that these skills would still be needed. In 2017, by contrast, we have no such certainties about the future of jobs, gender, economics or even death.

Human psychology, too, might turn out to be a key hurdle. Change is always stressful. Already we face an epidemic of stress and anxiety (see go.nature.com/2z96s57). As the volatility of the job market and of individual careers increases, we may wonder whether everyone will have the emotional

stamina necessary for a life of constant flux. We may need more-effective stress-reduction techniques — ranging from drugs through neurofeedback to meditation — to cope.

Creating new jobs might prove easier than retraining people to fill them. A huge useless class might appear, owing to both an absolute lack of jobs and a lack of relevant education and mental flexibility.

Test cases

It is particularly important to identify as early as possible the potential winners and losers from new technologies. Rosy overall statistics can hide growing gaps between disparate groups. Automation might have a very different impact on men and women, on 40-somethings and 20-somethings, on the university-educated and the illiterate.

The winners and losers are not the usual suspects. In the clinic, for example, automation might prove more of a threat to doctors than to nurses. Many physicians focus almost exclusively on processing information: they absorb medical data, analyse them and produce a diagnosis. Nurses also need good motor and emotional skills, to give a painful injection, replace a bandage and listen with care. We will probably have an AI family doctor on our smartphone years before we have a reliable nurse robot[1].

Exploring the relationship between intelligence and consciousness will also be crucial to understanding the economic, professional and ethical rapport between future computers and humans. We are seeing a tremendous development in computer intelligence, but zero development in computer consciousness. Just as aeroplanes fly faster than birds without ever developing feathers, so computers could come to solve problems and even to analyse human feelings much better than humans, without ever developing feelings. Studying these differences will help us to predict what AI can and cannot do, and to decide what should be kept out of its control.

There are a few areas in which AI has already made significant strides that, in my view, offer test cases for the impact of modern automation on the world

of work.

In chess, it has been 20 years since IBM's Deep Blue computer thrashed Gary Kasparov. Yet humans still play chess, and 'centaur' teams of humans-plus-AIs can outperform both. This seems at first to bode well for the future: the job market could nurture people who can leverage, rather than compete with, AI. Yet the balance of power in centaur teams is constantly shifting. Computers are becoming so good at chess that the humans are gradually losing value, and could soon become irrelevant. The same thing might happen in other human–AI teams[2].

Laura Lezza/Getty

A woman with a robot at an Italian nursing home in 2015.

Self-driving vehicles are another important test case. The race to produce self-driving vehicles now pits old steel giants such as Mercedes-Benz against new silicon giants such as Google. Transport leverages one of the core advantages of AI: connectivity. Even if a single computer-driven car is less

competent than a good human driver, a network of computer-driven cars is still likely to be much safer and more efficient than the chaos of fallible human drivers that currently dominates the roads.

Today, about 1.25 million people are killed annually in car accidents[3], more than 90% of which are estimated to be caused by human errors[4]. When two human drivers approach the same junction, they might miscommunicate and collide. But computer-driven vehicles can be connected — the chances that they might miscommunicate and collide are therefore much smaller. Similarly, it is easier to ensure that automated vehicles comply with rules such as speed limits (not to mention the ban on drink driving), even as those rules change[5, 6, 7].

Self-driving vehicles illustrate two important points. First, that in some fields it might make sense to replace all humans with robots and computers, even if individually some humans do a better job. Second, that when change comes to some realms, it might do so suddenly, not step-wise.

The military is another important bellwether, because armies are early adopters of much technology. Human soldiers carry a very high economic and political price tag, so replacing people with computers on the battlefield has proved attractive. The most advanced armies now increasingly rely on relatively small numbers of experts coupled with sophisticated and autonomous technologies, such as drones, robots, smart bombs, cyberworms and algorithms that sift through a mass of data[8, 9].

This shift has produced new classes of military jobs in maintenance, remote control, programming and cybersecurity. The US armed forces need 30 people to operate every Predator or Reaper drone flying over Syria, and analysing the harvest of information occupies at least 80 more. A careful study of the military job market might tell us a lot about potential future developments in the civilian economy.

New order

With insights gleaned from early warning signs and test cases, scholars

should strive to develop new socio-economic models. The old ones no longer hold. For example, twentieth-century socialism assumed that the working class was crucial to the economy, and socialist thinkers tried to teach the proletariat how to translate its immense economic power into political clout. In the twenty-first century, if the masses lose their economic value they might have to struggle against irrelevance rather than exploitation.

One new model has been gaining increasing attention and popularity: universal basic income (UBI). UBI suggests that the government should tax the rich and big corporations to provide every person with a stipend covering his or her basic needs. This will cushion the poor against job loss and economic dislocation, and protect the rich from populist rage. It will also free the masses to engage in more creative forms of work that might not currently have economic value, or to pursue further education.

In January 2017, Finland began a 2-year experiment, providing 2,000 unemployed citizens with €560 (US$657) per month, irrespective of whether they work. Similar experiments are under way in the Canadian province of Ontario, in the Italian city of Livorno and in several Dutch cities[10].

Of course, such national and municipal schemes might not solve the worst problems. Globalization has made people in one country utterly dependent on markets in others, and automation might unravel large parts of this global trade network with disastrous consequences for the weakest links. AI might generate immense wealth in hi-tech hubs such as Silicon Valley and Bangalore, while devastating the economies of underdeveloped countries that rely on cheap labour, such as Honduras and Bangladesh.

US voters might conceivably agree that taxes paid by tech giants Amazon and Google for their US business should be used to give stipends to unemployed coalminers in Pennsylvania or jobless taxi-drivers in New York. But they are unlikely to send their taxes to Honduras. We are still far from having any feasible models for a post-work economy, society or political system, and we don't have much time to formulate them.

In the nineteenth century, the Industrial Revolution created new conditions and problems that none of the existing social, economic and political models could cope with. Consequently, humankind had to develop completely new

models — liberal democracies, communist dictatorships and fascist regimes. It took more than a century of terrible wars and revolutions to experiment with these, separate the wheat from the chaff and implement the best solutions.

The challenges posed in the twenty-first century by the merger of infotech and biotech are arguably bigger than those thrown up by steam engines, railways, electricity and fossil fuels. Given the immense destructive power of our modern civilization, we cannot afford more failed models, world wars and bloody revolutions. We have to do better this time.

Journal name:
    Nature
Volume:
    550,
Pages:
    324–327
Date published:
    (19 October 2017)
DOI:
    doi:10.1038/550324a

Comments

Comments

There are currently no comments.

Eye in the sky offers clearest vision of Earth

The world’s latest carbon-monitoring satellite has advanced our understanding of how the planet functions. US politicians should take note.

16 October 2017

Bill Ingalls/NASA

Launched in 2014, the OCO-2 satellite has offered unprecedented views of carbon flow on Earth.

When a rocket failure saw NASA’s first carbon-monitoring satellite plunge

into the ocean in 2009, it was a major blow for climate scientists. Space-based greenhouse-gas monitoring was a promising new frontier — and perhaps an eventual tool for monitoring international climate commitments. It took several years to get a replacement into space, but the Orbiting Carbon Observatory-2 (OCO-2) began taking measurements in 2014. The first major scientific results were published last week in *Science*[1–5], and there can be no doubt that the mission is delivering. No doubts, either, that the US government should launch a successor.

The results give an unprecedented insight into one of the most important planetary phenomena: El Niño, the subtle but massively influential gathering of warm waters in the tropical Pacific Ocean. The 2015–16 El Niño was a monster, changing weather patterns and driving the largest and longest coral-reef-bleaching event on record. Through it all, scientists used OCO-2 to watch carbon move through oceans and ecosystems.

The overall trend came as little surprise — a massive increase in global atmospheric carbon levels. Scientists have measured similar rises in carbon dioxide during past El Niños. But the precise mechanism was elusive. OCO-2 helped clarify the matter by producing detailed maps. Researchers saw an initial decrease in the amount of CO_2 coming out of the tropical Pacific Ocean, a dip later swamped by CO_2 originating from Africa, South America and southeast Asia as the event wore on.

Tracking carbon is just the first step. Those data feed into atmospheric models that can provide a more comprehensive explanation for the origin — and destination — of any given CO_2 molecule. Fortunately, sensors on board OCO-2 can assess the amount of photosynthesis using methods other than measuring carbon flux. They detect a photosynthesis-linked signal called solar-induced chlorophyll fluorescence, which gives an independent measure of how much CO_2 plants are taking up.

With this suite of tools, scientists have managed to paint a finer picture of how the 2015–16 El Niño affected individual regions. Heat and drought set the stage for the massive wildfires that ravaged Indonesia during the event, whereas drought-stricken trees in the Amazon rainforest took up less carbon than usual. In Africa, the higher temperatures probably boosted plant

respiration. All three mechanisms for increasing atmospheric CO_2 have been proposed in the past, but it was a surprise to see all play out on different continents simultaneously.

Plenty of questions remain. The satellite measurements are not as precise as scientists would like, and they don’t always align perfectly with data from the ground. And getting the models right is a never-ending challenge. It will be some time before satellites are able to provide the precision needed to quantify the natural carbon cycle, let alone to separate out human emissions with enough confidence to verify whether countries are meeting their obligations to cut greenhouse-gas emissions. But OCO-2 is further validation that the effort is worth pursuing.

US politicians should take note. President Donald Trump has proposed scrapping a follow-on mission, OCO-3, presumably because it falls under the rubric of climate — a topic that is anathema to this administration. That would be a self-defeating and damaging move. The bulk of the budget for OCO-3 — which was built from the spare parts of its predecessor — has already been spent; all that’s left is the expense of launch and operation. Killing the mission now would waste time and money. But more importantly, as these latest studies show, humanity can learn from the measurements that it will make.

OCO-2 is an affirmation of climate science that everybody should be able to appreciate, regardless of political leanings. Trump might not like talking about climate. But surely his administration — and the lawmakers on Capitol Hill who will decide whether OCO-3 survives — cares about the weather.

El Niño has an impact on weather systems around the world. It raises the likelihood of heavy rainfall from California to the Gulf of Mexico, while increasing the chances of drought and extreme heat in areas farther north. El Niño and its opposite sister system La Niña factor heavily in longer-term seasonal forecasts, which can help governments prepare for fires like those tearing through California at the moment. The more we understand this system, the better we will be at forecasting changes in the weather, the climate — and the economy. A 2014 report from the International Monetary Fund argued that effects of El Niño should be taken into account when

nations plan their finances. This has nothing to do with politics, and everything to do with understanding the world in which we live.

Journal name:
Nature
Volume:
550,
Pages:
301
Date published:
(19 October 2017)
DOI:
doi:10.1038/550301a

Comments

Comments

There are currently no comments.

Colliding stars spark rush to solve cosmic mysteries

Stellar collision confirms theoretical predictions about the periodic table.

16 October 2017

Cosmic furnace

A simulation of the merger of two neutron stars, leading to the formation of a black hole. About 2% of the stars' mass gets ejected at high speed, producing radioactive, heavy atoms.

Credit: W. Kastaun/T. Kawamura/B. Giacomazzo/R. Ciolfi/A. Endrizzi via Caltech

Gold, platinum, uranium and many of the rare-earth elements that are crucial to today's high-tech gadgets are generated during the formation of black holes, astronomers have said. The collision of two small but dense stars simultaneously solved several cosmic mysteries, researchers announced at a press conference in Washington DC on 16 October. More than 30 papers have been published so far in five journals — *Physical Review Letters, Science*, *Nature*, *Nature Astronomy* and *Astrophysical Journal Letters*.

Astronomers watched as two neutron stars — small but very dense objects formed after the collapse of stars bigger than the Sun — collided and merged, forming a black hole, in a galaxy 40 million parsecs (130 million light years) away, according to two dozen researchers interviewed by *Nature*'s News team.

The collision generated the strongest and longest-lasting gravitational-wave signal ever seen on Earth. And the visible-light signal generated during the

collision closely matches predictions made in recent years by theoretical astrophysicists, who hold that many elements of the periodic table that are heavier than iron are formed as a result of such stellar collisions.

Neutron-star mergers are also thought to trigger previously mysterious short γ-ray bursts, a hypothesis that now also seems to have been confirmed.

Astronomers have good reasons to believe that they are looking at the same source of both the gravitational waves and the short γ-ray bursts, says Cole Miller, an astronomer at the University of Maryland in College Park, who was not involved in the research but who has seen some of the papers ahead of their publication.

Bright object

The event was detected on Earth on 17 August, and triggered weeks of febrile, round-the-clock activity on all 7 continents, as more than 70 teams of researchers scrambled to observe the aftermath.

The collision was felt first as a space-time tremor by the Laser Interferometer Gravitational-wave Observatory (LIGO) in the United States and by its Italy-based counterpart Virgo, and seen seconds afterwards as a smattering of high-energy photons by NASA's Fermi Gamma-ray Space Telescope.

Alerted by the LIGO–Virgo team, astronomers then raced to find and study what was seen as a bright object in the sky using telescopes big and small, famous and obscure, on land and in orbit, and spanning the spectrum of electromagnetic radiation, from radio waves to X-rays.

Cody Messick was at his home at 08:41 local time (12:41 UT) on 17 August when he first found out about the event. "I remember standing on my stairs and looking at my phone, thinking: 'Wow!" he says. Messick, who is a physicist at Pennsylvania State University in University Park, belongs to a small team of LIGO first-responders who receive frequent automated alerts from the two interferometers, which are based in Livingston, Louisiana, and Hanford, Washington. Normally, LIGO's algorithms flag a potential signal in real time only if both interferometers detect it. Messick was surprised,

because the message on his smartphone mentioned a strong signal — but one seen only at the Hanford site.

Messick quickly got on a conference call with his team leader, Chad Hanna, also at Pennsylvania State, and other colleagues. Together, they examined the data online. The Hanford signal looked like a textbook example of the waveform of the gravitational waves emitted by two compact objects, each slightly more massive than the Sun, as they spiral into each other, he says. In particular, the waves lasted much longer — about 100 seconds — and had a higher pitch than the signals from the much more massive black-hole mergers that LIGO had previously detected.

When they looked at the data stream coming from Livingston, the LIGO researchers found a similar signal there as well, but one with a loud, spurious glitch towards the end. It was that anomaly that had caused the real-time-analysis software to ignore the signal, says David Shoemaker, a physicist at the Massachusetts Institute of Technology in Cambridge who is LIGO's spokesperson.

Meanwhile, researchers received another alert: Fermi had detected a short γ-ray burst that had occurred 1.7 seconds after the gravitational waves had ended. Called GRB170817A, it was unusually faint for such a burst.

Second signal

In Italy, another technical glitch had suspended the continuous stream of data normally sent out by Virgo. So it took another 40 minutes for researchers to realize that they, too, had a signal — albeit a faint one. It transpired that the waves had travelled close to one of the interferometer's four blind spots, says Jo van den Brand, a physicist at the Vrije Universiteit Amsterdam and spokesperson for the Virgo Collaboration.

By 13:21 UT, 40 minutes after the event, the LIGO–Virgo team had decided to notify its roughly 70 follow-up partners — teams of astronomers on standby to look for related events using conventional telescopes.

Four and a half hours later, the team sent a second, much more useful alert.

The timing of Virgo's feeble signal had been sufficient for the LIGO-Virgo team to identify the source of the waves. It pointed to a region of the sky spanning an angle of just a few degrees, in the southern sky. They called the event GW170817, after the date it was detected.

Virgo had joined LIGO's observation campaign only on 1 August, after a five-year shutdown for upgrades. And just three days before the event's detection, on 14 August, LIGO and Virgo had made their first joint detection. It enabled them to rehearse the more precise identification of the patch of sky of interest. The event on 17 August enabled them to narrow it down even further. And the estimated distance was ten times closer to Earth than in the previous events. They could tell this because of how loud and persistent the waves were: it was the strongest signal LIGO had ever sensed. After the fact, Hanna's team was able to extract a signal that lasted a full six minutes.

Together, the alerts from LIGO–Virgo and Fermi sent astronomers into a frenzied rush. Each team wanted to be first to spot the fireworks produced by a neutron-star merger. It was daytime on most of the world's land mass, so teams began to formulate strategies for their nocturnal observations. They knew that, at that time of the year, the region to search was not far from the Sun. That left a window of observation of a couple of hours after dusk, before the region of sky would set below the horizon.

"We had a complicated, choreographed dance of telescopes that night," says Iair Arcavi, an astrophysicist at the University of California, Santa Barbara, whose team made non-stop observations using the Las Cumbres Observatory, a worldwide network of robotic telescopes. It began by activating a number of telescopes in Chile.

Three messengers

The first person to see the event may have been Charles Kilpatrick, an astronomer at the University of California, Santa Cruz. He was part of a team that was scanning the sky with the more modest means of the single one-metre Swope Telescope in Chile. Like his competitors, Kilpatrick was closely watching the exposures one by one as they came out, comparing them with

archival images of the same patch of sky. By the ninth exposure, he saw something very conspicuous in a galaxy called NGC 4993. “It looked exactly like a point source in this image that wasn’t in the reference image,” Kilpatrick says. The team named it SSS17a.

At least two other groups say they spotted the bright dot independently. They and other teams also made sure that there were no other plausible candidates within the search region. GW170817, GRB170817A and SSS17a really seemed to be three different messengers from the same source.

LIGO and Virgo lacked a sufficiently detailed signal of the final instants of the collision to be certain that the objects were neutron stars, Shoemaker says. From gravitational-wave data alone, they could have been two unusually small black holes. But the presence of visible light strongly suggested that at least one of the objects in the merger was a neutron star, he and other researchers say.

The group at the University of California, Santa Cruz, was also the first to measure the optical spectrum of SSS17a. On the first night, the dot was bright blue, says astronomer Ryan Foley, who led that effort. NASA’s Swift telescope also detected blue, as well as ultraviolet, light. But during the next few nights of observation, those colours faded away, and the object became more red, according to multiple teams.

Colliding neutron stars should spread debris — a mix of neutrons, but also some protons — in three ways, says Brian Metzger, a theoretical astrophysicist at Columbia University in New York City. First, they fling matter out from their outer layers during the final orbits. Then some matter gets squeezed out in the actual collision. Finally, as the two stars begin to collapse into a black hole, it forms an accretion disk of matter, some of which flies out instead of falling in.

Over the past decade or so, astrophysicists had come to believe that this was the most plausible mechanism to explain the abundance of the heavier elements of the periodic table[1]. The theory held that, overall, about 2% of the combined mass of the stars would escape the fate of the rest. Within one second of the collision, this material would have expanded to become a cloud tens of thousands of kilometres across, but still about as dense as the Sun. In

this cauldron, protons and neutrons would immediately clump together to form neutron-heavy nuclei, which would then begin to decay radioactively. This radioactivity would keep the cloud glowing hot for several days, even as it reached the size of the Solar System. Within a million years, it would spread across an entire galaxy.

As predicted

Metzger says that the switch from blue to red was just what he expected to see. His models suggest that nuclei in this early cloud would reach the masses of many of the elements beyond iron, although not the heaviest ones. This chemical composition would cause the cloud to glow blue.

But the real smoking gun for this model, the signatures of the formation of the heaviest elements, would be a cloud that glowed in the red and infrared. These would be elements forged in a separate wave of the explosion, probably the one coming from the accretion disk, says Metzger.

“We had predicted exactly what kind of red,” says Daniel Kasen, a theoretical astrophysicist at the University of California in Berkeley. Jennifer Barnes, another theorist then in Kasen’s team who is now at Columbia University, had run the supercomputer simulations that predicted the experimental signatures in 2013[2]. “I had just finished my PhD thesis predicting what these things would look like,” she says.

Eleonora Troja, an astronomer at NASA Goddard Space Flight Center in Greenbelt, Maryland, was part of one of the first teams to use the Hubble Space Telescope to view the event. “The spectra were phenomenal,” she adds, and almost indistinguishable from the theoretical predictions. “You could clearly see the fingerprints of the metals that had formed.”

But Troja and other observers were also puzzled, because they couldn't find any signal in the X-ray and radio regions of the spectrum. These would be expected during the formation of a black hole, which is thought to shoot jets of out of its poles at close to the speed of light. Nine days later, Troja’s team was the first to find the X-rays.

Alessandra Corsi, an astronomer at Texas Tech University in Lubbock, and her collaborators kept looking for radio emissions using the Very Large Array in New Mexico. Day after day, the dishes recorded nothing. “It turned out we had to wait 16 very long days in order to see the first radio glow,” she says.

The late onset of the radio and X-ray signals, together with the weakness of the initial γ-rays, suggest that the jets were pointed away from the line of sight to Earth. Gamma-ray bursts that happen to be pointed in the right direction can look very bright even from billions of parsecs away.

After a few weeks, most observatories had to stop looking at the object, because that part of the sky had got too close to the Sun. But radio telescopes are still tracking it to this day, Corsi says. More discoveries might yet be made.

“The idea that all this stuff has happened, it’s too much. It is just hard to process,” says Daniel Holz at the University of Chicago in Illinois. “It’s unreasonable that we have done so much with just one event of its kind.”

“All our hopes and dreams have basically come true,” says Jocelyn Read, an astrophysicist at California State University, Fullerton. “All this time we have been saying, look at this amazing thing we are going to be able to see. And it is still hard to believe when it actually happens.”

Journal name:
Nature
Volume:
550,
Pages:
309–310
Date published:
(19 October 2017)
DOI:
doi:10.1038/550309a

Comments

Commenting is currently unavailable.

Prepare for larger, longer wildfires

Climate change makes land management more urgent than ever, says Kathie Dello[1].

13 October 2017

Neighbourhoods burned this week in northern California, with more than 30 people reported dead and 2,000 buildings destroyed. Downtown San Francisco is hazy with smoke from wildfires covering 465 square kilometres, more than 30 kilometres north of the Golden Gate Bridge.

Whatever the proximate cause, these should serve as reminders that climate change is not a future problem, nor a hazard just for tiny island nations. It is a problem now, and our land-management plans need to do a better job of incorporating it.

Scientists must walk a careful line when attributing specific events to climate change. Wildfires are part of a healthy ecosystem and a fact of life in the western United States. Many aspects of a landscape affect them, including past fire suppression, land use and human carelessness.

But climate change increases the threat: fires that do start are larger and last longer. Warmer summer temperatures mean more evaporation. Overall, that means drier forests during the fire season. Ironically, California’s past wet winter ended a long drought, but meant that there was more vegetation to become tinder. A 2016 study showed that the fire area attributed to human-

caused climate change has doubled since 1984, largely because vegetation has dried out more. Another 2016 study found that the average area of burnt forest in the northwest United States each year from 2003 to 2012 was almost 5,000% larger than in the years 1972 to 1983, and that the fire season grew from an average of 23 days to 116 days over the same periods. Four other forest areas studied — the Northern Rockies, Southern Rockies, Sierra Nevada and Southwest — also saw increases in both the area burnt and the length of the fire seasons.

Talk about climate change can focus exclusively on avoiding temperature increases in the vague future. The US government's moves to pull out of the Paris climate accord and the home-grown Clean Power Plan are short-sighted, and states' and municipalities' efforts to cut their own emissions are laudable. But it's not enough. We have to manage the effects of climate change that are already here. That means recognizing that threats are increasing.

The cost of fighting US wildfires this year exceeded a staggering US$2 billion, more than half the US Forest Service's budget. The agency has to use funds to fight fires that would otherwise go towards prevention and forest management. It needs more resources so that plans for prevention can become bolder and more expansive.

In fact, the Forest Service is incorporating some climatic adaptation into its regional plans. These include planting seedlings less densely, for instance. But we need many more plans in place, and we need to make sure that goals are met.

What does adaptation mean for wildfires? We have to manage risk even more aggressively than we have done, and incorporate greater uncertainty. We are likely to need an expansion of the areas considered to be at risk. We should avoid building in the urban–wildland interface and mandate the use of materials that are less likely to catch fire. We can boost attempts to thin woody growth and remove brush.

A public-education component is needed as well. At the end of August, a wildfire ravaged the breathtakingly beautiful Columbia River Gorge near Corvallis, Oregon, where I live. It was probably caused by a teenager

throwing a firework off a cliff during one of the hottest summers on record in the Pacific Northwest. Everyone has to realize that the consequences of foolish behaviour or bad luck (many wildfires are started by lightning) are getting worse, so prevention and mitigation are even more important.

Let’s face it — adapting to a changing climate makes the already difficult task of land management even tougher. The aspects we need to manage aren’t isolated — for instance, the burn scars left by the fires will be prone to landslides in the rainy season and dust storms in the summer.

Those living far from fire hazards also need to adapt. The 2014 US National Climate Assessment counts only 15 states with climate-adaptation plans, mainly concerned with flooding and saltwater hazards. The Georgetown Climate Center in Washington DC, which has been tracking progress, says that most states have completed only a few of their goals, many set nearly a decade ago, although work on others is in progress.

The irony is that catastrophes can make for better planning. We should not be afraid to talk about them. Recent events — such as the fires this summer, and the crippling five-year drought that ended in 2015 — motivate us to account for more of these events in the future. Part of my job is talking to policymakers, natural-resource managers and the general public about climate change. Contrary to stereotypes, people in rural areas in the US West are ready to discuss it.

Approaches to climate change that start off in an atmosphere of blame and aggressive policy proposals rarely stick. Instead, discussions about the land that people know provide a common ground that images of lonely polar bears on ice floes do not. There’s always an entry point, and it’s around shared values and solutions. That’s as true in Pocatello, Idaho, as it is in Portland, Oregon.

The wildfires in northern California are horrendous. There is much to mourn. And we can bet that these and other disasters will get worse. Our planning needs to take that into account. We need to protect our livelihoods now, to help ensure better prospects for future generations.

Journal name:

Nature
DOI:
doi:10.1038/nature.2017.22821

Comments

Commenting is currently unavailable.

Global networks of small telescopes will chase companion signals of gravitational waves

Seeing cosmic events is one thing, but what if you could hear them and taste them, too?

13 October 2017

Krzysztof Ulaczyk/University of Warwick

The Gravitational-wave Optical Transient Observer (GOTO) in La Palma, Spain, will look for flares of light coming from the same spot as any gravitational waves.

A cottage industry of small observatories is springing up around the globe to take advantage of astronomers' new ability to capture the gravitational waves from major cosmic events. These new facilities will enable researchers to match up those gravitational waves with electromagnetic signals and perhaps one day even particles of matter from some of the cataclysms that send measurable ripples through space-time.

The main goal is to look for flares of light originating from the same spot as any gravitational waves detected by the US-based Advanced Laser Interferometer Gravitational-Wave Observatory (LIGO), or the Virgo observatory near Pisa, Italy. These smaller telescopes, often built on a shoestring budget, will serve as first-line responders, filling the gap between gravitational-wave detectors and the major facilities of conventional astronomy. “Once you know where to look, you can swing the whole world’s telescopes at it,” says Danny Steeghs, an astronomer at the University of Warwick, UK.

Moving quickly is key. It’s tricky to pinpoint the source of gravitational waves — astronomers can typically narrow it down to a region of the Universe that could contain thousands of galaxies — and observatories may have only a few days before any promising flares of light dissipate. “You need to look at a lot of sky,” says Steeghs, “and you don’t have a lot of time for it.”

Robots of the sky

Steeghs leads a small UK–Australian collaboration that built the Gravitational wave Optical Transient Observer (GOTO) in La Palma, Spain. It is an array of four small robotic telescopes that will eventually grow to 8 telescopes, and perhaps 16. So far, it has cost just £800,000 (around US$1 million).

Alan Watson of the National Autonomous University of Mexico (UNAM) in Mexico City and his collaborators spent even less. They built the Deca-Degree Optical Transient Imager (DDOTI), currently consisting of a pair of robotic telescopes at Sierra San Pedro Martir, Mexico, for a mere

US$350,000, largely by using off-the-shelf components, he says. They plan eventually to have six telescopes, perhaps followed by more facilities in France and Australia.

Some of the facilities, including GOTO, are being designed and built specifically to follow up on gravitational-wave signals. Most of these will be robotic, using machine-learning algorithms to alert each other to point at particular regions of sky and search for interesting flares without the need for human intervention.

Other projects have grown out of existing collaborations that are familiar with looking for visible-light counterparts to the γ-ray bursts spotted by space observatories, or tracking other transient phenomena, such as supernovae explosions or asteroids that are potentially Earth-bound. And some venerable telescopes, including one of those once used by Edwin Hubble in Palomar, California, have been retrofitted. The 1.2-metre telescope is now part of GROWTH (Global Relay of Observatories Watching Transients Happen), a network of 17 facilities around the globe that can track an object seamlessly as the Earth spins. “The idea is, basically, to beat sunrise,” says Mansi Kasliwal, an astronomer at the California Institute of Technology in Pasadena, who is part of GROWTH.

Twan Bekkers

Engineers install a prototype of the BlackGEM telescopes at the South African Astronomical Observatory in Sutherland.

Astrophysicist Paul Groot of Radboud University in Nijmegen, the Netherlands, whose group is part of the Virgo collaboration itself, is leading a Dutch-funded project called BlackGEM. It will initially consist of three telescopes in La Silla, Chile, costing about €6 million (US$7.1 million), that will continuously map the southern sky to build up a database of archived images. If news of a gravitational-wave detection arrives, BlackGEM will scan the relevant patch of sky within hours, and automatically compare that to its archived images to search for anything new.

Neutrino chasers

Similar efforts are already following up on detections of notable particles from space, such as unusually energetic neutrinos or cosmic rays. The

Astrophysical Multimessenger Observatory Network (AMON), started in 2016, got its first interesting hint on 22 September, when it responded to a high-energy neutrino detected by IceCube, the world's largest neutrino observatory, at the South Pole.

When AMON researchers looked towards the source of the neutrino, they saw that a known quasar — an entity consisting of heated matter orbiting a supermassive black hole at the centre of a distant galaxy — was flaring up. This is the type of heightened activity that theorists think could produce an excess of neutrinos, but so far, no high-energy neutrinos have been traced conclusively back to their sources.

In the future, researchers hope that they might detect all three types of emission together: electromagnetic radiation, gravitational waves and particles of matter. Some compare that to seeing, hearing and tasting an astrophysical event at once.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22828

Comments

Commenting is currently unavailable.

Weather-company chief is Trump's pick to lead climate agency

Barry Myers would bring private weather-forecasting experience to the National Oceanic and Atmospheric Administration.

12 October 2017 Updated:

1. 12 October 2017

Mandel Ngan/AFP/Getty

Barry Myers has been nominated to lead the US National Oceanic and Atmospheric Administration.

Barry Myers, the chief executive of weather-forecasting firm AccuWeather, is US President Donald Trump's pick to head the National Oceanic and Atmospheric Administration (NOAA), the White House said on 11 October.

Myers, an attorney by training, has led AccuWeather — based in State College, Pennsylvania — since 2007. This experience could prove useful if the US Senate confirms Myers as NOAA's chief, given that the agency includes the US National Weather Service. But some scientists worry that Myers's ties to AccuWeather could present conflicts of interest, and note that Myers has no direct experience with the agency's broader research portfolio, which includes the climate, oceans and fisheries.

"I think the science community has real cause for concern," says Andrew Rosenberg, head of the Center for Science and Democracy at the Union of Concerned Scientists in Cambridge, Massachusetts.

Rosenberg notes that Myers was an early proponent of carving out a larger role for the private sector in providing weather services. And in 2005, while Myers served as executive vice-president and general counsel, AccuWeather lobbied for legislation to prevent the National Weather Service from competing with private firms in providing products including basic weather forecasting. "Is he going to recuse himself from decisions which might potentially be of interest to his company down the road?" asks Rosenberg.

A different perspective

Myers will probably advance efforts to bring commercial weather data into the national weather-forecasting system, says Bill Gail, chief technology officer for the Global Weather Corporation in Boulder, Colorado. Still, Gail says, Myers respects the importance of the public sector in such activities. "I've got a lot of respect for him, and I think he could do a pretty good job," adds Gail, the co-chair of a decadal survey of US Earth-science satellites being conducted by the National Academies of Sciences, Engineering, and Medicine.

The chief executive's views on climate change are a little harder to parse,

because Myers hasn't taken any strong public positions on global warming. But in a position statement on the Accuweather website, the company says there is "little doubt" that human activities influence the planet's climate. "At the same time, our knowledge of the extent, progress, mechanisms and results of global climate change is still incomplete," the statement says. The company says it encourages its scientists to express their own views, and it publishes a blog featuring posts about climate research.

If Myers ascends to NOAA's top job, he will lead an agency facing an uncertain financial future. Trump has proposed slashing NOAA's budget by 17% in fiscal year 2018, compared to the 2017 level of US$5.7 billion. Although Congress has so far rebuffed Trump's attempts to cut funding for several key science agencies, funding for the 2018 budget year — which began on 1 October — is still up the air. The government is currently running on a stopgap spending bill that will expire on 8 December, prompting another round of budget negotiations.

Ultimately, Myers will need to build a solid team to handle the full NOAA portfolio, says Antonio Busalacchi, president of the University Corporation for Atmospheric Research in Boulder. "He's going to face a lot of challenges, but the bottom line is that Barry does bring a lot of relevant experience to the table."

Whoever ends up leading the agency will have help. On 5 October, the Senate confirmed oceanographer Timothy Gallaudet as assistant secretary of commerce for oceans and atmosphere, the number-two position at NOAA. Gallaudet, a 32-year veteran of the US Navy, has experience ranging from weather and ocean forecasting to developing policies to counter illegal fishing and assessing the national-security implications of global warming, according to the White House.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22311

Updates

Updated:

> This story has been updated with information about Myers' views on climate change and the recently confirmed assistant secretary of commerce for oceans and atmosphere, Timothy Gallaudet.

Comments

Comments

There are currently no comments.

European drug regulation at risk of stalling as agency prepares to leave London

Post-Brexit plans to relocate the European Medicines Agency could trigger severe staff losses, its head has warned.

12 October 2017

Chris Ratcliffe/Bloomberg via Getty Images

The European Medicines Agency in London

Drug regulation in Europe could temporarily freeze if the European Medicines Agency (EMA) loses staff during its post-Brexit move from London. Up to 70 per cent of its 900 staff have said they would quit if the agency relocated to some of the cities bidding to host the organisation.

According to a battle plan drawn up by agency management, failure to retain enough staff would result in a shutdown of essential operations until more people could be hired. If fewer than 30% of the staff move with the agency to its new destination — to be decided next month — it would cease operation, Guido Rasi, the agency's executive director, told *Nature*.

The EMA, an agency of the European Union, needs to leave London — where it has been headquartered since 1995 — as a result of Brexit. In addition to its permanent staff, the agency hires many other experts on a short-term basis. Following an internal staff survey undertaken in September, the agency urged European heads of state to pick a location to which at least 65% of staff would relocate.

Bids for a home

Some 19 cities across Europe have applied to host the prestigious organization. Last week, the EMA released its own assessment of the applications, and warned that several locations are entirely unsuitable for the agency's location. Proposals for Sofia, Malta and Warsaw met almost none of the requirements put forward by the agency and could result in huge staff losses, Rasi warned. Amsterdam was the most popular alternative to London.

"The best case is, of course, a continuum of our activities, with only about 20% staff loss," he says. "The worst case scenario we have come up with is 94% staff loss. For our business-continuity plan, we found three levels of activities we can delay, put on hold or stop completely."

According to Rasi, the agency's core mission — the regulation and monitoring of innovative drugs across Europe — would be the last thing to stop. But even with 50% staff loss, the agency would have to reduce advisory support to new research projects, which could stall work on innovative medicines, he says (see 'European Medicines Agency chief raises alarm at forced relocation').

The agency assesses all medicines, including veterinary products, to be sold on the European market, and passes on recommendations to the European Commission for authorization. It evaluates reports of adverse reactions and, if necessary, works with national agencies to ban medicines that are suspected of being dangerous. The EMA also has in-house scientists who provide advice to drug developers on which criteria they need to fulfil to get a product passed.

In 2016, the agency recommended 81 new medicines for authorization and answered more than 450 requests for scientific advice.

Medication mediation

The European Federation of Pharmaceutical Industries and Associations, headquartered in Brussels, has called on member states to put the agency's well-being first when choosing a location. “There are many cities that could have the right criteria for the agency to settle,” said a spokesman. “There is a potential for disruption, but also a potential for harmony. It all depends on what you choose.”

In the United Kingdom, pharmaceutical companies worry about how they will get their medicines approved after Brexit. The BioIndustry Association, a group of British life-sciences companies, has backed a UK government proposal to maintain authorizations for medicines granted before Brexit and the continuation of work with the agency during a transition period.

“The alternative — organizing and delivering a wholesale change — would be a gargantuan task for companies and regulators across the UK and Europe,” says Steve Bates, the association’s chief executive officer. “It would be extremely challenging to successfully deliver in the short amount of time left until Brexit in March 2019.”

Meanwhile, the uncertainty about the agency’s future is already causing problems. The agency has been unable to fill a position as head of veterinary medicine; all three potential candidates said that they would wait for the final location to be announced before deciding whether or not to take the job, according to Rasi.

Europe’s heads of state will meet on 18–20 October to begin hammering out an agreement. A decision is due to be announced on 20 November, at the next EU General Affairs Council meeting.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22817

Comments

Comments

There are currently no comments.

European Medicines Agency chief raises alarm at forced relocation

Guido Rasi says that ensuring the safety of drugs could be compromised.

12 October 2017

Finbarr O'Reilly/REUTERS

The European Medicines Agency (EMA), which oversees drug safety in the 28 countries that are members of the European Union, must move out of London because the United Kingdom is leaving the EU. Nineteen cities have bid to host it and a decision on its new home is expected in November. But EMA staff – and its executive director, Guido Rasi – are worried that the move could severely disrupt the agency’s functions. On 26 September, the agency revealed an internal staff survey which suggested that more than 70%

of current staff would quit, rather than move country, in the case of eight candidate cities. Rasi says he fears that the EMA – which licenses drugs for use in the EU, monitors adverse reactions to medicines and sets standards – could find itself hobbled by the wrong choice of city. *Nature* talked to him about how this might affect European researchers and public health. The interview has been edited for length and clarity.

What kind of activities would stop first if you lost staff?

Initiatives for the elderly, initiatives for tailoring medicine to male and female patients, engagement with patients, efforts to increase transparency, our communication — all these are for the improvement of our work, but they can be stopped if we need to focus on more essential activities. We must ring-fence the approval process, monitoring and inspections. So the second layer would be to decrease our engagement with scientists. The third layer would be to stop scientific advice and abandon early engagement during the research process.

What is the worst-case scenario?

If we retained less than 30% of our staff, we simply could not operate. We could see the collapse of entire services. For example, think of clinical-trials assessment. If we lose all the statisticians, all the experts, we'll sink. We might maintain some activities that are not so relevant, because we have people there, but might have to cancel core activities because those people are gone. In other words, we cannot replace plumbers with blacksmiths. The best case is, of course, a continuum of our activities, with only about 20% staff loss.

How would this affect the average European?

In the worst-case scenario, there would be no approval of medicines and no management of adverse reactions at the central level. Member states would urgently have to make provisions to approve new medicines and decide what standards they want to see. Many innovative medicines would be delayed or simply not be known, because there are no assessors. Innovation would be available only at the cost of uncertainty. Monitoring would rely on local efficiency, and there would be 28, sorry, 27 different approaches and standards.

And what does it mean for researchers?

We would cease the many activities we are doing to support research and development. For example, we get involved at the EU level to define strategy, such as planning for big EU funding programmes or its Innovative Medicines Initiative. We also provide scientific advice, innovation passports for drugs, protocol assistance and advice around clinical trials. For example, we are working with the commission to reduce the regulatory pool around clinical trials while maintaining the standards. This would stop completely for about two years or so. The impact would be huge, because without staff, we cannot engage with researchers and listen to their needs.

How did you react to the results of the staff survey?

We were surprised by the possible severity of staff loss. This is the worst thing that has happened during my experience here. Now, we feel the imperative responsibility to highlight the consequences of the choice of location. What is at stake now is not where to put the agency; it’s about where you can maintain its activities.

How likely is it that people will leave the agency?

You have to consider that people made a choice to come to London. They competed hard to get here. It’s not their choice to go away. In 14 months, from November 2017 to April 2019, they will have to recast their lives, give up their houses, their mortgages, the plans they had for the future of their children, the jobs of their partners, their cultural lives. These people are the crème de la crème of Europe. It will not be difficult for most of them to find a job elsewhere, and the headhunters are already around.

But wherever the agency goes, can’t you find experts there?

I am sure there are smart people in each country. But to train someone into an expert takes five or six years. It is unlikely that the local environment in any single member state can give us back the knowledge that we are losing.

Would you consider leaving the agency?

You know, the captain is the last to abandon his ship. I will go along with the agency, and I will do whatever will be in my capacity and power to retain as many people as I can.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22818

Comments

Commenting is currently unavailable.

| 章节菜单 | 主菜单 |

Male scientists share more — but only with other men

Evolutionary differences blamed for squeezing out female researchers.

12 October 2017

Old Visuals/Everett Coll./Mary Evans Picture Library

Male scientists are more likely to collaborate with other men than with women, says a study.

Male scientists are more likely to share their published work than are women — but only with other men, a study of hundreds of researchers has found.

Humans are generally considered to be a highly cooperative species, says

Jorg Massen, a cognitive biologist at the University of Vienna. But most of the evidence for that assumption comes from artificial situations such as computerized cooperation tasks. “I wanted to test human prosociality in an everyday situation,” he says. So he chose one of the most competitive situations he could think of: his own field of research psychology.

To investigate cooperation among psychologists, Massen turned his fellow researchers into guinea pigs. He and his colleagues e-mailed nearly 300 researchers and asked them to share either a PDF of one of their latest papers, or some raw data (pretending that they wanted to include it in a meta-analysis). The results were published in *Scientific Reports* on 10 October[1]. In general, the scientists contacted were highly cooperative, with almost 80% willing to share a PDF and almost 60% willing to send raw data. “I was surprised,” says Massen. “Humans are prosocial even in this competitive field.”

Even more unexpected, however, was a strong gender difference in how the scientists responded to the request for help. Massen and his colleagues had wondered whether men might respond more favourably to women, or vice versa. In fact, men were more likely to share, but only with other men. A male–male request was 15% more likely to be granted than any other gender combination.

Evolution at work?

Massen and his colleagues say that one possible explanation for their results “may be that among male academics there is a network at play, in which they favor each other much like 'Old Boy' networks”. They also suggest that this imbalance might have evolutionary roots and point to an idea called the male-warrior hypothesis, which states that men have evolved to form strong bonds with other males in their group because in the past this enabled them to defend territory from hostile attackers.

“Men are more ready to cooperate with genetic-stranger males to form these fighting coalitions,” says Mark van Vugt, an evolutionary psychologist at the Free University of Amsterdam who first suggested the theory in 2007[2]. Some

of the evidence for this idea comes from lab-based tasks such as public-goods games (in which volunteers choose how many tokens to keep or share), but there are some real-world hints too, he says. Boys tend to play in larger groups than girls, van Vugt says, and in sports such as tennis and boxing, men make more effort to bond with their opponent after a match or fight than women do. However cultural factors are also thought to be at work.

Massen's results "sit very well" with these previous findings, says van Vugt, who suggests that such gender differences might affect professional situations beyond psychology research. Any roles that involve teaming up with strangers — such as business, politics, law and economics — could end up favouring men, he predicts. "Men are always on the lookout to find coalition partners," he says, whereas women tend to be more cautious about cooperating with strangers. "That's an obstacle to building up the same networks that men have."

Many factors, including cultural ones, contribute to gender bias at work. "It is very clear that in science and many other professions, women are discriminated against," says Massen. "Something needs to change." But he suggests that an increased awareness of differences in cooperation might encourage both men and women — in science and other fields — to look at their own behaviour and consider how they might respond differently. "I hope people read it and think about it," he says.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22820

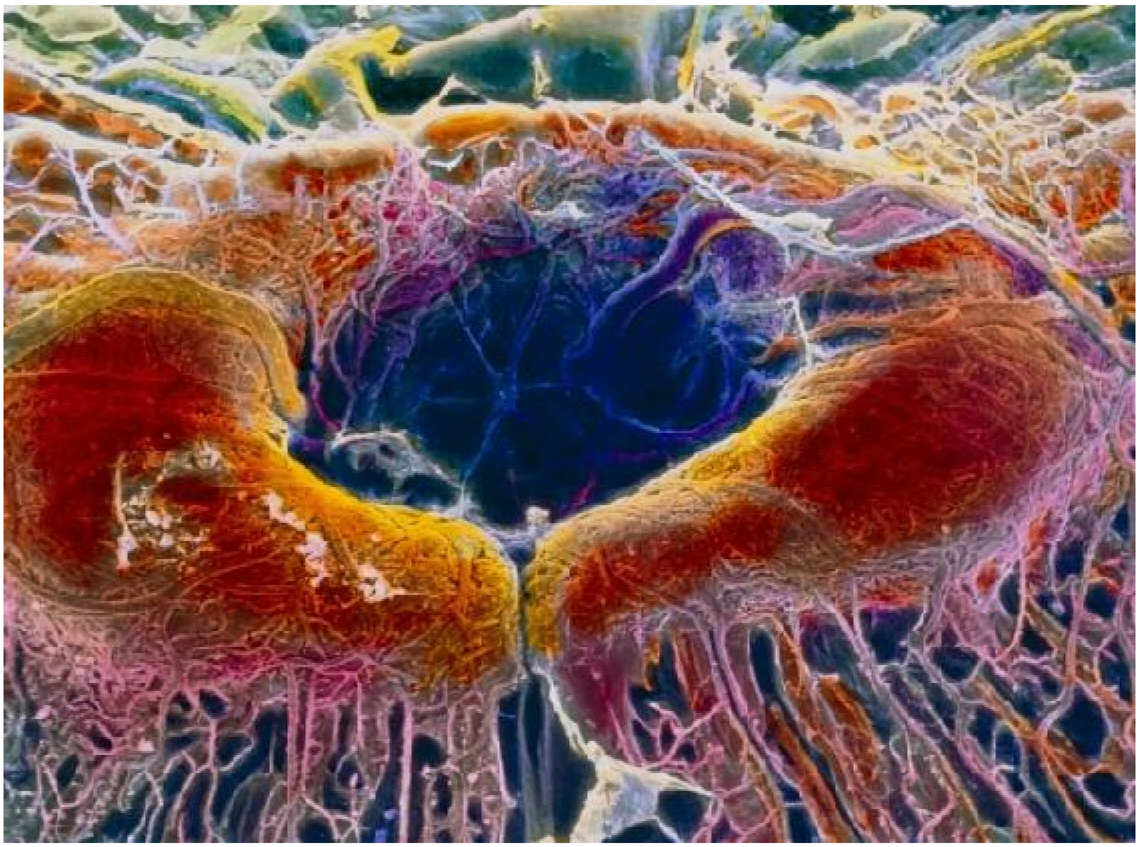
Comments

Commenting is currently unavailable.

FDA advisers back gene therapy for rare form of blindness

Therapy that targets disease-causing mutations could become the first of its kind approved for use in the United States.

12 October 2017



P. Motta/Dept. of Anatomy/University “La Sapienza”, Rome/SPL

The US government is considering whether to approve a gene therapy to prevent the degradation of cells in the retina (shown here in an image from a scanning electron microscope).

Advisers to the US Food and Drug Administration (FDA) have paved the way for the agency's first approval of a gene therapy to treat a disease caused by a genetic mutation.

On 12 October, a panel of external experts unanimously voted that the benefits of the therapy, which treats a form of hereditary blindness, outweigh its risks. The FDA is not required to follow the guidance of its advisers, but it often does. A final decision on the treatment, called voretigene neparvovec (Luxturna), is expected by 12 January.

An approval in the lucrative US drug market would be a validation that gene-therapy researchers have awaited for decades. "It's the first of its kind," says geneticist Mark Kay of Stanford University in California, of the treatment. "Things are beginning to look more promising for gene therapy."

Gene replacement

Luxturna is made by Spark Therapeutics of Philadelphia, Pennsylvania, and is designed to treat individuals who have two mutated copies of a gene called *RPE65*. The mutations impair the eye's ability to respond to light, and ultimately lead to the destruction of photoreceptors in the retina.

The treatment consists of a virus loaded with a normal copy of the *RPE65* gene. The virus is injected into the eye, where the gene is expressed and supplies a normal copy of the RPE65 protein.

In a randomized controlled trial that enrolled 31 people, Spark showed that, on average, patients who received the treatment improved their ability to navigate a special obstacle course[1]. This improvement was sustained for the full year during which the company gathered data. The control group, however, showed no improvement overall. This was enough to convince the FDA advisory committee that the benefits of the therapy outweigh the risks.

Long road

That endorsement is an important vote of confidence for a field that has struggled over the past 20 years. In the early 1990s, gene therapy was red hot, says David Williams, chief scientific officer at Boston Children's Hospital in Massachusetts. "You couldn't keep young people out of the field," he says. "Everyone wanted in." Then came the death of a young patient enrolled in a gene-therapy clinical trial, and the realization that a gene therapy used to treat children with an immune disorder could cause leukaemia.

Investors backed away from gene therapy, and some academics grew scornful of it. Although European regulators approved one such therapy in 2012, for a condition that causes severe pancreatitis, many doubted that it worked. (The company that makes it has announced that it will not renew its licence to market the drug when it expires on 25 October.) "You're too smart to work in this field," a colleague told Kay. "It's a pseudoscience."

But some researchers kept plugging away at the problem, improving the vectors that shuttle genes into human cells. Over time, new clinical trials began to show promise, and pharmaceutical companies became more interested in developing treatments for rare genetic diseases. Gradually, investors returned.

Now, demand for gene-therapy vectors is so high that suppliers are oversubscribed, and researchers have to wait between 18 months and 2 years to get some of the reagents that they need for clinical studies, says Williams.

Measured expectations

In the past few years, gene therapies have shown promise in clinical trials for a range of diseases — including haemophilia, sickle cell disease and an immune disorder called Wiskott–Aldrich syndrome. On 4 October, Williams and his colleagues published results of a gene-therapy trial to treat cerebral adrenoleukodystrophy (ALD), a devastating and sometimes fatal disorder that affects the nervous system and adrenal glands[2]. Disease progression was halted for the roughly 2-year duration of the study in 15 of 17 boys who were treated.

The FDA approved its first gene therapy, a treatment in which immune cells are engineered to combat cancer, on 30 August. Unlike Spark's therapy, the cancer treatment does not target a specific disease-causing mutation, and is administered to immune cells that are removed from the body, engineered and then reinfused.

That is why researchers say that an FDA approval for voretigene neparvovec would be a landmark. "The general concept of gene therapy is replacing or compensating for a missing gene, and that's what this does," says Matthew Porteus, a paediatric haematologist also at Stanford. "People are so excited."

But Spark's treatment also highlights the limitations of this generation of gene therapies. Although the treatment seems to improve vision, it is still unclear how long the virus will continue to express the normal *RPE65* gene — and thus how long its effects will last. "It isn't a cure," says Kay.

Similarly, the cerebral ALD therapy seemed to slow the effects of the disease in the brain, but is not expected to treat symptoms in other parts of the body, which can emerge later in life.

"I think we still need to have major improvements in the technology before we're going to be able to cure these diseases," says Kay. "But along the way there may be treatments that help make improvements."

Journal name:
Nature
Volume:
550,
Pages:
314
Date published:
(19 October 2017)
DOI:
doi:10.1038/nature.2017.22819

Comments

Commenting is currently unavailable.

Nature News

周五, 20 10月 2017

Nature News

[周五, 20 10月 2017]

- **Nature News**

Nature News

Nature is a weekly international journal publishing the finest peer-reviewed research in all fields of science and technology on the basis of its originality, importance, interdisciplinary interest, timeliness, accessibility, elegance and surprising conclusions. Nature also provides rapid, authoritative, insightful and arresting news and interpretation of topical and coming trends affecting science, scientists and the wider public.

- **The Human Cell Atlas: from vision to reality** [周三, 18 10月 08:00]
  As an ambitious project to map all the cells in the human body gets officially under way, Aviv Regev, Sarah Teichmann and colleagues outline some key challenges.
- **Top Chinese university to consider social-media posts in researcher evaluations** [周三, 18 10月 08:00]
  Controversial policy means mainstream media are starting to rival rigorous academic publications in some universities in China.
- **Mysterious particles spotted in Saturn's atmosphere** [周三, 18 10月 08:00]
  Source may be dust shed by planet's iconic rings, according to data from NASA's doomed Cassini probe.
- **Efforts to save leading Hungarian university hit hurdle** [周三, 18 10月 08:00]
  US-registered Central European University faces another year of uncertainty over whether it can continue to operate in Hungary.
- **Sleeping sickness can now be cured with pills** [周三, 18 10月 08:00]
  Researchers seek approval from regulators for this quicker, easier treatment.
- **Self-taught AI is best yet at strategy game Go** [周三, 18 10月 08:00]
  Artificial-intelligence program AlphaGo Zero trained in just days, without any human input.
- **Science must examine the future of work** [周三, 18 10月 08:00]
  As automation changes employment, researchers should gather the evidence to help map the implications.
- **Blue is in the eye of the bee-holder** [周三, 18 10月 08:00]
  Flowers have evolved an ingenious way to attract pollinators.
- **Epic star collision, asteroid fly-by and journal resignations** [周三, 18 10月 08:00]
  The week in science: 13–19 October 2017.
- **New definitions of scientific units are on the horizon** [周三, 18 10月 08:00]
  Metrologists are poised to change how scientists measure the Universe.
- **The future of work** [周三, 18 10月 08:00]

Digital technologies are upending the workforce. The right research can tell us how.

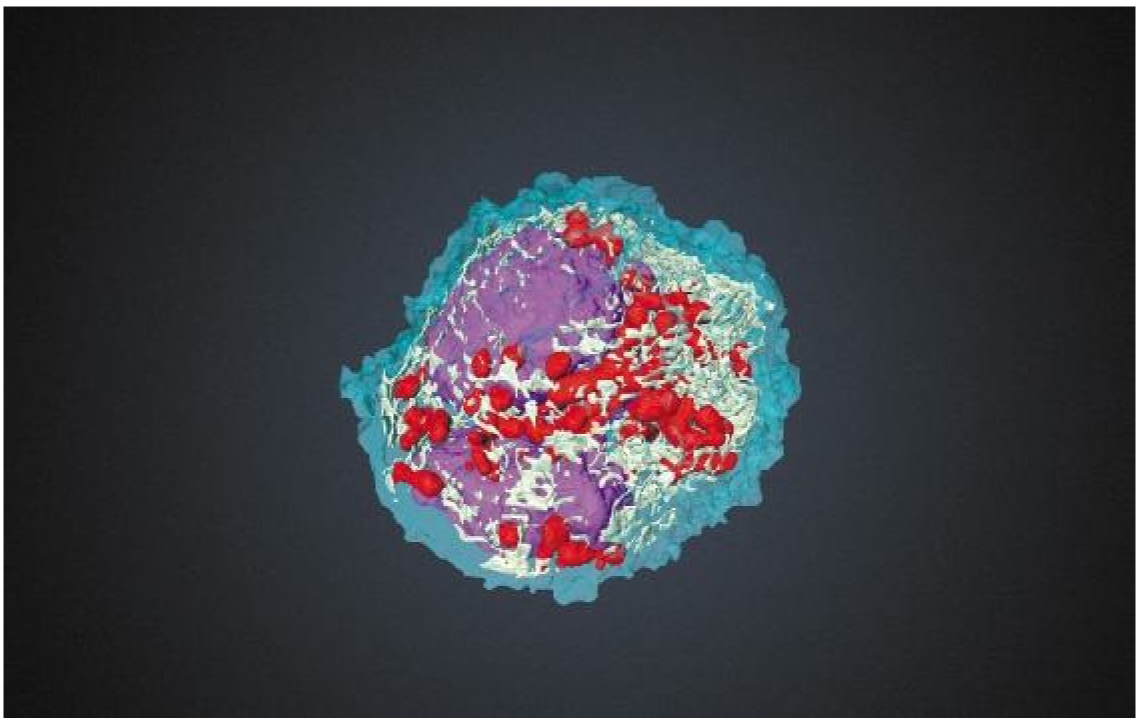
- **[The shape of work to come]** [周三, 18 10月 08:00]
  Three ways that the digital revolution is reshaping workforces around the world.
- **[Lessons from history for the future of work]** [周三, 18 10月 08:00]
  Global comparisons of previous social and economic upheavals suggest that what is to come depends on where you are now, argues Robert C. Allen.
- **[The second Renaissance]** [周三, 18 10月 08:00]
  Ian Goldin calls on scientists to help society to weather the disruptive transformations afoot.
- **[Archaeology: The wonder of the pyramids]** [周三, 18 10月 08:00]
  Andrew Robinson enjoys a volume rounding up research on the complex at Giza, Egypt.
- **[Books in brief]** [周三, 18 10月 08:00]
  Barbara Kiser reviews five of the week's best science picks.
- **[History: Five millennia of Indian science]** [周三, 18 10月 08:00]
  James Poskett applauds a show celebrating discovery on the subcontinent, from zero to the boson.
- **[Federal funding: Stifled by budgets, not irrelevance]** [周三, 18 10月 08:00]
- **[Ornithology: Danish dairy farmer delivers data coup]** [周三, 18 10月 08:00]
- **[Open data: Spot data glitches before publication]** [周三, 18 10月 08:00]
- **[PhD students: living wage key to diversity]** [周三, 18 10月 08:00]
- **[PhD students: side jobs are no solution]** [周三, 18 10月 08:00]
- **[Breaking and entering]** [周三, 18 10月 08:00]
  Escape is not an option.
- **[Brazilian Amazon still plagued by illegal use of natural resources]** [周二, 17 10月 08:00]
  Practices such as poaching and illegal logging are concentrated near inhabited areas and along rivers, study finds.
- **[Give researchers a lifetime word limit]** [周二, 17 10月 08:00]
  Brian C. Martinson imagines how rationing the number of publications a scientist could put out might improve the scientific literature.
- **[Japanese research leaders warn about national science decline]** [周二, 17 10月 08:00]
  Concern mounts over budget cuts and other changes that undermine basic science.
- **[Reboot for the AI revolution]** [周二, 17 10月 08:00]
  As artificial intelligence puts many out of work, we must forge new economic, social and educational systems, argues Yuval Noah Harari.

- **Eye in the sky offers clearest vision of Earth** [周一, 16 10月 08:00]
  The world’s latest carbon-monitoring satellite has advanced our understanding of how the planet functions. US politicians should take note.
- **Colliding stars spark rush to solve cosmic mysteries** [周一, 16 10月 08:00]
  Stellar collision confirms theoretical predictions about the periodic table.
- **Prepare for larger, longer wildfires** [周五, 13 10月 08:00]
  Climate change makes land management more urgent than ever, says Kathie Dello.
- **Global networks of small telescopes will chase companion signals of gravitational waves** [周五, 13 10月 08:00]
  Seeing cosmic events is one thing, but what if you could hear them and taste them, too?

The Human Cell Atlas: from vision to reality

18 October 2017

As an ambitious project to map all the cells in the human body gets officially under way, Aviv Regev, Sarah Teichmann and colleagues outline some key challenges.



Villani, A.-C. ET AL. SCIENCE 356, EAAH453 (2017); image Kathryn White; reconstruction James Fletcher

A new type of human dendritic cell recently discovered using single-cell RNA sequencing.

Our knowledge of the cells that make up the human body, and how they vary

from person to person, or throughout development and in health or disease, is still very limited. This week, a year after project planning began, more than 130 biologists, computational scientists, technologists and clinicians are reconvening in Rehovot, Israel, to kick the Human Cell Atlas initiative[1] into full gear. This international collaboration between hundreds of scientists from dozens of universities and institutes — including the UK Wellcome Trust Sanger Institute, RIKEN in Japan, the Karolinska Institute in Stockholm and the Broad Institute of MIT and Harvard in Cambridge, Massachusetts — aims to create comprehensive reference maps of all human cells as a basis for research, diagnosis, monitoring and treatment.

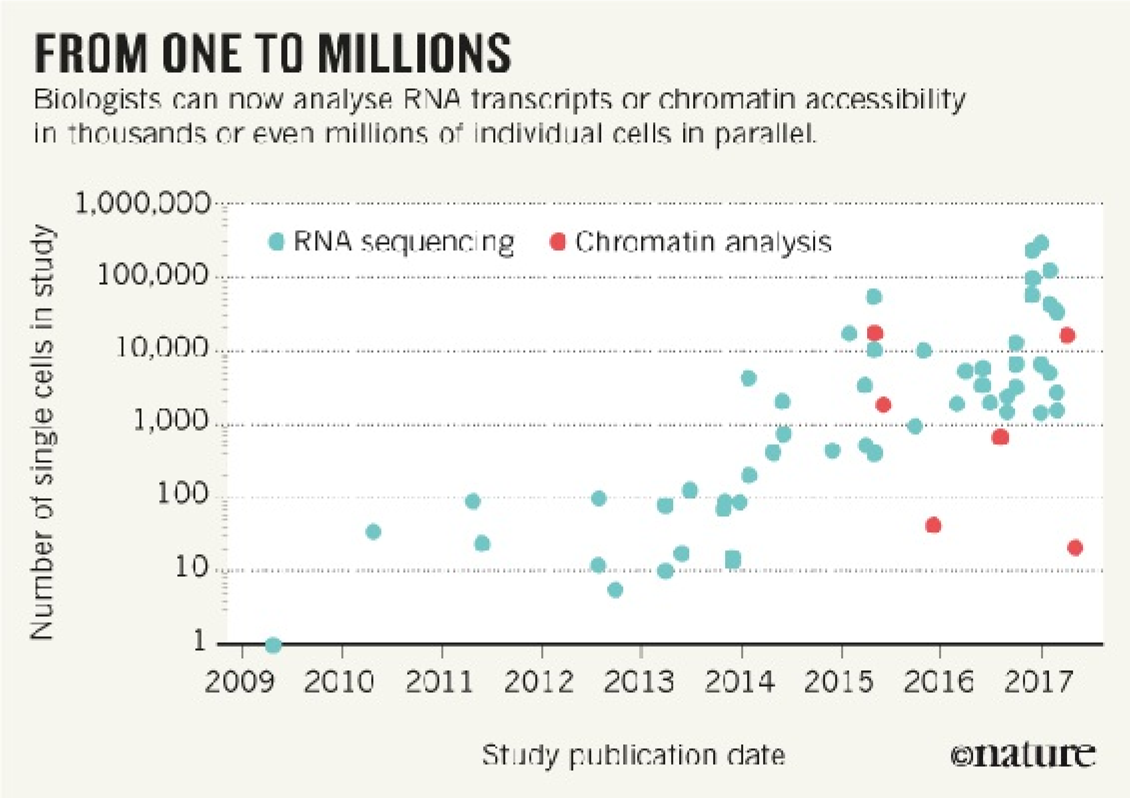
On behalf of the Human Cell Atlas organizing committee, we outline here some of the key challenges faced in building such an atlas — and our proposed strategies. For more details on how the atlas will be built as an open global resource, see the white paper[2] posted on the Human Cell Atlas website.

Cells have been characterized and classified with increasing precision since Robert Hooke first identified them under the microscope in the seventeenth century. But biologists have not yet determined all the molecular constituents of cells, nor have they established how all these constituents are associated with each other in tissues, systems and organs. As a result, there are many cell types we don't know about. We also don't know how all the cells in the body change from one state to another, which other cells they interact with or how they are altered during development.

Technology revolution

New technologies offer an opportunity to build a systematic atlas at unprecedented resolution. These tools range from single-cell RNA sequencing to techniques for assessing a cell's protein molecules and profiling the accessibility of the chromatin. For example, we can now determine the RNA profiles for millions of individual cells in parallel (see 'From one to millions'). Protein composition and chromatin features can be studied in hundreds or thousands of individual cells, and mutations or other markers tracked to reconstruct cell lineages. We can also profile multiple

variants of RNA and proteins *in situ* to map cells and their molecules to their locations in tissues.



Source: Svensson, V., Vento-Tormo, R. & Teichmann, S. A. Preprint at https://arxiv.org/abs/1704.01379 (2017)

We anticipate that the atlas will help researchers to answer key questions in diverse biological fields. In cellular taxonomy, it might enable the discovery and identification of cell types and molecular markers or signatures (a collection of genes, say, that characterize a specific cell type). In histology, it should enable researchers to relate tissue structure to the position of cells and molecules. Developmental biologists will be able to use it to track cell fate and lineage. Physiologists could characterize dynamic states, such as the cell cycle, and transient responses such as a T cell's reaction to a pathogen.

The atlas could also facilitate research on the molecular mechanisms of communication within and between cells. And it should allow biologists to compare cell types across species to better understand human evolution, and

to determine to what extent animal model systems and organoids reflect human biology.

Crucially, the atlas should help researchers to compare healthy reference cells to diseased ones in the relevant tissues — and so facilitate the development of better drugs and more accurate predictions of unintended toxicity. The atlas could also aid regenerative medicine — the process of replacing, engineering or regenerating human cells, tissues or organs to establish normal function. Key diagnostic tests, such as the complete blood count — a routine blood screen that provides crude counts of white blood cells, red blood cells and so on — would become vastly more informative if cell types and states could be identified with much finer granularity. Such information could, for example, help to diagnose blood cancer, autoimmunity or infection before clinical symptoms appear.

Early studies are already showing tremendous potential in all these areas. New cell types have been found in the brain[3–7], gut[8], retina[9] and immune system[10], and these discoveries have yielded new insight — into how the immune system[11] functions, for example, and into the dynamics of tumour ecosystems[12]. Yet, to take the next step — to build a human cell atlas that is truly useful — requires taking the long view and addressing various systemic and organizational challenges, as well as technical and scientific ones.

The challenges

Agree on scope. In light of the enormous complexity of the human body, and the rapid evolution of technologies for probing cells and tissues, and for analysing the data, we plan to build this resource in phases and generate reference maps at increasing resolution as the project progresses.

The first draft of the atlas will profile cells' molecular and spatial characteristics, capturing only those cell types that occur above a pre-specified rarity — ones that make up more than 1% of a sample, say. These cells will be obtained from major tissues from healthy donors, taking into account the genetic diversity, geographical location and person's age. Although disease will not be a focus of the first draft of the atlas, we plan to

look at some disease samples to compare them with healthy cell types.

The first draft will focus on tissues, not whole organs. Extremely rare cells may be missed, and sample sizes may be too small to fully reveal the links between cellular characteristics and human diversity. In later phases, the atlas could take on entire organs, include small cohorts of people (say, 50–60) with diseases of interest, gather bigger sample sizes and provide greater power to associate molecular variation with the underlying genetic diversity. A similar step-wise strategy was deployed in the Human Genome Project; even a partially assembled genome proved immediately useful to researchers, and human genetic variation in health and disease was tackled over several years after the full genome was sequenced.

The atlas will provide an important starting point for functional studies — for instance, those aimed at establishing the mechanistic links between cell states and disease. But such studies are themselves beyond its scope. Again, this parallels what happened with the Human Genome Project: studies of functional elements in the genome, which are ongoing, have relied on the reference sequence obtained through the project.

The atlas will aim to provide a detailed representation of molecules, cells, tissues, organs and systems, allowing researchers to zoom in and out to identify patterns and interactions at various levels of resolution. To this end, those compiling the atlas must establish how many cells to sample, which types of molecular features to analyse, how to assign cells to different categories and how to subdivide those categories. At the spatial level, they must decide how to sample complex anatomies and histologies. Lastly, they need to establish ways of connecting the various layers of cellular and spatial information from different samples to a single anatomical reference by developing what is termed a common coordinate framework.

To ensure the best use of resources, those involved in the initiative must agree on the desired resolution for each phase of the atlas. Researchers could, of course, try to pursue ever-rarer cell types, but potentially at ever-greater expense. In this respect, the Human Cell Atlas will pursue similar approaches to those used in human genetic studies that focus on variants present at a certain frequency. Here, geneticists have begun to tackle increasingly rare variants as technologies have advanced.

Be open and fair. To have maximum impact, the Human Cell Atlas must be an open resource, on many levels.

The project is already open to all interested participants who are committed to its values. Discussions about particular organs, tissues, technologies or computational approaches are running on more than a dozen Slack channels that anyone can join.

Wherever consent agreements allow, atlas data will be made publicly available in an open-source data-coordination platform as soon as possible, after they have been collected and have passed quality-control checks. All standards established to ensure the production of high-quality data, and any updates to those standards, will also be shared. The same goes for new technologies and computational methods resulting from the project.

Atlas data and analysis products will exist in multiple public clouds (currently, those hosted by Google, Amazon and Microsoft) to ensure that people with different preferred cloud environments can access them. Because computation will happen in the cloud, individual researchers will not need to download and store all the data or have access to their own high-performance computing power. Finally, in addition to the continual release of data and periodic formal data releases, publications interpreting the data will help to establish standardized approaches and disseminate the insights and value that can be gained from them.

As much as possible, the atlas must reflect the diversity of humans and human experience. The broad distribution of participating researchers, institutions and countries involved in the initiative will, in itself, help to ensure tissue diversity. The initiative currently includes members from 5 continents and more than 18 countries, including Japan, Israel, South Africa, China, India, Singapore, Canada and Australia.

Getting appropriate consent agreements and fostering public trust from the outset will also help efforts to obtain sufficient geographical, gender, age and genetic diversity in sampling. As part of the global initiative, an ethics working group will establish how best to obtain informed consent from sample donors, how the terms of that consent can be adhered to and how to protect the privacy of participants and donors appropriately. Various existing

projects involving human samples, such as the public-research project ENCODE (the Encyclopedia of DNA Elements), which aims to identify all the functional elements of the human genome, can provide guidance on this.

Procure samples appropriately. Obtaining tissue samples using standardized procedures, with appropriate consent and in a way that enables other researchers to know exactly where the sample came from is a complex endeavour. To access the diversity of human tissues needed, researchers will work with both fresh tissue from live donors and specimens obtained postmortem or from transplant organ donors.

We plan to learn from, and build on, pre-existing reliable procurement processes. Examples include those used in the Genotype-Tissue Expression Project (GTEx, a database and tissue bank designed to help researchers to gain insight into the mechanisms of gene regulation in humans) and the Cambridge Biorepository for Translational Medicine, a resource for multidisciplinary research projects for which fresh tissue is required.

Organize effectively. The Human Cell Atlas consortium is built on four distinct and interconnected pillars. Collaborative biological networks involve experts in biological systems or organs as well as in genomics, computation and engineering, working together to build maps of each tissue, system or organ. Several biological-network pilot projects have been formulated through grass-roots efforts in the Human Cell Atlas community. As well as revealing new biology and helping to build a collaborative international network, these activities are informing the community about how to structure sampling and conduct analyses for a full-scale cell atlas.

A technical forum involving genomics experts, imaging specialists and biotechnologists, is developing new technologies, and testing, comparing and disseminating existing ones. A data-coordination platform is being designed to bring researchers to the data by developing the software to upload, store, process and serve data. The platform also provides an open environment in which computational methods and algorithms developed by any interested group can be shared. Finally, an analysis garden involves computational biologists working together to develop sophisticated techniques for data mining and interpretation.

Activities across all areas are currently governed by a scientific steering group, the Human Cell Atlas organizing committee. Co-chaired by two of us (A. R. and S. A. T.), this includes 27 scientists from 10 countries and diverse areas of expertise. The committee establishes working groups (about 5 so far, consisting of about 5 to 15 members each) that tackle specific key areas. For instance, an analysis working group is crafting best practices for computational analysis through a community-wide process, including workshops and jamborees. The committee governs the data-coordination platform, including making all policy decisions and approving its overall plan.

Join the effort

Having a catalogue of genes at our fingertips has transformed research in human biology and disease. Similarly, we believe that the Human Cell Atlas will catalyse progress in biology and medicine. Descriptors such as 'cell type' and 'cell state' can be difficult to define at the moment. An integrative, systematic effort by many teams of scientists working together and bringing different expertise to the problem could dramatically sharpen our terminology, and revolutionize the way we see our cells, tissues and organs. We invite you to join the effort.

Journal name:
Nature
DOI:
doi:10.1038/550451a

Supplementary information

PDF files

1. HCA organizing committee (61K)

Comments

Comments

There are currently no comments.

Top Chinese university to consider social-media posts in researcher evaluations

Controversial policy means mainstream media are starting to rival rigorous academic publications in some universities in China.

18 October 2017

Wang Zhao/AFP/Getty

News articles written by researchers at some Chinese universities will now be considered in evaluations.

One of China's most prestigious universities plans to give some articles in

newspapers and posts on major social-media outlets the same weight as peer-reviewed publications when it evaluates researchers.

The policy has sparked a vigorous debate among Chinese academics. Proponents say it will encourage researchers to engage with the public, but many are concerned that it will promote those who toe the party line established by China’s strictly censored media and social media, at the expense of more highly qualified researchers. Critics also say the system could be manipulated to inflate a researcher’s impact, for example by artificially boosting page views.

Zhejiang University in Hangzhou announced the policy on its WeChat page on 15 September, saying that it would mainly apply to the humanities and social sciences. But Chinese researchers say the move could influence science as well, by giving a hiring and promotion advantage to politically minded scientists.

“You do not need to be good scientist, you do not need to publish good science papers,” says one biologist at a prominent Beijing-based university who requested anonymity. He is concerned that the policy could alter evaluations at China’s main grant agency, the National Natural Science Foundation of China (NSFC). “If they open the Pandora’s box, the NSFC might change its policy as well,” he says. The agency's head, Yang Wei, says it will do no such thing. NSFC grants are given solely “according to the judgement of peer reviewers”, he says.

Viewing figures

The Zhejiang policy sets specific criteria: articles have to be original, written by the researcher and at least 1,000 words long; they need to be picked up by major news outlets and widely disseminated through social media; and they need to have been seen by a large number of people. The policy requires an article to be viewed more than 100,000 times on WeChat, China’s most popular instant-messaging service, or 400,000 times on news aggregators such as Toutiao. Articles that meet the criteria will be considered publications, alongside papers in peer-reviewed journals.

The university has also established a publication hierarchy, with official media outlets such as the *People's Daily* considered most important, regional newspapers and magazines occupying a second tier, and online news sites such as Sina, NetEase or Sohu ranking third.

Ping Fu, who researches library science at Central Washington University in Ellensburg, is concerned that the policy will blur the distinction between peer-reviewed academic publications and popular writing. This could affect the top levels of scholarship in China, he says. Liu Jin-ping, a biologist at Hainan University in Haikou, also worries that the policy will give prominence to stories that “flatter the government”. Some academics will aim to “become Internet stars” so they can be promoted, he wrote on his blog.

Full credit

Lin Boqiang, an energy-policy and climate-change researcher at Xiamen University who has published some 800 media commentaries, thinks researchers should get credit for this work. He “criticizes government policy all the time” and would never write something incorrect to please political powers, he says: “Our reputation is on the line.”

But both Liu and Lin are concerned the system could be gamed, either for self-interest or with political motivation. Lin says these articles should not be considered equal to academic publications. “Other universities will do this,” he says. “I hope they do it in a more sophisticated way.”

Zhejiang University refused to answer *Nature*'s questions about the policy, but it posted a statement on its homepage in response to the controversy, saying that the commentaries in the mainstream media will supplement and not replace peer-reviewed journals: “This policy is to explore more forms of exposure of research, especially for humanities and social sciences, and the assessment will be made by a strict panel review, which will not lower the academic standard.”

Grant committees in other countries encourage researchers to do public outreach, but the Zhejiang policy is rare in how it ranks such efforts for

researcher evaluation. Jilin University in Changchun announced a similar policy in August.

Balancing act

Glen Peters, a climate-policy researcher at the Center for International Climate Research in Oslo, agrees that researchers should be acknowledged for important contributions to public understanding, but he says the challenge in giving scientists credit for public outreach is how to measure its quality and impact against those of conventional journal publications. “If you don’t get the weighting right, then incentives could be perverted and lead to bad outcomes, such as poor quality and political bias,” he says. “The potential is high, but so are the risks.”

One journalist at China’s *Legal Daily* has questioned whether such a policy is legal. It was drafted by the university’s propaganda department, part of the Communist Party of China. According to the laws that govern universities, evaluation decisions are supposed to be made by university administrative departments or faculty committees, writes the journalist.

Some scientists contacted by *Nature* are confident that this initiative will not affect science. But others see it as part of the government’s attempts to control information. There is already concern about Chinese President Xi Jinping’s efforts to align education with communist values and to control what is written by journalists or on social media. Scientists say that bans on Google, Google Scholar and other Internet-based technologies hamper their ability to stay in touch with international peers. “There are certainly many layers of concern,” says one environmental scientist who did not want to be named for fear of damaging relationships with Chinese colleagues.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22822

Comments

Commenting is currently unavailable.

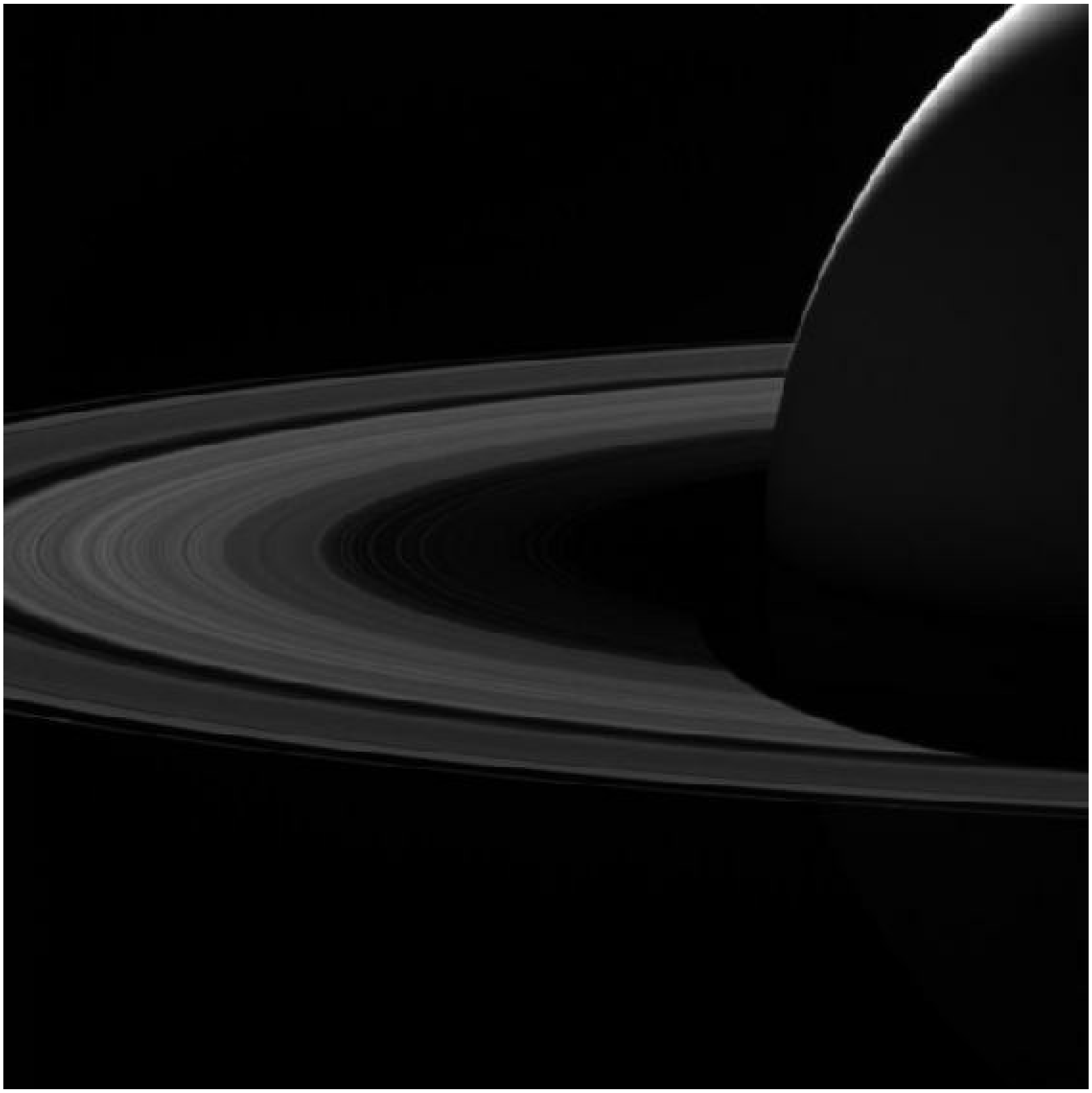
| 章节菜单 | 主菜单 |

Mysterious particles spotted in Saturn’s atmosphere

Source may be dust shed by planet’s iconic rings, according to data from NASA's doomed Cassini probe.

18 October 2017

Provo, Utah



NASA/JPL-Caltech/SSI

Saturn's rings are made of whirling bands of ice and dust.

NASA's Cassini spacecraft continues to yield surprising discoveries, more than a month after it burned up on its mission-ending dive into Saturn. New data from the probe suggest that Saturn's majestic rings are showering tiny dust particles into the planet's upper atmosphere, where they form a complicated and unexpected chemical mix.

A mass spectrometer aboard Cassini detected the strange chemistry as the

probe spent its final five months looping between Saturn and its rings.

“We really hit the jackpot,” said Mark Perry, a planetary scientist at the Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland. He reported the findings on 17 October at a meeting of the American Astronomical Society’s Division for Planetary Sciences in Provo, Utah.

Mission scientists had expected Cassini's mass spectrometer to spot the signature of water molecules as the spacecraft slipped between the planet and its rings. In the 1970s and 1980s, NASA's Pioneer and Voyager missions found fewer charged particles than expected in Saturn’s uppermost atmosphere. On the basis of those data, researchers proposed in 1984 that water molecules coming off the rings — mostly in the form of ice — act as catalysts to strip charged particles from the atmosphere[1]. Cassini's final months gave scientists their first opportunity to test this idea directly.

Chemical surprise

But it wasn't evidence of water that jumped out at Cassini's science team. Data from the mass spectrometer revealed a witch’s brew of chemicals, including methane, a molecule that could be carbon monoxide and more-complex molecules. The concentrations of these chemicals are greatest around Saturn’s equator and at high altitudes, which suggests that the material is shedding off the planet’s rings.

The deeper the probe went into the atmosphere, the stranger the measurements became. Cassini’s closest swings past Saturn's surface revealed a panopoly of heavy molecules, Perry told conference attendees. The scientists have not yet pinpointed each type of molecule, but clearly, there is much more than just water around.

By analysing the types of material that could be coming off the rings, Perry’s team concluded that the debris must be fragments of tiny dust particles, which measure just 1 to 10 nanometres across but are relatively heavy. When these particles spiralled off the rings and slammed into Cassini’s mass spectrometer, they shattered into smaller pieces.

Exactly how those particles make the journey from the rings to the atmosphere remains to be seen. “We have a lot of work to do to understand how they are getting in there,” Perry said. “None of the models predict this.”

On these final plunges, pulled along by Saturn’s gravity, Cassini was zooming along at more than 30 kilometres per second — a speed more than four times greater than the mass spectrometer was designed to withstand. “These are higher speeds than anything it has ever seen,” noted Linda Spilker, a planetary scientist at the Jet Propulsion Laboratory in Pasadena, California, and Cassini’s project scientist.

At such enormous speeds, anything that Cassini rammed into would have splintered into bits.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22838

Comments

Comments

There are currently no comments.

Efforts to save leading Hungarian university hit hurdle

US-registered Central European University faces another year of uncertainty over whether it can continue to operate in Hungary.

18 October 2017

Ferenc Isza/AFP/Getty Images

A sudden change to Hungarian higher-education law in April led to widespread protests.

The threatened Central European University (CEU) in Budapest has been dealt a blow in its efforts to avert possible closure in Hungary.

The country’s parliament voted on 17 October to postpone for a year a

decision that would allow the university to keep operating there. At a press conference held by the university shortly after the vote, CEU rector Michael Ignatieff called the delay “unacceptable” and “unnecessary”.

In April, the Hungarian government unexpectedly amended its higher-education law to require that all foreign-accredited universities there had to operate as higher-education institutes in their countries of origin by 1 January 2018.

The change drew protests and was widely believed to be politically motivated. Critics saw it as an attack on billionaire philanthropist George Soros, who founded the university in 1991 and has openly criticized Hungary’s strict refugee policies.

The CEU took steps to comply with the new requirements and on 3 October sealed an agreement with Bard College in Annandale-on-Hudson, New York, to provide educational activities there. Accredited courses run jointly by the universities would be launched next year, the CEU said. The agreement still needs to be signed by the Hungarian government and ratified by the country’s parliament.

But on 16 October the government proposed delaying the implementation of the amendment until 1 January 2019, and the parliament approved the delay the next day.

A government spokesperson told *Nature* that the purpose of the delay was to give other foreign higher-education institutions time to comply with the new requirements, adding that three institutions, including the CEU, are still in negotiation.

Zoltan Balogh, Hungary’s minister for human capacity, suggested on 16 October that government sign-off of the CEU’s agreement might have to wait for the new deadline.

“We are being deliberately kept in legal limbo,” said Ignatieff, who fears the uncertainty will make it hard to retain faculty and recruit students. “We are being slowly strangled in this battle for academic freedom.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22855

Comments

Comments

There are currently no comments.

| 章节菜单 | 主菜单 |

Sleeping sickness can now be cured with pills

Researchers seek approval from regulators for this quicker, easier treatment.

18 October 2017

Neil Brandvold

Health workers screen people in a remote village in the Democratic Repulic of the Congo for sleeping sickness.

For the first time, researchers have cured the deadly neurological disease sleeping sickness using pills instead of a combination of intravenous infusions and pills. The investigators presented the results from final clinical trials on 17 October at the European Congress on Tropical Medicine and

International Health in Antwerp, Belgium, providing hope that the treatment will help to eliminate the malady within a decade.

The oral therapy — called fexinidazole — cured 91% of people with severe sleeping sickness, compared with 98% who were treated with the combination therapy. It also cured 99% of people in an early stage of the disease who would typically undergo a spinal tap to determine whether they needed infusions. The relative ease of the treatment with fexinidazole means that if approved, it might save more lives than the current option, say the investigators leading the phase 3 trial, the final phase of testing before the drug goes to regulators for approval.

Sleeping sickness is endemic to Africa and generally infects extremely poor people who live in remote regions. The sick often suffer from the disease for years before seeking treatment, causing them and those caring for them to miss work and spend their savings on traditional medicines. Trekking to a hospital and remaining there for intravenous infusions is costly as well.

“It’s not just the person with sleeping sickness, it’s the family that takes care of them during years of this neurological, very serious disease,” says Philippe Büscher, a sleeping-sickness specialist at the Institute of Tropical Medicine in Antwerp, Belgium, who was not involved in the study. “Whatever money they have, they’ll spend on this instead of anything else.”

Büscher commends the team for conducting a quality clinical trial under extraordinary circumstances in countries hit hardest by the disease, the Democratic Republic of the Congo and the Central African Republic. Investigators had to carry equipment to remote clinics over rugged terrain; one study site was repeatedly robbed; and early on in the trial, some participants fled armed conflict. “I need to congratulate them for beautiful work,” Büscher says.

Neil Brandvold

The hospital where Pablo Loela was being treated for sleeping sickness canno afford to provide food for their patients: families must provide meals for their loved ones.

A better way

Sleeping sickness — also known as human African trypanosomiasis — is spread through the bite of tsetse flies carrying parasites, most commonly *Trypanosoma brucei gambiense*. The organism infects the central nervous system, and patients can experience confusion, daytime sleepiness, night-time insomnia and various psychiatric symptoms, including manic episodes and aggression. If left untreated, they enter a coma and die. For decades, the only treatment was a toxic arsenic-based drug that killed one in 20 patients.

In 2009, researchers introduced a safer option: nifurtimox–eflornithine combination therapy, or NECT, which consists of pills and 14 intravenous

infusions. For the first time in 50 years, the incidence of sleeping sickness slipped below 10,000 new cases per year; it’s currently around 2,200, according to the World Health Organization. But the need for infusions, along with the spinal tap required to qualify a patient for the treatment, still present obstacles in regions where sterile equipment, electricity and doctors are in short supply.

The group that developed NECT — a non-profit research organization based in Geneva, Switzerland, called the Drugs for Neglected Diseases initiative (DNDi) — continued searching for a better therapy. In 2007, it discovered fexinidazole, a compound that had been shelved by Paris-based pharmaceutical company Sanofi. With the firm's agreement, the DNDi took the drug through clinical trials. It estimates that developing the therapy through to approval will cost a total of around US$50 million — a fraction of what pharmaceutical companies often spend on new drugs.

Just the beginning

Sanofi will soon submit an application for drug approval through the European Medicines Agency, whose sign-off could pave the way for regulators in the Democratic Republic of the Congo. The drug might get a green light by the end of next year, says Nathalie Strub Wourgraft, the DNDi’s medical director. Because it is a simple oral treatment, she suggests that patients might even be treated at home, which would save them and their families the expense of hospital stays.

However, Büscher argues that home treatments could be dangerous because people who don’t respond to fexinidazole could die of the disease if not seen immediately by medical staff. It’s imperative that patients follow up with health workers, he says, and he suggests offering people incentives to return to the clinic, such as money or staples including salt or sorghum. “This is a success,” he says, “but it is not the end.”

DNDi researchers and their colleagues are currently working on what they hope will be an even better oral treatment to cure the disease in a single dose, and more reliably than fexinidazole.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22856

Comments

Commenting is currently unavailable.

Self-taught AI is best yet at strategy game Go

Artificial-intelligence program AlphaGo Zero trained in just days, without any human input.

18 October 2017

Xavierarnau/Getty

AlphaGo Zero came up with Go strategies that human players haven't invented in thousands of years.

An artificial intelligence (AI) program from Google-owned company DeepMind has reached superhuman level at the strategy game Go — without learning from any human moves.

This ability to self-train without human input is a crucial step towards the dream of creating a general AI that can tackle any task. In the nearer-term, though, it could enable programs to take on scientific challenges such as protein folding or materials research, said DeepMind chief executive Demis Hassabis at a press briefing. “We’re quite excited because we think this is now good enough to make some real progress on some real problems.”

Previous Go-playing computers developed by DeepMind, which is based in London, began by training on more than 100,000 human games played by experts. The latest program, known as AlphaGo Zero, instead starts from scratch using random moves, and learns by playing against itself. After 40 days of training and 30 million games, the AI was able to beat the world's previous best 'player' — another DeepMind AI known as AlphaGo Master. The results are published today in *Nature*[1], with an accompanying commentary[2].

Getting this technique, known as reinforcement learning, to work well is difficult and resource-intensive, says Oren Etzioni, chief executive of the Allen Institute for Artificial Intelligence in Seattle, Washington. That the team could build such an algorithm that surpassed previous versions using less training time and computer power “is nothing short of amazing”, he adds.

Strategy supremo

The ancient Chinese game of Go involves placing black and white stones on a board to control territory. Like its predecessors, AlphaGo Zero uses a deep neural network — a type of AI inspired by the structure of the brain — to learn abstract concepts from the boards. Told only the rules of the game, it learns by trial and error, feeding back information on what worked to improve itself after each game.

At first, AlphaGo Zero’s learning mirrored that of human players. It started off trying greedily to capture stones, as beginners often do, but after three days it had mastered complex tactics used by human experts. “You see it rediscovering the thousands of years of human knowledge,” said Hassabis.

After 40 days, the program had found plays unknown to humans (see 'Discovering new knowledge').

Discovering New Knowledge

Deepmind

Approaches using purely reinforcement learning have struggled in AI because ability does not always progress consistently, said David Silver, a scientist at DeepMind who has been leading the development of AlphaGo, at the briefing. Bots often beat their predecessor, but forget how to beat earlier versions of themselves. This is the project's first "really stable, solid version of reinforcement learning, that’s able to learn completely from scratch," he said.

AlphaGo Zero’s predecessors used two separate neural networks: one to predict the probable best moves, and one to evaluate, out of those moves, which was most likely to win. To do the latter, they used ‘roll outs’ — playing multiple fast and randomized games to test possible outcomes. AlphaGo Zero, however, uses a single neural network. Instead of exploring possible outcomes from each position, it simply asks the network to predict a winner. This is like asking an expert to make a prediction, rather than relying on the games of 100 weak players, said Silver. “We’d much rather trust the predictions of that one strong expert.”

Merging these functions into a single neural network made the algorithm both stronger and much more efficient, said Silver. It still required a huge amount of computing power — four of the specialized chips called tensor processing units, which Hassabis estimated to be US$25 million of hardware. But its predecessors used ten times that number. It also trained itself in days, rather than months. The implication is that “algorithms matter much more than either computing or data available”, said Silver.

Think outside the board

Several DeepMind researchers have already moved from working on AlphaGo to applying similar techniques to practical applications, said Hassabis. One promising area, he suggested, is understanding how proteins fold, an essential tool for drug discovery.

Generating examples of protein folding can involve years of painstaking crystallography, so there are few data to learn from, and there are too many possible solutions to predict structures from amino-acid sequences using a brute-force search. The puzzle shares some key features with Go, however. Both involve well-known rules and have a well-described goal. In the longer term, such algorithms might be applied to similar tasks in quantum chemistry, materials design and robotics.

Silver acknowledged that to apply its approach to real-world tasks more generally, the AI will need the ability to learn from smaller amounts of data and experience. Another essential step will be learning the rules of a game for itself, as another DeepMind bot did in 2015 for arcade games. Hassabis reckons this is something AlphaGo Zero could eventually do: “We’re pretty sure it would work, it would just extend the learning time a lot,” he said.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22858

Comments

Comments

There are currently no comments.

Science must examine the future of work

As automation changes employment, researchers should gather the evidence to help map the implications.

18 October 2017

VCG/Getty

Automation will take away jobs, but a bigger question is how many it will generate.

In 2014, the *Los Angeles Times* began beating its rivals to report earthquakes, using an algorithm to convert announcements from the US Geological Survey

(USGS) to breaking news within a few minutes. This June, it announced that a magnitude-6.8 quake had shaken Santa Barbara, California. That was certainly news to the distinctly unshaken residents of Santa Barbara; the earthquake the newspaper was reporting on had actually happened in 1925. The paper's Quakebot had misinterpreted an update to the USGS seismic database and published its story online without anyone checking. The story was deleted and Santa Barbarans (and human journalists everywhere) could breathe a sigh of relief.

The tale encapsulates many of the issues that surround the intensifying debate about the roles of computers and humans in the workplace of the future — both the very near and the very far. Much of that debate places people and algorithms in direct competition. From lorry drivers threatened by self-driving vehicles to doctors who could be replaced by know-it-all diagnostic devices, many jobs as we know them could be done by artificial intelligence (AI) systems.

In an Editorial last year on the likely role and risks of AI in future society, *Nature* noted that even academic debate on the topic is polarized between sceptics and fanciful futurists (see *Nature* **532,** 413; 2016). In a special issue this week, we try to find and explore some middle ground, by bringing together and assessing the evidence on how automation will affect the future of work.

In a sense, this debate is nothing new. Technology and automation have been putting people out of jobs for hundreds of years, as historian Robert Allen discusses in a Comment. So have other factors — chiefly economic trends and globalization. But the spread of technology has also created new roles. In broad terms, as manufacturing jobs in the West have been transferred to low-wage economies elsewhere, politicians and economists have looked to tech to help fill the gap. These new industries, they argue, both need direct labour to develop them and create employment indirectly through the need for service and support. But will this trend continue? The true debate over the future of work is not whether computers will replace people in many jobs — they surely will — but whether they are team players. For how long will Quakebot and its descendants need a human supervisor?

Both sceptics and fanciful futurists will find something to agree and disagree

with in the articles that follow. In a Comment, Yuval Noah Harari, historian and best-selling author of *Sapiens* (Harper, 2014) and *Homo Deus* (Harvill Secker, 2015), argues: “The challenges posed in the twenty-first century by the merger of infotech and biotech are arguably bigger than those thrown up by steam engines, railways, electricity and fossil fuels.” He also offers reassurance about job prospects for some people, from a perhaps unlikely source. Each US military drone flying over Syria keeps 110 people in a job, he writes — 30 operators and 80 analysts to process the information it sends back. This is not an argument for more drones, the use of which is controversial. But, as Harari writes: “A careful study of the military job market might tell us a lot about potential future developments in the civilian economy.”

Careful study, *Nature* naturally argues, is something that (human) scientists and other academics excel at. As the 2016 editorial put it, “it is crucial that progress in technology is matched by solid, well-funded research to anticipate the scenarios it could bring about”, such as impacts on mental health and management, and how humans interact with robots. It’s important, too, to study possible political and economic reforms that will allow those usurped by machinery to contribute to society.

The Oxford Martin Programme on Technology and Employment at the University of Oxford, UK, is doing just this (see go.nature.com/2xxauvm). Oxford economist Ian Goldin offers his own thoughts.

Among the topics worthy of examination is the future fate of science and scientists. So far, the application of technology and automation to research has fuelled, and not felled, the need for human support. Indeed, fields such as bioinformatics exist only because of the work that computers generate for scientists. But as explored in a Careers Feature, science is not immune from the gig economy — short-term employment on specialist tasks such as writing a literature review or managing a database. The trend towards parcelling off and even publishing science as a series of steps rather than full papers could see demand for freelance services rise. (The breakdown of complex tasks into a series of simpler steps is, of course, also a proven path to automation.)

Still, browse ‘help needed’ adverts for scientific gigs and the future looks less

rosy. As little as US$80 to perform a detailed meta-analysis of published studies? It’s hardly worth even plugging in for that.

Journal name:
Nature
Volume:
550,
Pages:
301–302
Date published:
(19 October 2017)
DOI:
doi:10.1038/550301b

Comments

Comments

There are currently no comments.

| 章节菜单 | 主菜单 |

Blue is in the eye of the bee-holder

Flowers have evolved an ingenious way to attract pollinators.

18 October 2017

Ron Reznick/VW Pics/UIG via Getty Images

Nanostructures on flowers generate a blue halo that attracts bees.

The car maker Lexus announced a new paint job for its LC coupé this month, which it says will appeal to drivers who value the interaction of science and craftsmanship. The car is blue and the science it leans on is the optics of iridescence. Lexus says that it uses several layers of pigment to increase the amount of incoming light that reflects as blue. The finish, it claims, is “more blue” than anything seen before — and more time-consuming to apply. People who buy the model are unlikely to suffer that common psychological

bias experienced by owners of a new car who suddenly notice other vehicles everywhere the same colour as theirs: at present, the company can make just two a day.

Lexus says that its new blue is based on the famous wings of the morpho butterfly. These contain no pigment, but look blue because of how the wing structure physically separates the various components of white light and reflects only certain wavelengths. The company could also have borrowed the idea from the (less PR friendly) tarantula spider, many species of which use the hairs on their legs and body to show off the same blue effect. In fact, such iridescence is fairly common in plants and animals — sometimes deliberate (the shimmer of the peacock tail) and sometimes less so (the same effect from a fresh cut of meat). It's why a blue-cooked steak really does look blue. blue pigments are rare), and this week a paper online in *Nature* explores its role in flowering plants (E. Moyroud *et al. Nature* http://dx.doi.org/10.1038/nature24285; 2017).

Fewer than 10% of the 280,000 species of flowering plant naturally produce blue petals. This presents a problem, because the bees on which many flowers rely for pollination struggle to see any colour other than blue. So how do these flowers attract the insects they need?

The new study shows that they use structural-colour techniques to generate an iridescent blue halo. From the tulip to the golden perennial sweet pea, a dozen different flowering plants of varying colours were found to have surface nanostructures that produced the optical effect. It's visible to the human eye, too, and best seen against dark-coloured petals.

In a series of tests with bumblebees (*Bombus terrestris*), the researchers demonstrate that the insects avoid artificial flowers made to have smooth surfaces that don't produce the blue ring. And they show how the insects see the halo more easily than we do, because bee vision can better distinguish the ultraviolet frequencies into which the structural-colour effect spreads. The findings are discussed in an accompanying News & Views article (D. D. Deheyn *Nature* http://dx.doi.org/10.1038/nature24155; 2017).

Lexus boasts that it took more than a decade to develop its new blue paint. It took the flowers a lot longer: their ability to generate the halo effect has

evolved over millions of years, and perhaps emerged in each species independently. In both cases, the colour is best appreciated at first hand. Photographs do not do it justice. Take a stroll in the garden. And keep one eye on the road.

Journal name:
Nature
Volume:
550,
Pages:
302
Date published:
(19 October 2017)
DOI:
doi:10.1038/550302a

Comments

Comments

There are currently no comments.

Epic star collision, asteroid fly-by and journal resignations

The week in science: 13–19 October 2017.

18 October 2017

Events | People | Research | Facilities | Policy | Awards | Funding | Trend watch

EVENTS

Flames devastate northern California Wildfires have scorched about 890 square kilometres in Northern California, leaving at least 41 people dead as of 17 October, making them the deadliest fires in the state's history. Nearly 100,000 residents of Napa and Sonoma Counties had been evacuated from their homes, although this week officials have started to let people return. At least 88 of the many hundreds of people who were reported missing are still unaccounted for. The exact cause of the flames is unknown, but the area was primed for a conflagration. Vegetation flourished in the region after record rainfall last winter, and heatwaves this summer dried everything out, turning it into kindling. Winds gusting at more than 100 kilometres per hour hindered the efforts of firefighters to bring the blazes under control.

Justin Sullivan/Getty

Journal editors quit Five German scientists said on 12 October that they have resigned their editorial positions at journals published by Elsevier, after negotiations over a national licensing agreement for German institutes ground to a halt. For more than a year, a consortium of German science organizations called Projekt DEAL has been pushing for a new type of nationwide licence with Elsevier that would include open-access options and replace the need for individual institutional subscriptions. About 200 German universities and research institutes have cancelled their individual contracts with the Dutch publisher.

Asteroid buzz A house-sized asteroid whizzed by Earth on 12 October, passing within 44,000 kilometres of the planet — just above the orbits of geostationary satellites — and providing a test of international planetary defences. Telescopes around the globe swivelled to track the body, which is estimated to be 15–30 metres wide and is known as 2012 TC4. NASA, the European Space Agency and other asteroid-hunting groups gathered data to fine-tune orbital calculations and establish its future path. The asteroid's next

close pass will be in 2050, when it will safely fly by Earth. Future Earth impacts after that date have not been ruled out.

PEOPLE

Trump nominations Barry Myers, the chief executive of weather-forecasting firm AccuWeather, is US President Donald Trump's pick to lead the National Oceanic and Atmospheric Administration (NOAA), the White House said on 11 October. Myers, an attorney by training, has led AccuWeather — based in State College, Pennsylvania — since 2007. Some scientists worry that his ties to the company could lead to conflicts of interest, and note that he has no direct experience with NOAA's broader research portfolio, which includes the climate, oceans and fisheries. Two days later, the White House announced that Trump had nominated Kathleen Hartnett White, a former Texas environmental regulator and prominent climate sceptic, for its top environmental post. If confirmed as chair of the Council on Environmental Quality, White would advise the president and coordinate federal policies on energy and the environment. White is a fellow at the Texas Public Policy Foundation, a conservative think tank based in Austin. She has called efforts to shift away from fossil fuels "environmental lunacy".

New Pasteur chief Stewart Cole was appointed on 13 October as the next president of the Pasteur Institute in Paris, replacing Christian Bréchot, who had reached the institute's mandated retirement age. Many of the Pasteur's researchers had wanted Bréchot to stay on, but a campaign to change the age-limit rule was unsuccessful. Cole, a microbial-pathogenesis specialist, has held several posts at the biomedical research institute and will begin his four-year term in January. Last month, Bréchot was appointed president of the Global Virus Network, an international coalition of virologists based in Baltimore, Maryland.

RESEARCH

Epic stellar clash Researchers announced on 16 October that they had for the first time witnessed the collision of two neutron stars — and perhaps the

subsequent formation of a black hole. The event was first spotted on 17 August by gravitational-wave detectors in the United States and Italy and by a NASA γ-ray probe. More than 70 observatories rushed to observe the collision's aftermath; their discoveries are detailed in dozens of papers and solve several cosmic mysteries.

FACILITIES

FAST's first pulsars The world's largest single-dish telescope has observed its first two pulsars. The Five-hundred-meter Aperture Spherical Telescope (FAST) in southern China's Guizhou province detected the neutron stars in August. Researchers at the National Astronomical Observatories of China reported the results on 10 October after they were confirmed by an Australian telescope. The observations suggest FAST is working well, despite its radical design: the dish consists of thousands of panels that move to track radio signals, requiring elaborate coordination. Signals from the two pulsars were captured a year into an estimated three-year debugging phase. FAST, which is expected to find hundreds, possibly thousands, of pulsars, is looking for clues to how the Universe formed, as well as for signs of extraterrestrial life.

China Daily/Reuters

POLICY

Climate-rule repeal On 10 October, the US Environmental Protection Agency moved to repeal former president Barack Obama's landmark regulations to reduce greenhouse-gas emissions from power plants. Agency administrator Scott Pruitt signed a measure to begin the process of rescinding the Obama policy, a move that is expected to spark lawsuits by environmental groups and some states. The power-plant rule would reduce greenhouse-gas emissions to 32% below 2005 levels by 2030. In 2016, the Supreme Court blocked the policy from taking effect; legal challenges from 27 state governments are still pending, although a federal appeals court has put the case on hold while the administration of President Donald Trump reviews the rule.

Measuring impact UK science minister Jo Johnson has announced plans to

assess universities on their economic impact and engagement with wider society. Higher-education bodies will consult on creating a Knowledge Exchange Framework, an evaluation system designed to incentivize activities such as transferring technology into industry, spinning off companies and conducting contract research, training and consultancy, Johnson said on 12 October. If implemented, the framework would become a third strand of UK university assessment, alongside the Teaching Excellence Framework and Research Excellence Framework.

AWARDS

MacArthur grants The philanthropic MacArthur Foundation in Chicago, Illinois, announced its 2017 award recipients on 11 October. Six of the 24 winners — often referred to as MacArthur geniuses — are scientists. They include anthropologist Jason De León of the University of Michigan in Ann Arbor, who uses methods including archaeology and forensic science to study undocumented migrants on the US–Mexican border; computational linguist Regina Barzilay of the Massachusetts Institute of Technology in Cambridge, who deciphers ancient languages using machine learning; and immunologist Gabriel Victora of the Rockefeller University in New York City, who observes how antibodies evolve in the immune system in real time. Each winner gets US$625,000 over 5 years, with no restrictions on how they can spend the money.

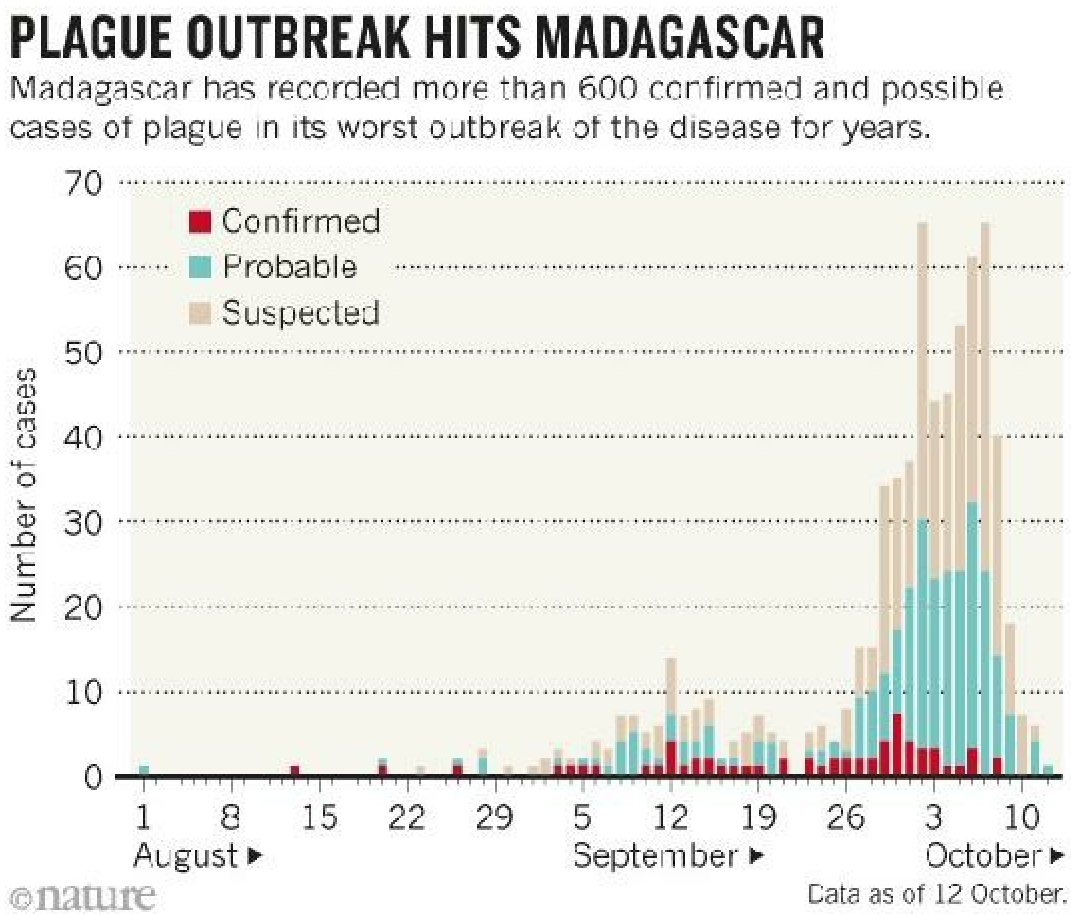
FUNDING

Research boost Online shopping giant Alibaba will set up seven international research laboratories as part of its plan to spend US$15 billion on research and development over the next three years. The company, based in Hangzhou, China, announced the Alibaba DAMO Academy on 11 October. The seven labs will be established in China, the United States, Russia, Israel and Singapore. Research topics will include data intelligence, the ‘Internet of things’, quantum computing and human–machine interfaces. Recruitment of the first 100 researchers is under way. The advisory board of the academy includes prominent scientists from outside China, including

geneticist George Church of Harvard University in Cambridge, Massachusetts.

TREND WATCH

Madagascar is battling an outbreak of plague, with more than 600 cases and at least 57 deaths since 1 August. Plague is endemic to the island and surfaces almost annually. But the current outbreak is unusually large, and cases are mostly of pneumonic plague, which is deadlier and more transmissible than the more usual bubonic form. Untreated, pneumonic plague can kill within 24 hours. On 10 October, the World Health Organization reported a linked case of plague in the Seychelles.



Source: WHO

Journal name:
Nature
Volume:
550,
Pages:
306–307
Date published:
(19 October 2017)
DOI:
doi:10.1038/550306a

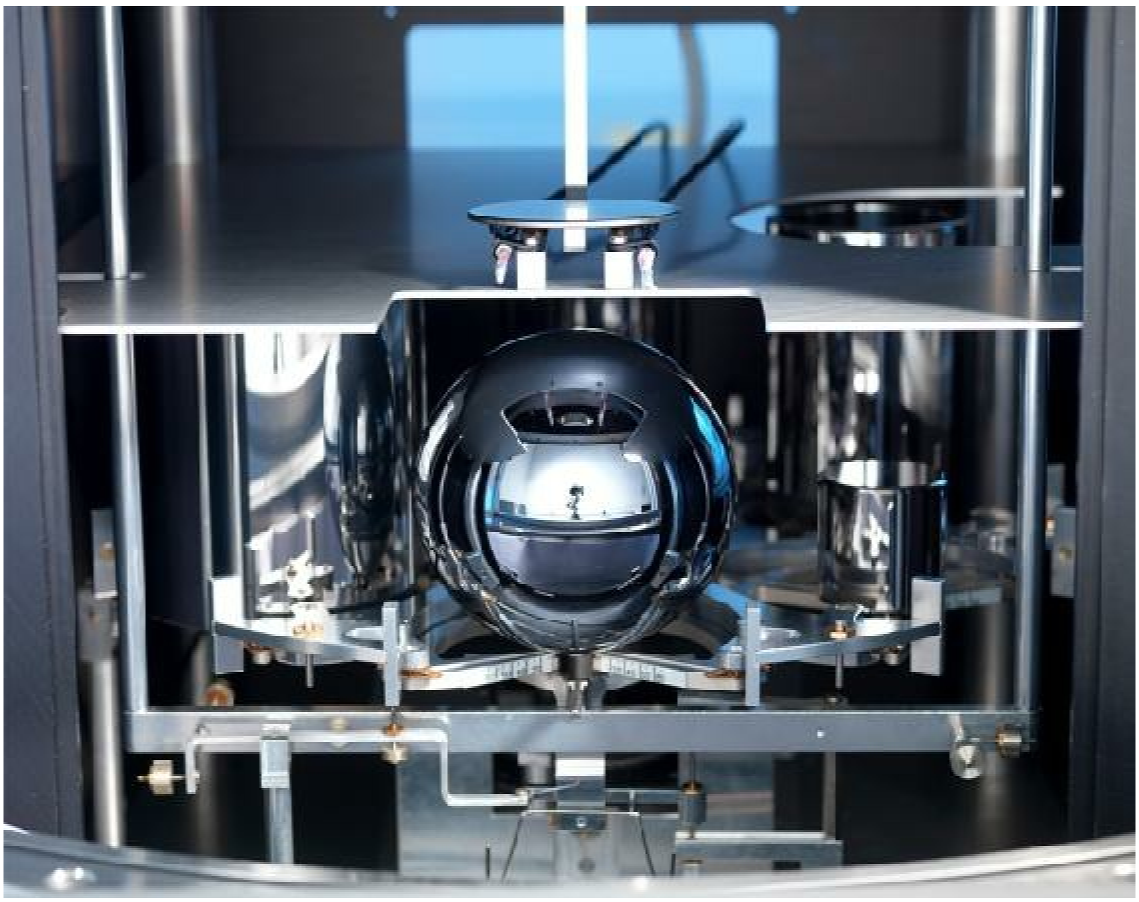
Comments

Commenting is currently unavailable.

New definitions of scientific units are on the horizon

Metrologists are poised to change how scientists measure the Universe.

18 October 2017



Natl. Phys. Lab., UK

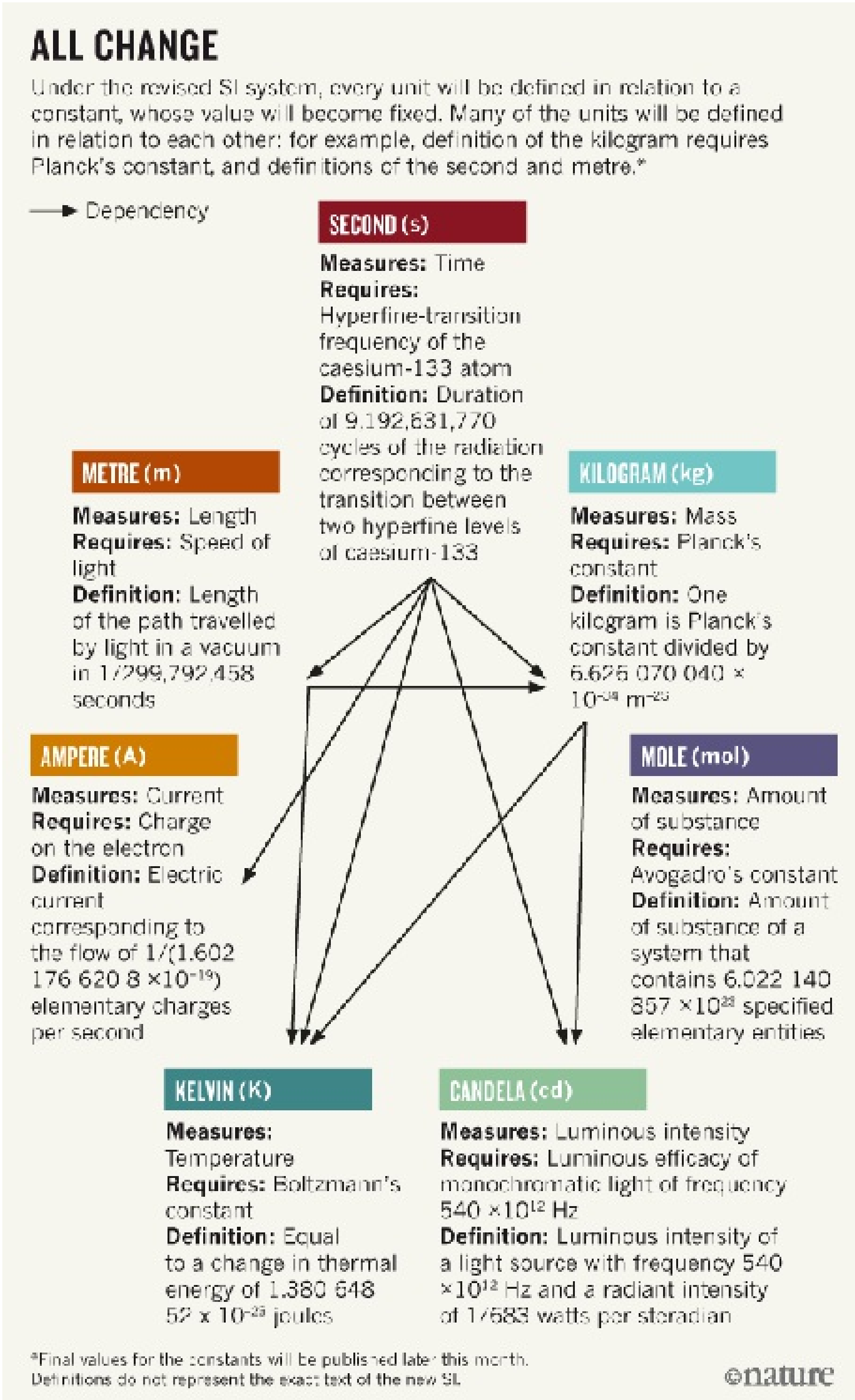
A sphere of pure silicon can be used to define a unit of measurement known as a mole.

Revamped definitions of scientific units are on their way. In the biggest

overhaul of the international system of units (SI) since its inception in 1960, a committee is set to redefine four basic units — the ampere, the kilogram, the kelvin and the mole — using relationships to fundamental constants, rather than abstract or arbitrary definitions. The International Bureau of Weights and Measures is reviewing the plans at a meeting near Paris from 16 to 20 October. Its recommendations will then go before the General Conference on Weights and Measures, which oversees the SI system, in November 2018. The changes would take effect in May 2019.

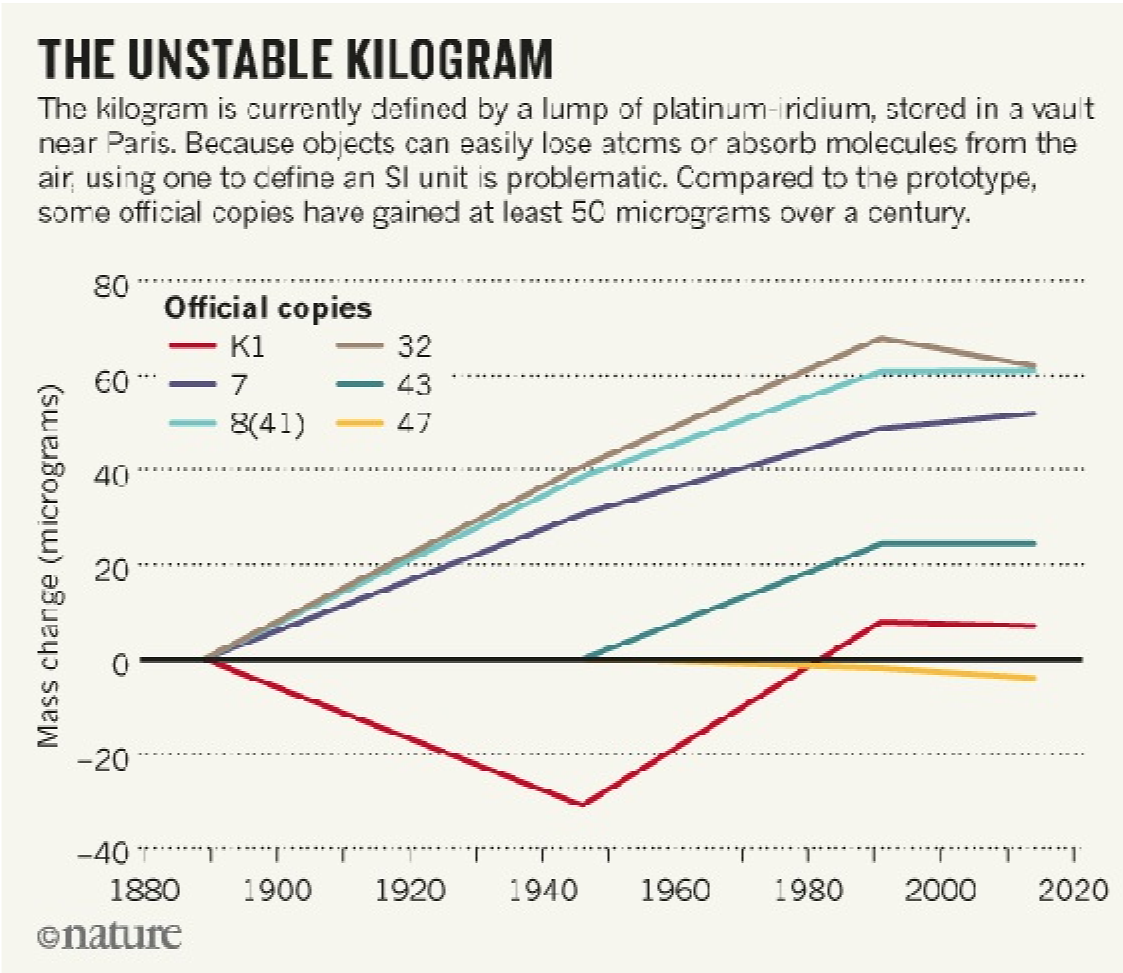
The kilogram is currently defined as the mass of a chunk of metal in a vault in Paris. And an imaginary experiment involving the force between two infinite wires defines the ampere, the unit of electrical current. The mole, meanwhile, is the amount of substance in a system with as many elementary entities as there are atoms in 0.012 kilograms of carbon-12, while the kelvin relates to the temperature and pressure at which water, ice and water vapour co-exist in equilibrium, known as the triple point of water. In the future, these units will be calculated in relation to constants — for example, the ampere will be based on the charge of an electron.

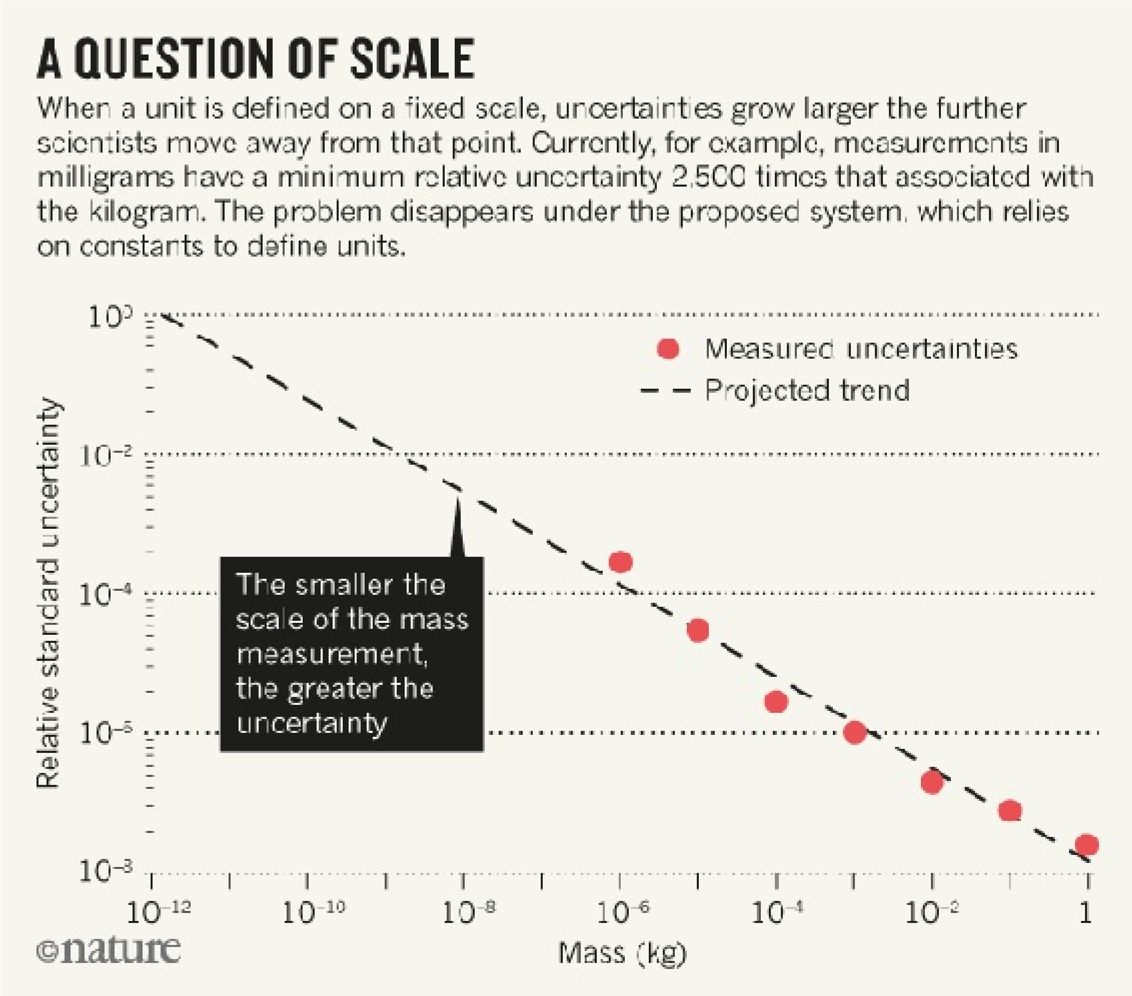
Redefinition might not affect everyday measurements, but it will enable scientists working at the highest level of precision to do so in multiple ways, at any place or time and on any scale, without losing accuracy.


ALL CHANGE
Under the revised SI system, every unit will be defined in relation to a constant, whose value will become fixed. Many of the units will be defined in relation to each other: for example, definition of the kilogram requires Planck's constant, and definitions of the second and metre.*
Dependency
SECOND (s)
Measures: Time
Requires: Hyperfine-transition frequency of the caesium-133 atom
Definition: Duration of 9,192,631,770 cycles of the radiation corresponding to the transition between two hyperfine levels of caesium-133
METRE (m)
Measures: Length
Requires: Speed of light
Definition: Length of the path travelled by light in a vacuum in 1/299,792,458 seconds
KILOGRAM (kg)
Measures: Mass
Requires: Planck's constant
Definition: One kilogram is Planck's constant divided by 6.626 070 040 × 10^{-34} $m^{-2}s$
AMPERE (A)
Measures: Current
Requires: Charge on the electron
Definition: Electric current corresponding to the flow of 1/(1.602 176 620 8 × 10^{-19}) elementary charges per second
MOLE (mol)
Measures: Amount of substance
Requires: Avogadro's constant
Definition: Amount of substance of a system that contains 6.022 140 857 × 10^{23} specified elementary entities
KELVIN (K)
Measures: Temperature
Requires: Boltzmann's constant
Definition: Equal to a change in thermal energy of 1.380 648 52 x 10^{-23} joules
CANDELA (cd)
Measures: Luminous intensity
Requires: Luminous efficacy of monochromatic light of frequency 540 × 10^{12} Hz
Definition: Luminous intensity of a light source with frequency 540 × 10^{12} Hz and a radiant intensity of 1/683 watts per steradian
*Final values for the constants will be published later this month.
Definitions do not represent the exact text of the new SI.
©nature

The problem

For measurements on conventional scales, existing definitions of SI units suffice. But they are poor tools for modern science at the extremes. And basing units on specific points or materials can be troublesome and inelegant, say metrologists.





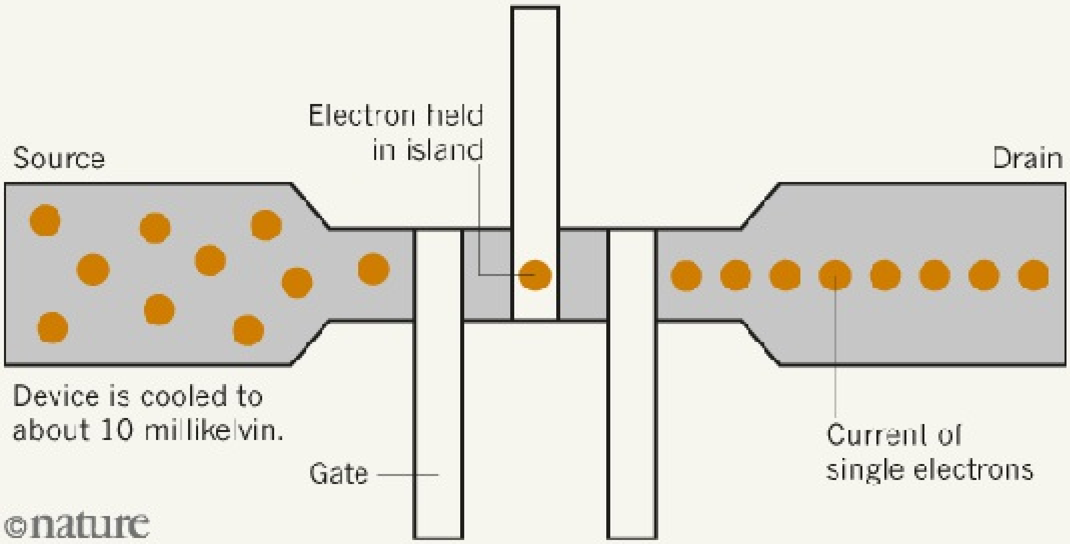
Source: Shaw, G. et al. Metrologia 53, A86–A94 (2016).

The techniques

Under the revamped SI system, researchers will be able to use various experiments to relate constants to each of the units measured.

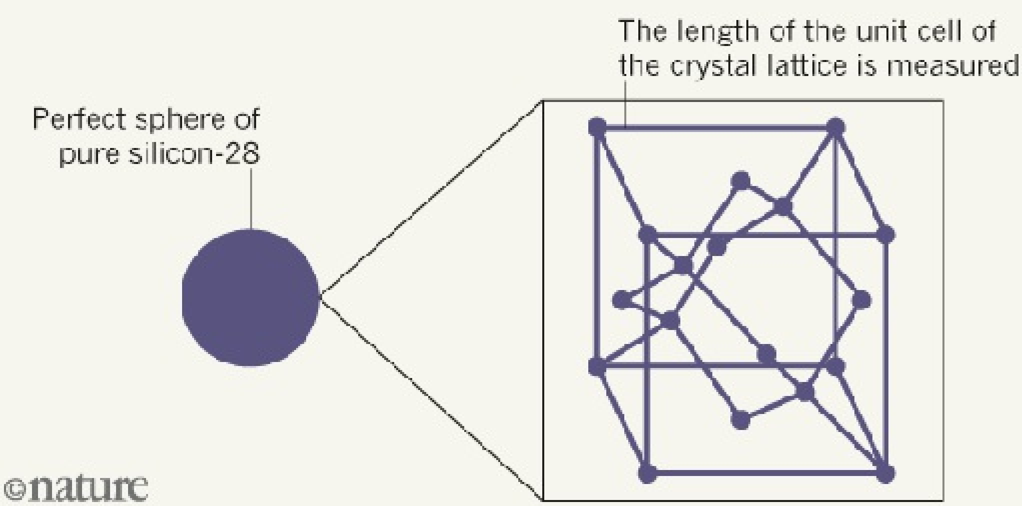
AMPERE: THE SINGLE-ELECTRON PUMP

Used to measure the charge of an electron, an electron pump could become one tool for determining the ampere. By trapping individual electrons as they travel rapidly across a conductor, the pump can generate a measureable current by counting single electrons.



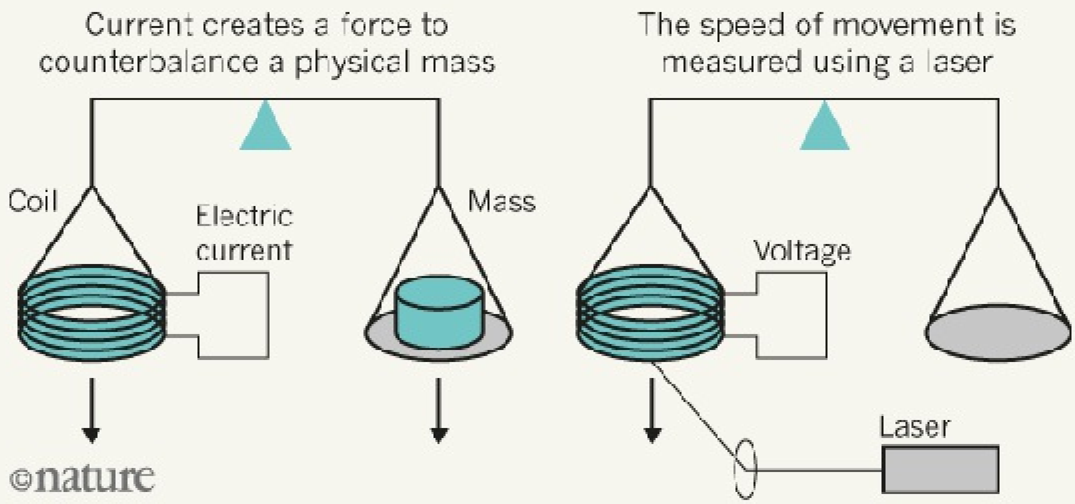
MOLE: THE SILICON SPHERE

As the device that gives scientists Avogadro's constant, this silicon sphere offers a state-of-the-art way to measure a mole. It would determine the precise number of atoms in a perfect sphere of pure silicon-28. Researchers do this by using lasers to measure the length of a unit of the sphere's crystal lattice, and its mean diameter.



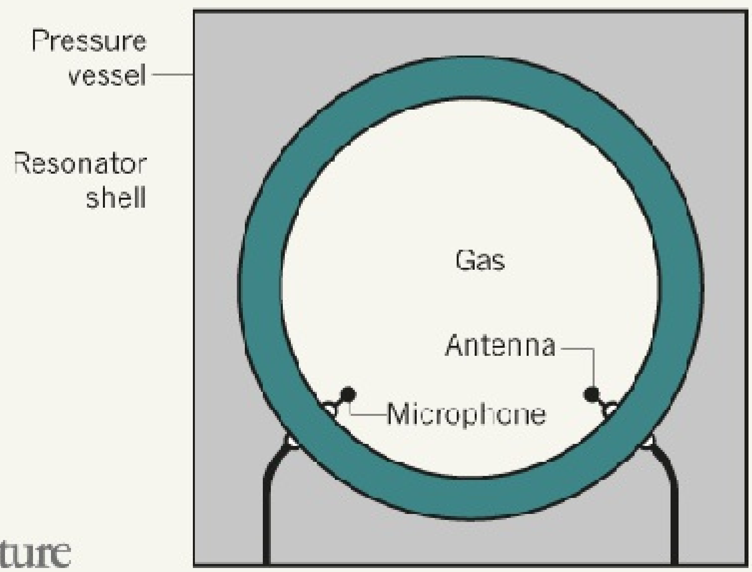
KILOGRAM: THE WATT BALANCE

The Watt balance compares mechanical power with electromagnetic power using two separate experiments. First, a current is run through a coil in a magnetic field to create a force that counterbalances a known physical mass. Then, the coil is moved through the field to create a voltage. By measuring the speed as well as experimental values that relate the voltage and current to Planck's constant, scientists can precisely determine the weight of a mass in kilograms.



KELVIN: ACOUSTIC THERMOMETRY

This technique could be used to derive precise temperature measurements. The speed of sound in a gas-filled sphere (which is proportional to the average speed of the atoms in it) can be determined at a fixed temperature, by analysing the frequency of sound waves that resonate within in it and measuring the sphere's volume.



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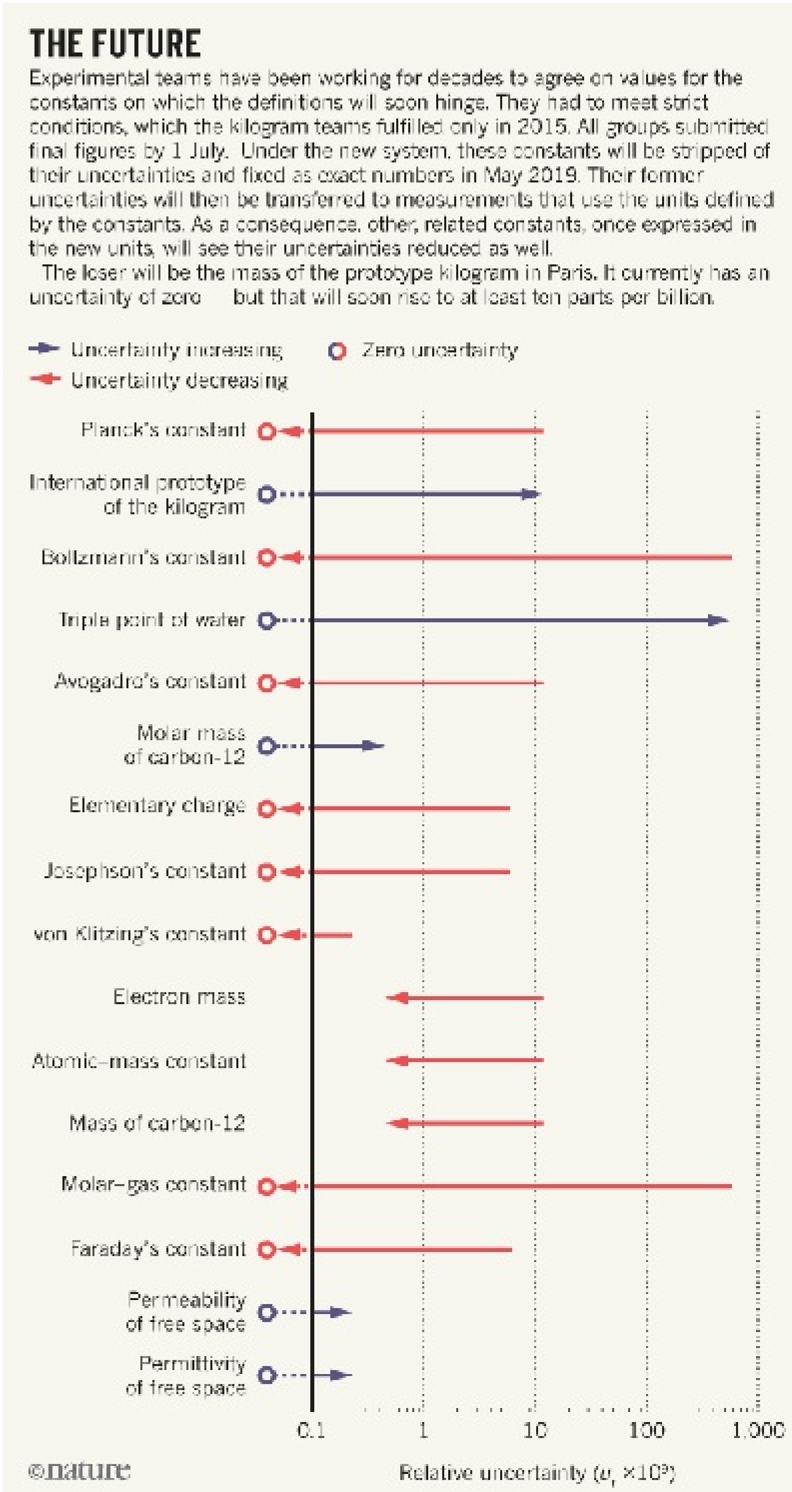

Journal name:

Nature

Volume:

550,
Pages:
312–313
Date published:
(19 October 2017)
DOI:
doi:10.1038/550312a

Comments

Comments

There are currently no comments.

The future of work

Digital technologies are upending the workforce. The right research can tell us how.

18 October 2017

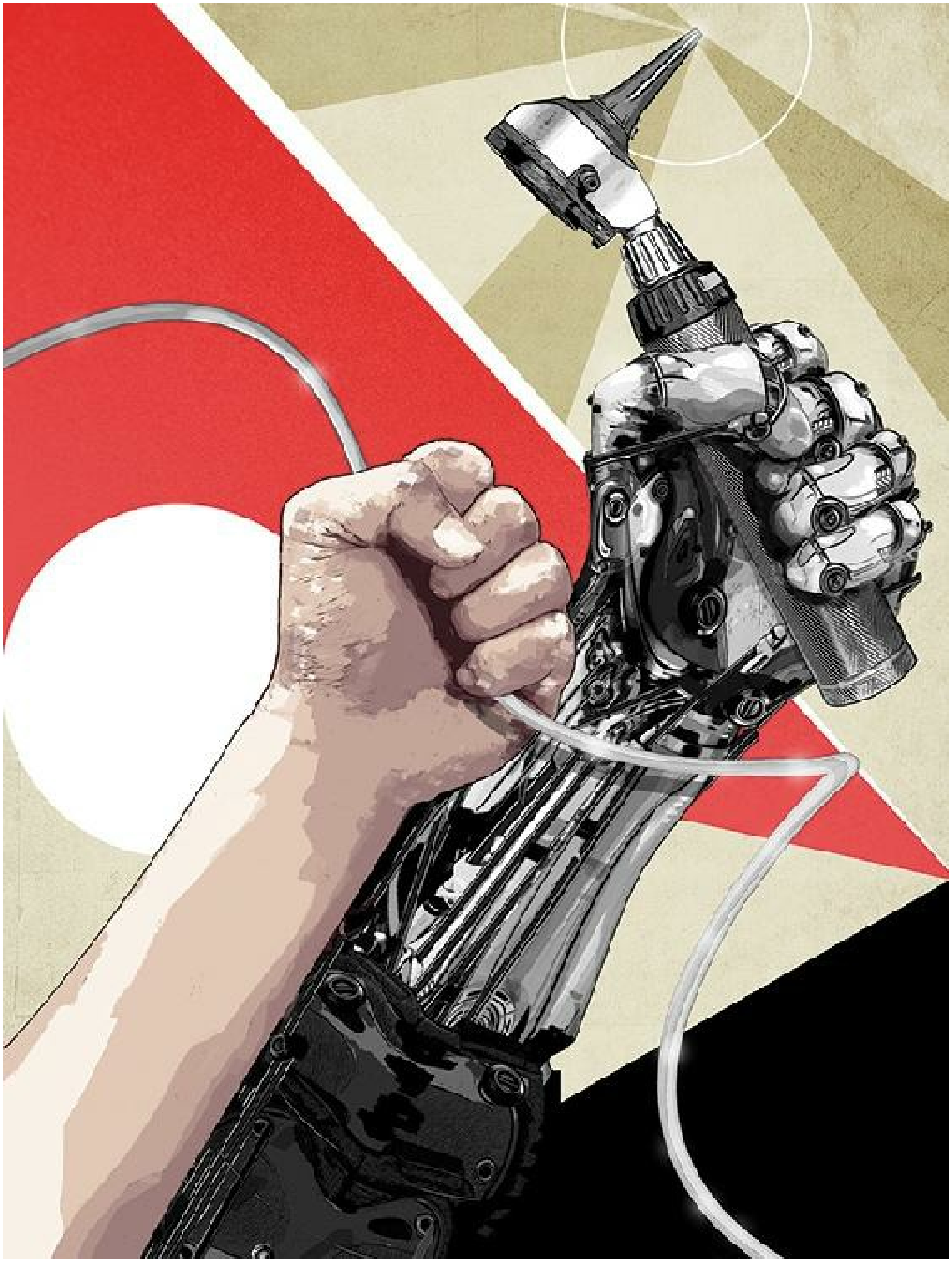

Illustration by Chris Malbon

Robots did not write this sentence, or any other part of *Nature*. But that could

change. Dramatic shifts in labour are reshaping society, the environment and the political landscape. Consider this disorienting estimate from the World Economic Forum: 65% of children entering primary schools now will grow up to work in jobs that do not yet exist. This week, *Nature* asks: what light is research shedding on the future of work, and how will the changes affect scientists' working world?

A News Feature explores which jobs are most at risk of being replaced by artificial intelligence and machine learning; whether a decentralized 'gig economy' will democratize work; and what programmes will best prepare workers. “There's a huge need, a huge opportunity, to study the changes,” says economist Erik Brynjolfsson. And the scientific workforce is feeling these shifts. A Careers Feature reports on people doing research outside the traditional career path. “I love the freedom,” says Cecile Menard, an independent land-surface modeller in Edinburgh, UK, “but for other people, it may be too stressful.”

Important lessons can be drawn from the past. Economic historian Robert Allen synthesizes three centuries of data to see when and where the relationship between wages and productivity was most like today's — and finds that some regions are in uncharted waters. These changes call for new socio-economic models and a revolution in education, concludes historian Yuval Noah Harari. And economist Ian Goldin argues that our era has more parallels with the Renaissance than the Industrial Revolution. This time, he urges, “knowledge and enquiry must find a way to conquer prejudice and ignorance”.

Journal name:
Nature
Volume:
550,
Pages:
315
Date published:
(19 October 2017)
DOI:
doi:10.1038/550315a

Comments

There are currently no comments.

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The shape of work to come

Three ways that the digital revolution is reshaping workforces around the world.

18 October 2017

Illustration by Chris Malbon

Last year, entrepreneur Sebastian Thrun set out to augment his sales force with artificial intelligence. Thrun is the founder and president of Udacity, an education company that provides online courses and employs an armada of salespeople who answer questions from potential students through online chats. Thrun, who also runs a computer-science lab at Stanford University in California, worked with one of his students to collect the transcripts of these chats, noting which resulted in students signing up for a course. The pair fed

the chats into a machine-learning system, which was able to glean the most effective responses to a variety of common questions.

Next, they put this digital sales assistant to work alongside human colleagues. When a query came in, the program would suggest an appropriate response, which a salesperson could tailor if necessary. It was an instantaneously reactive sales script with reams of data supporting every part of the pitch. And it worked; the team was able to handle twice as many prospects at once and convert a higher percentage of them into sales. The system, Thrun says, essentially packaged the skills of the company's best salespeople and bequeathed them to the entire team — a process that he views as potentially revolutionary. “Just as much as the steam engine and the car have amplified our muscle power, this could amplify our brainpower and turn us into superhumans intellectually,” he says.

The past decade has seen remarkable advances in digital technologies, including artificial intelligence (AI), robotics, cloud computing, data analytics and mobile communications. Over the coming decades, these technologies will transform nearly every industry — from agriculture, medicine and manufacturing to sales, finance and transportation — and reshape the nature of work. “Millions of jobs will be eliminated, millions of new jobs will be created and needed, and far more jobs will be transformed,” says Erik Brynjolfsson, who directs the Initiative on the Digital Economy at the Massachusetts Institute of Technology in Cambridge.

But making firm predictions is difficult. “The technology is rushing ahead, which in a way is a good thing, but we have a huge gap in understanding its implications,” Brynjolfsson says. “There's a huge need, a huge opportunity, to study the changes.” Researchers are beginning to do just that, and the emerging evidence resists simple storylines. Advances in digital technologies are likely to change work in complex and nuanced ways, creating both opportunities and risks for workers (see 'More research needed').

More research needed

Illustration by Chris Malbon

Scientists are grappling with how technology could alter workplaces.

The changing world of work presents an almost endless number of topics for

scientists to explore. Here are two other workplace trends and the research questions — as yet mostly unanswered — that they raise.

How will workers respond to new forms of tracking and surveillance?

Although employers have long monitored the performance of their staff, workplace surveillance is entering a new era.

Companies can now log workers' keystrokes and remotely take screenshots of their computers, for example, or use motion sensors, biometrics, radio-frequency identification (RFID) chips and the Global Positioning System to track their movements, even after hours.

But it's not yet clear whether workers will show widespread resistance to the increasing use of surveillance technology, or where they might draw the line. And could new forms of surveillance backfire in less obvious ways, undermining trust, morale or innovation?

How will human-enhancement technologies affect worker health and safety?

Technologies for improving human performance — from cognition-boosting drugs to bionic 'exoskeletons' that are designed to make physical labour safer and easier — are beginning to make their way into the workplace.

In some cases, these technologies could help to protect the health and safety of workers. An alertness-enhancing drug, such as modafinil, might help long-haul drivers avoid accidents, and exoskeletons could reduce joint stress and muscle fatigue. But researchers don't know whether the long-term use of these technologies could harm workers, either directly or indirectly, perhaps by encouraging overwork or increased risk-taking.

Here are three pressing questions about the future of work in a digital world and how researchers are beginning to answer them.

Will machine learning displace skilled workers?

In previous waves of automation, technological advances have allowed machines to take over tasks that were simple, repetitive and routine. Machine learning opens up the possibility of automating more complex, non-routine cognitive tasks. “For most of the last 40 or 50 years, it was impossible to automate a task before we understood it extremely well,” Brynjolfsson says. “That's not true anymore. Now machines can learn on their own.”

Machine-learning systems can translate speech, label images, pick stocks, detect fraud and diagnose disease — rivalling human performance in some new and surprising domains. “A machine can actually look at many, many, many more data samples than a human can handle,” says Thrun. Earlier this year, he led a team that demonstrated that some 129,000 images of skin lesions could be used to train a machine to diagnose skin cancer with a level of accuracy that matches that of qualified dermatologists[1].

LISTEN

Reporter Benjamin Thompson finds out how lessons from the past can help explore the future of work.

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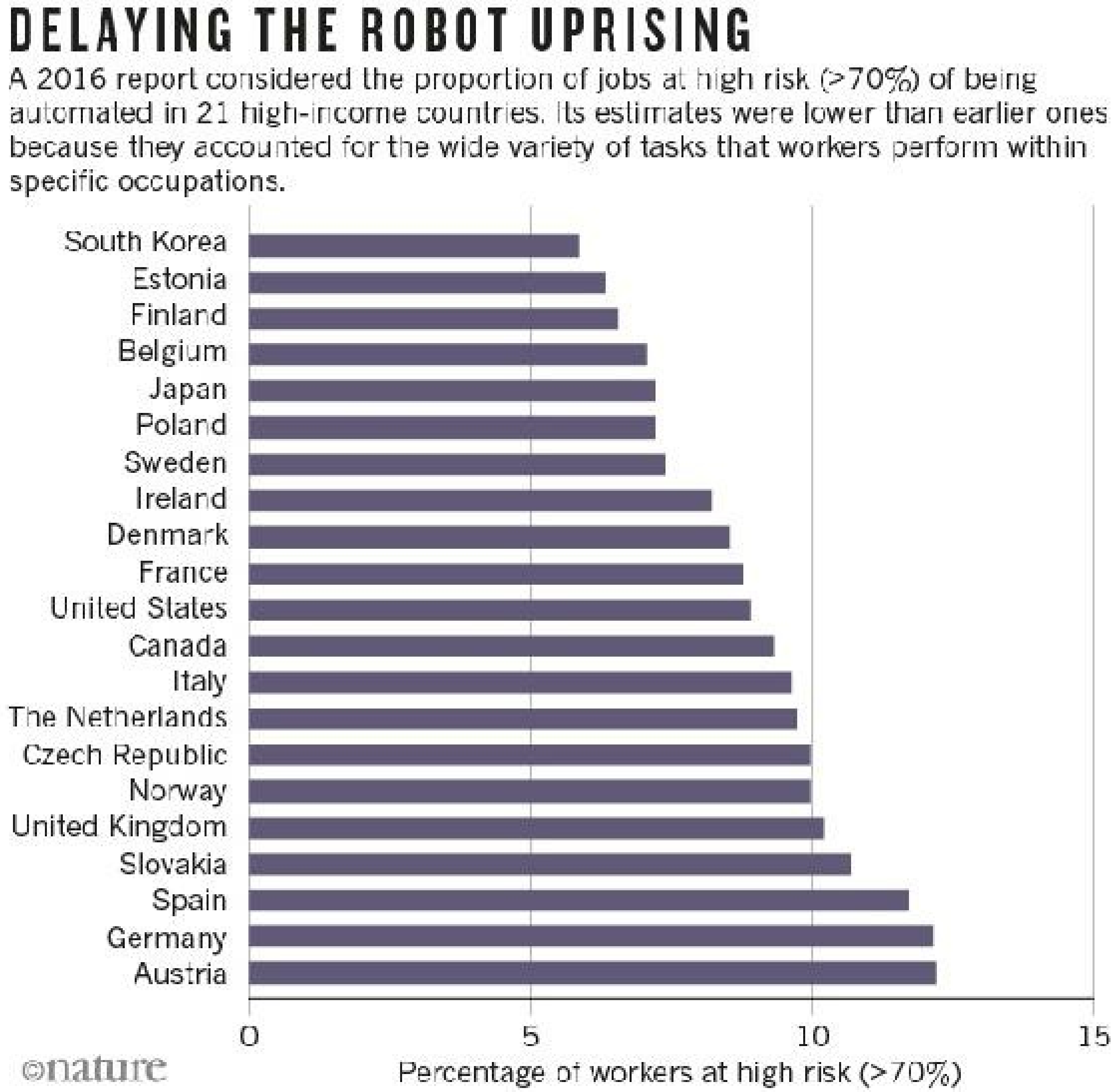
These advances have raised concerns that such systems could replace human workers in fields that once seemed too complex to be automated. Early estimates seemed dire. In 2013, researchers at the Oxford Martin Programme on Technology and Employment at the University of Oxford, UK, reviewed the advances and lingering challenges in machine learning and mobile robotics to estimate how susceptible 702 different occupations were to automation[2]. Their startling conclusion was that 47% of jobs in the United States were at high risk of computerization, with jobs in transportation, logistics, production and administrative support particularly vulnerable. That spelt trouble for workers such as taxi drivers, legal secretaries and file clerks.

Since then, however, other researchers have argued that the 47% figure is much too high, given the variety of tasks that workers in many occupations

tend to perform. “Once you go deeper, once you look into the task structure of what people really do at work, then you find that the estimates get much lower,” says Ulrich Zierahn, a senior researcher at the Centre for European Economic Research in Mannheim, Germany.

For instance, the Oxford study reported that clerks in bookkeeping, accounting and auditing face an automation risk of 98%. But when Zierahn and his colleagues analysed survey data on what people in those professions actually do, the team found that 76% of them had jobs that required group work or face-to-face interaction. For now at least, such tasks are not easily automated[3]. When the authors extended their approach to other professions, they found less-alarming figures for the number of at-risk jobs in the 21 countries surveyed. In the United States, the share of workers at high risk of automation was just 9%, and the figure ranged from a low of 6% in South Korea and Estonia to a high of 12% in Germany and Austria (see 'Delaying the robot uprising').



Sources: OECD/Ref. [3] (http://go.nature.com/2KK4D4Y)

Brynjolfsson is now working with Tom Mitchell, a computer scientist at Carnegie Mellon University in Pittsburgh, Pennsylvania, to drill deeper into the impact of machine learning. They have developed a rubric outlining the characteristics that make certain tasks especially amenable to this approach. For instance, machine-learning systems are adept at tasks that involve translating one set of inputs — say, images of skin lesions — into another set of outputs, such as cancer diagnoses. They're also most likely to be used for tasks in which the large digital data sets required for training the system are readily available. Brynjolfsson and Mitchell are now going through several

large occupational databases to determine how well a variety of workplace tasks match up with these and other criteria.

Even with these kinds of analysis in hand, determining the consequences for the labour market is complex. Just because a task can be automated doesn't mean that it will be; new technologies often require costly and time-consuming organizational changes. Legal, ethical and societal barriers can also delay or derail their deployment. “AI is not yet an off-the-shelf product,” says Federico Cabitza, who studies health-care informatics at the University of Milano-Bicocca in Italy. Implementing medical machine-learning systems, for instance, requires both technological readiness and willingness to devote the thousands of person-hours necessary to make these systems operational, he says — not to mention buy-in from caregivers and patients.

Research suggests that the workforce is flexible in adapting to new technologies. In the second half of the twentieth century, increasing automation prompted shifts within occupations as employees began performing more complex and non-routine tasks. In some future cases, these shifts could be positive; if automated systems start making routine medical diagnoses, it could free doctors to spend more time interacting with patients and working on complex cases. “The fact that computers are becoming good at medical diagnosis doesn't mean that doctors will disappear as a job category,” Mitchell says. “Maybe it means we'll have better doctors.”

Indeed, many people might find themselves working alongside AI systems, as the Udacity salespeople did, rather than being replaced by them. Self-driving cars, for instance, are not yet able to navigate all situations on their own, so car manufacturer Nissan is developing a human-powered solution. If one of its autonomous cars encounters a situation it doesn't understand, such as roadworks or a traffic accident, it will contact a remote command centre where a human 'mobility manager' can take control until the car has passed the trouble spot. “Machines think in a very different way, fundamentally, than humans do, and each has its strengths,” says Pietro Michelucci, executive director of the Human Computation Institute in Fairfax, Virginia. “So there's a real natural marriage between machines and humans.”

Will the gig economy increase worker

exploitation?

Flexibility, variety and autonomy: these are the promises of the burgeoning gig economy, in which workers use online platforms to find small, short-term jobs. This sort of on-demand, digitally mediated gig work can take a variety of forms, from driving for the taxi service Uber to completing microtasks — including taking surveys, translating a few sentences of text or labelling an image — on a massive crowd-working platform such as Amazon Mechanical Turk.

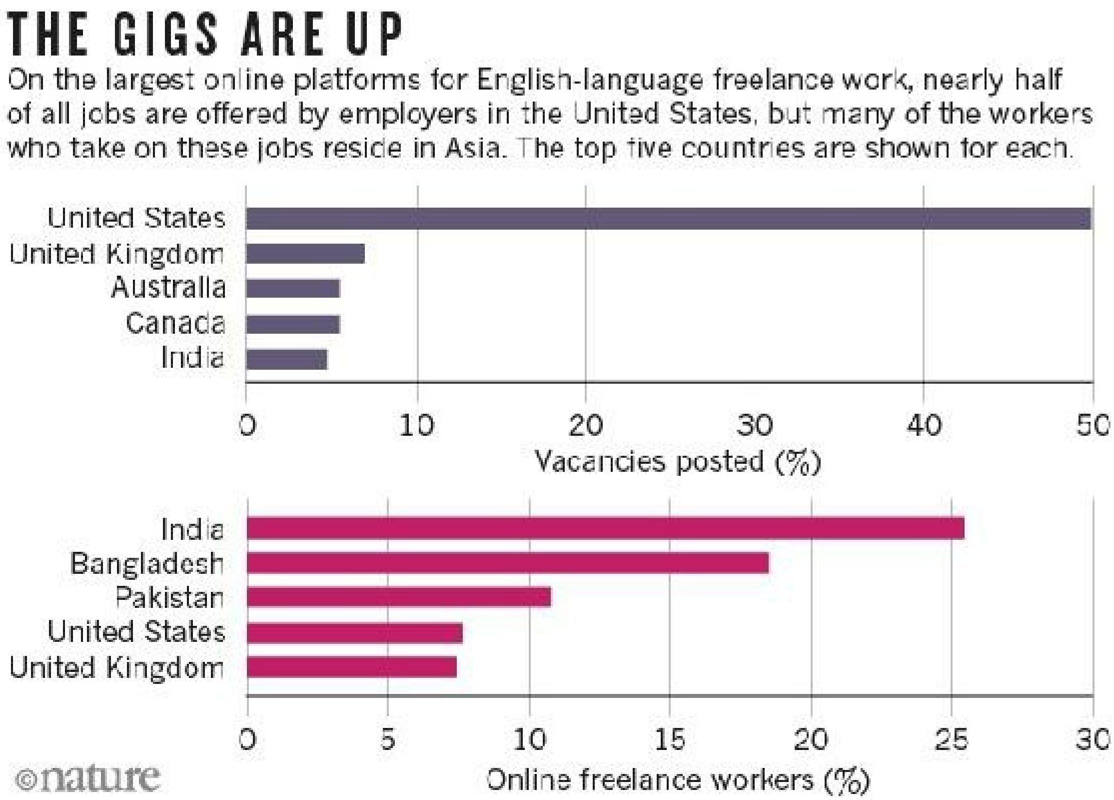
These digital platforms allow workers to complete tasks from anywhere, meaning they could remove some geographical barriers to getting good jobs. “Someone in Nairobi is no longer constrained by the local labour market,” says digital geographer Mark Graham of the University of Oxford.

Graham and his colleagues have spent several years studying the digital, on-demand economy in southeast Asia and sub-Saharan Africa. They have conducted face-to-face interviews with more than 150 gig workers in these regions, surveyed more than 500 people and analysed hundreds of thousands of transactions on online labour platforms.

Their preliminary results show that these jobs do pay off for some gig workers; 68% of the survey respondents said that the work makes up an important part of their household income. And digital platforms provided jobs to a variety of people — including women who were primary caregivers and migrants without work permits — who said that their employment opportunities were otherwise limited. “There are some people who really thrive in this system,” Graham says. “But it's not like that for everyone.”

There is a pronounced oversupply of labour in the gig economy, leading some workers to drop their rates below what they consider fair. Many also work long hours at high speeds and to tight deadlines. “They tend to have a very precarious existence, so they're worried about saying no to jobs that they do get,” Graham says. “We talked to quite a few people who have done things like stay up for 48 hours straight, just working solidly in order to get their contracts done on time.”

Considerable geographical inequities remain. In a 2014 study[4], Graham and several colleagues analysed more than 60,000 transactions on one major platform in March 2013. Most jobs, they found, were listed by employers in high-income countries and completed by workers in low- or middle-income countries (see 'The gigs are up').



Source: Ilabour (http://go.nature.com/2GZE5TZ)

But those who live close to where the jobs are still seem to have an advantage. They win a disproportionate share of jobs and earn significantly more — US$24.13 per hour, on average — than foreign workers, who earned $11.66 per hour for comparable work. And some low- and middle-income nations attracted many more jobs than others; India and the Philippines are the top two recipients in Graham's analysis.

Practical concerns could explain some of these disparities. Language and time-zone differences might make some employers reluctant to hire foreign workers, and the history of outsourcing labour to India and the Philippines

may have helped make workers there more attractive to employers. But discrimination, both conscious and unconscious, could play a part, too; Graham's team found task listings explicitly stating that people from certain countries need not apply. “Even though these technologies have been able to connect different parts of the world, they have not been able to bridge these kinds of differences as much as we hoped,” says Mohammad Amir Anwar, a researcher who works with Graham.

Another large ethnographic study of gig workers is beginning to reveal more about how this work gets done. It also provides some clues about what workers need to succeed. Between 2013 and 2015, two senior researchers at Microsoft Research — anthropologist Mary Gray in Cambridge, Massachusetts, and computational social scientist Siddharth Suri in New York City — surveyed roughly 2,000 gig workers in the United States and India and conducted longer interviews with nearly 200 of them.

One of the first things they discovered was that, although gig workers are often portrayed as independent, autonomous labourers, many of them were in fact communicating and collaborating with each other[5]. Workers helped each other to set up accounts and profiles, shared information about good employers and newly posted jobs, and provided technical and social support. Workers are making a deliberate effort to add human connections back into the system, Suri says, and they're doing it on their own time. “So they clearly must value it.”

In a more quantitative follow-up study[6], in which they mapped the social connections among more than 10,000 Amazon Mechanical Turk workers, Gray, Suri and their colleagues found that this kind of collaboration can have real pay-offs. Workers who had connections to at least one other person on the platform had higher approval rates, were more likely to gain elite 'master' status, and found out about a new task more quickly than unconnected workers. For people to be productive, says Gray, “it turns out that they really need to collaborate. They need each other.”

Can the digital skills gap be closed?

For years, experts have been sounding the alarm about a looming shortage of digital skills. They have warned that there are too few trained workers to fill high-tech jobs, and that a lack of basic digital literacy could prevent workers in certain geographical regions or demographic groups from thriving in the digital economy. In response, various innovative programmes for boosting digital literacy and skills have sprung up worldwide. Research is now starting to provide some clues about what does and doesn't work — and about where skills training might fall short.

There have been some documented successes. More than a decade ago, the US Defense Advanced Research Projects Agency began developing a personalized, interactive and adaptive 'digital tutor' system to train new recruits to the US Navy for jobs as information-systems technology (IT) technicians. Students would work with the tutor one-to-one, completing lessons on different topics and solving related problems. The system prioritized conceptual learning and reflection, regularly prompting students to review what they'd learnt. When the tutoring system judged that a student had mastered the material, it would move on to the next subject.

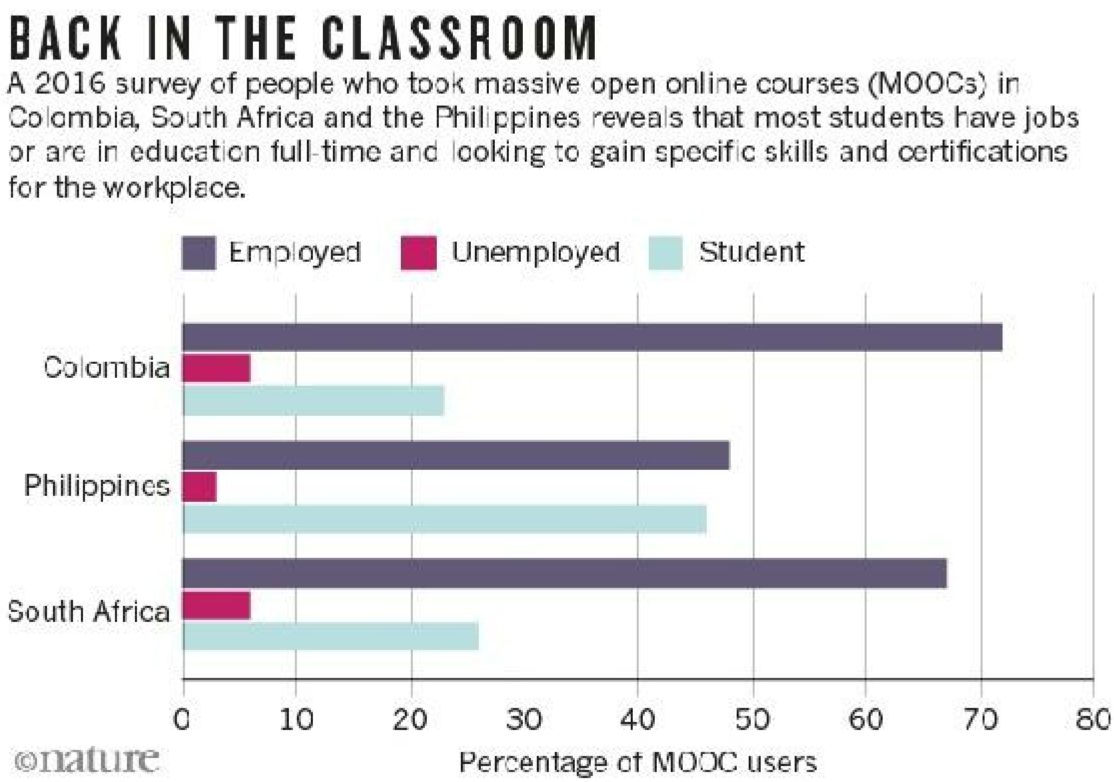
In a 2014 review[7] of the programme, researchers at the Institute for Defense Analyses in Alexandria, Virginia, found that 12 recruits who completed the 16-week course outperformed graduates of conventional, classroom-based US Navy IT training that lasted more than twice as long. The 12 even did better than a group of senior naval IT technicians — who each had an average of nearly ten years' experience — on almost every measure. “If we can do that, why not do more of it?” says Dexter Fletcher, who co-authored the review. “Why not begin to apply this seriously to workforce training?”

In a follow-up study[8], Fletcher found that a slightly modified version of the digital tutor yielded similar results when it was used to train 100 military veterans for civilian jobs in IT. Within six months of completing the programme, 97% of the veterans who wanted IT jobs had landed them, earning an average annual salary roughly equal to that of someone with 3–5 years of experience in the field.

Numerous other strategies have been promoted to improve digital skills and employment, including massive open online courses (MOOCs) — university-

level classes that are delivered over the Internet — and coding bootcamps, which are intensive, short-term training courses that teach the basics of computer programming.

In a 2016 analysis[9] of 1,400 MOOC users in Colombia, the Philippines and South Africa, researchers determined that 80% of students were from low- or middle-income backgrounds and that 41% had only basic computer skills. More than half of the students (56%) were female, and computer science was the most popular MOOC topic. “Women are actually engaging in MOOCs in areas where they are underrepresented,” says Maria Garrido, a co-author of the report at the University of Washington's Information School (see '[Back in the classroom]').



Source: Ref. [9] (http://go.nature.com/2YFAPWC)

But the quality of these programmes can vary enormously, and few have been rigorously evaluated. Coding bootcamps can be expensive, require a significant time investment and are located primarily in technology corridors

and urban settings. And achievement gaps remain; in a 2015 study[10] of more than 67,000 MOOC students, two Stanford researchers found that female students and students of both genders from Africa, Asia and Latin America were less likely to reach certain course milestones — such as watching more than 50% of the lectures — and earned lower grades than male students and MOOC students from North America, Europe and Oceania.

Even those who complete digital-skills courses can still face a variety of barriers to employment. When researchers interviewed students in a Kenyan IT programme at Strathmore University in Nairobi in 2004, some of the students said that they were worried about graduating into a local economy that didn't appreciate their expertise or have jobs in which they could put it to use[11]. “And this was especially true for the women,” says Lynette Yarger, an information scientist at Pennsylvania State University in University Park, who was involved in the research. As one student put it: “Because I am a woman, employers may not think that they should give me a job working in IT, so I may never fully get to use all that I have learned to do, work that I want to do.”

One thing the research is already making clear is that even well-designed training programmes might not be sufficient to ensure success in the world of digital work. “The fact that you have better skills and know how to use a computer doesn't necessarily mean that you automatically can get a good job,” Garrido says. “Digital skills are an important piece of the puzzle, but they're not enough.”

Journal name:
Nature
Volume:
550,
Pages:
316–319
Date published:
(19 October 2017)
DOI:
doi:10.1038/550316a

Comments

There are currently no comments.

Lessons from history for the future of work

18 October 2017

Global comparisons of previous social and economic upheavals suggest that what is to come depends on where you are now, argues Robert C. Allen.

Lewis Hine/Pictorial Press Ltd/Alamy

Children working in a cotton mill in Macon, Georgia, in January 1909.

Today is not the first time that people have worried that machines will render

human labour obsolete, making a few very rich and the majority very poor.

Since the Industrial Revolution, mechanization has been controversial. Machines pushed up productivity, raising incomes per capita. But they threatened to put people out of work, to lower their wages and to divert all the gains from growth to the owners of businesses. The stocking-frame operators of Nottingham, UK (the Luddites), wrecked improved knitting machines that threatened their jobs. Mobs burnt down the first mills housing spinning and weaving equipment in the 1760s and 1790s.

Now, it is robots that threaten work, wages and equality[1]. Are the gains of technological progress destined to benefit only the top 1% of earners?

Economists' stock answer to this question is 'no'[2]. Technical progress in the past three centuries has led to incomes in the West (that is, the developed nations of today) that are much higher than they were in 1700 in real terms, and the fraction of the adult population employed in these countries is at record levels. Despite mechanization, automation and computerization, people have found jobs. Somehow the economy has always adjusted; somehow in the future it always will.

I think this answer is too simplistic.

Phase shift

There have been long periods of economic history in which things did not work out well, and we must wonder whether we are in another. Also, the 'future of work' depends very much on where you are in the world. Most discussions in the West focus on how technological evolution in the West affects jobs in the West. This frame is too narrow for the twenty-first century: we must investigate the effect of technological change on work everywhere. For the past three centuries, the global economy has been sufficiently integrated that new technology in one place affects work in others.

LISTEN

Reporter Benjamin Thompson finds out how lessons from the past can help explore the future of work.

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Rather than ask (unanswerable) questions about how machines will affect work over the next centuries, we can ask what the invention of the textile mill meant for a girl growing up in Manchester, UK, in 1800 or the wife of a subsistence rice farmer in China's Yangtze Delta at the same time. Technological change affected their futures of work very differently and often detrimentally. Similar things are happening now.

We need to divide the past into periods defined by trends. The periods I suggest here reflect Western history, which is not as limiting as it sounds: globalization means that developments in one region affect others.

The three phases are: the Industrial Revolution (1750–1830); the Western ascent to affluence (1830–1970); and the problem-ridden present (since 1970). Each holds lessons and pressing research questions for today.

The industrial revolution

The Industrial Revolution was Britain's creative response to the globalization of the world economy that occurred after Columbus's voyage to America in 1492 and Vasco da Gama's sail around Africa to India in 1498. Britain's colonies in North America, the Caribbean and India formed a large market for Britain's handicraft industries. Exports boomed, and by the mid-eighteenth century about one-third of Britain's workforce was employed in making metal goods and cloth.

Large data sets of wages and prices over this period[3] have been assembled since the 1980s and show that real wages rose as a consequence of this export boom[4]. Inventors designed machines to save expensive labour. Mechanization paid in Britain rather than elsewhere because labour was more expensive relative to capital; that is why the Industrial Revolution was

primarily a British affair.

Textiles were the world's most important manufactured product in terms of employment before the Industrial Revolution, and the first to be mechanized. Indian cotton cloth was imported to Europe, where it was a smash hit. English manufacturers struggled to compete because English wages were so high. The invention in the 1760s and 1770s of spinning machines to speed up cloth-making, including Hargreave's spinning jenny, Arkwright's water frame and Crompton's spinning mule, solved the problem. The first victims of technological unemployment were the British women spinning cotton by hand and, later, the much-larger number spinning wool, once machinery was adapted to that fibre.

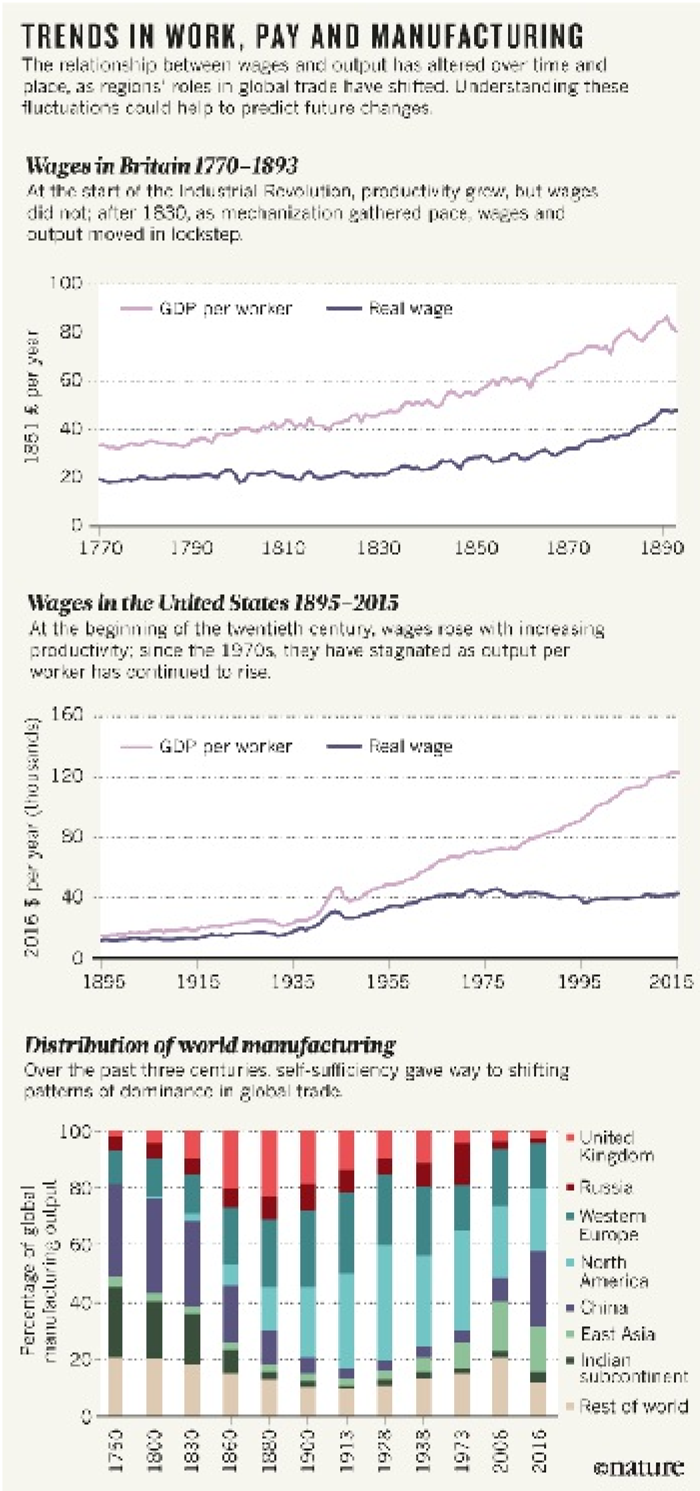
Soon jobs were lost from Casablanca to Canton. Investing in spinning machines made sense only in the high-wage economy of eighteenth-century England, thus they greatly increased English competitiveness without benefiting other nations. As jobs proliferated in the British cotton mills, massive technological unemployment spread across Africa and Asia[5]. The collapse of the Indian cotton trade around the 1830s led the British governor general to remark[6]: “The bones of the cotton-weavers are bleaching the plains of India.”

In 1820, the future of work for the wife of a farm labourer in England was an unhappy one. She had lost the opportunity to increase her family's income by spinning part-time, as her mother had done. The same impoverished fate befell a farmer's wife in the Ganges or Yangtze deltas. Some British women found work in the cotton mills (but a smaller number than had been employed to spin cotton by hand). By contrast, the future of work was auspicious for railway engineers, bricklayers and metal workers, to say nothing of the vast number of middle-class entrepreneurs and professionals who directed and serviced the industrial economy.

Machines were invented to save labour in most sectors of the economy in the first half of the nineteenth century. As one trade after another was eliminated in Britain, earnings collapsed in the affected trade, and that, in itself, lowered average national earnings. The displaced workers shifted into other trades, pushing down those wages. The Luddites and other opponents of

mechanization are often portrayed as irrational enemies of progress, but they were not the people set to benefit from the new machinery, so their opposition makes sense.

The implications were stark (see 'Trends in work, pay and manufacturing'). Although output per worker grew from 1770 to 1890, there was little growth in the real wage from 1770 to about 1830. During the Industrial Revolution (phase one) the 'normal' relationship was booming productivity and constant average wages — rather like the past 40 years.



Sources: See Supplementary Information

The western ascent to affluence

The average real wage only began to rise in the middle of the nineteenth century, when higher-productivity factory work replaced the hand trades. By 1850 Britain was the 'workshop of the world'. Comprising only around 3% of the world's population, the United Kingdom produced about half of the world's iron, for instance.

Industrial pre-eminence saw in the next phase of history. The new normal in the West was productivity and wages advancing together, as the Industrial Revolution spread across Europe and North America. Although there were shocks along the way owing to the depression of the 1930s and the Second World War, the period from the mid-nineteenth century to 1970 was one in which the working class benefited from the growth in productivity. Incomes became more equal. This is the economic performance that many have come to regard as normal.

How this favourable situation arose is a fundamental question. It seems that a positive-feedback system was in operation. Rising incomes led to the demand for fancier manufactured goods (for example, bicycles then cars) and more services (such as travel, retail trade and medical care). These created markets that encouraged technological change and led to jobs that were performed more effectively by educated people[7].

The need for educated workers led to the expansion of state provision of education. The increasing number of educated people prompted the invention of technologies that took advantage of education[8]. Those technologies led to further demand for education. At the same time, the public provision of infrastructure — roads and airports, for instance — was crucial for the development of industries involving cars and aircraft. Public support for research in medicine, agriculture and technologies with military applications, such as electronics and aircraft, underlaid many advances. The welfare state helped to spread the benefits of this economic development across the population.

The upshot was a pattern of economic growth in which technical progress benefited most people in the West.

The same was not true in Asia and Africa. Before the Industrial Revolution, China and India had the largest manufacturing sectors in the world because they had the largest populations, and nations were mostly self-sufficient in the pre-globalization era. As the Industrial Revolution gathered pace, Britain's share of goods manufactured worldwide increased, reaching a peak of about one-quarter in the late nineteenth century. Western Europe's share and that of North America also increased. In the same period, the shares of India and China collapsed. This drop represented absolute de-industrialization and not simply shifting percentages.

The technological revolution that spread prosperity in the West created modern 'underdeveloped countries' in the East (that is, Asia, Africa and South America). It converted them into economies that exported solely primary products — wheat, rice, bauxite, oil — rather than secondary ones such as cloth and porcelain.

By the 1830s, technological progress in the West meant a bleak future of work elsewhere.

The problem-ridden present

The past four decades have seen many job losses in the manufacturing sector in Western countries, static or falling real wages, and rising inequality as the gains from growth accrue to the top 1%. Did the 'new normal' end in 1970, or are the recent trends just a blip? Might what was 'normal' in 1850–1970 return soon — that is, the concurrent advance of productivity and wages?

Some people believe that the feedback loops between education and technology will kick in again, generating new knowledge-based, high-income jobs in the West to replace lost manufacturing jobs. Computers and robots will save us.

I am more pessimistic. The rise in real wages that began in the mid-nineteenth century and tracked the rise in output per worker ended in the 1970s (see 'Trends in work, pay and manufacturing'). Real wages rose at a slower rate than productivity in the 1980s and 1990s — or stagnated

altogether, as in the United States. In some cases (for example, the United Kingdom) wages have actually been falling in real terms over the past decade. A deviation of this magnitude from the trend suggests that the new pattern may not be transitory.

Similarly, the rebound in overall inequality in mature economies, such as the United States, over the past 40 years is unprecedented. Inequality rose in many countries as they industrialized and fell thereafter — this trend is called a Kuznets curve (after the Nobel laureate Simon Kuznets)[9]. The rise in inequality since 1970 has shown that this is a reversible feature of economic history.

Inequality is an area that has seen much recent research, with large data sets assembled and interrogated. Some scholars have focused on the share of total income going to the top 1% or 5%[10]. Others use indices that incorporate information from every level of the income distribution[11]. How we interpret the results depends on our breadth of vision. A common pattern in many countries is a fall in inequality from the early twentieth century to the 1970s and then a rise. This is true of the United States, the United Kingdom and China, for instance. At the global level, inequality increased steadily from 1820 to 1990 and then declined slightly. This pattern takes into account inequality between countries as well as within. Rising per capita incomes in the West in phase two increased global inequality. In phase three, global inequality fell even though inequality increased in many rich and poor countries[12].

Why are the feedback loops that led to general prosperity in the West between 1850 and 1970 seemingly inoperative now[13, 14, 15]? A big change is the industrialization of Asia — first Japan starting in the 1870s, then South Korea and Taiwan since the Second World War, and now China (see 'Trends in work, pay and manufacturing'). These countries have supplanted Western nations as the low-cost producers of manufactured goods. Trade flows have reversed, with Asia shipping textiles and steel to Europe rather than the other way around. Technological progress in Asia has raised incomes and levels of employment dramatically in the region.

The future of work to someone born in China in 1990 is bright indeed —

provided that the country can avoid environmental crises and resource depletion.

Globalization means that Asia's bright future causes havoc elsewhere. Imports of cheap Japanese steel and vehicles caused the collapse of the rust belt in the United States and its counterparts in Western Europe (with Germany as something of an exception). Western de-industrialization was the flip side of the East Asian miracles. And cheap Chinese imports may benefit Africans as consumers, but could blight their employment prospects as African industries struggle to compete. Indeed, China is now purchasing large areas of land in Africa to guarantee access to food and minerals. It is hard to believe that manufacturing or information technology will ever recover in the West, no matter how many robots are installed, visas rescinded, trade agreements ripped up or walls built.

We cannot forecast the future without an understanding of the relationships between science, technology and the economy, because technical change is such an important determinant of the future. I have studied these questions for the Industrial Revolution using business accounts and histories of inventions. The steam engine, for instance, was an application of seventeenth-century science (the discoveries that the atmosphere has weight and that condensing steam creates a vacuum). By contrast, the cotton mills owed little to science and much to attempts to cut costs of relatively expensive employment[16].

How has the balance between knowledge and incentives evolved? The more technology advances in response to economic incentives rather than 'random' scientific discoveries, the more feasible it is to direct the course of technical progress to benefit more people. Furthermore, the cotton mills of the Industrial Revolution increased the demand for workers without education, whereas more-recent technology requires more education. Why the difference? Will the recent trend of needing educated workers persist? If not, then the hope that a knowledge-based future will make everyone better off is doomed.

Journal name:
Nature
Volume:

550,
Pages:
321–324
Date published:
(19 October 2017)
DOI:
doi:10.1038/550321a

Supplementary information

PDF files

1. Supplementary Information 550321a (49K)

Comments

Comments

There are currently no comments.

The second Renaissance

18 October 2017

Ian Goldin calls on scientists to help society to weather the disruptive transformations afoot.

Jay Shaw Baker/NurPhoto/Getty

Workers protest in London in February.

The Renaissance that began in Europe in the mid-1400s and ended in the early 1500s brought a radical transformation of the sciences, the humanities and politics. Building on the invention of the printing press and cheap paper, information was democratized, there was a hunger for literacy and the Catholic Church's near-monopoly on knowledge was challenged. The

resulting breakthroughs took Europe from being one of the more backward regions of the world to being the most advanced by far, within just 80 years.

But it ended in tears. Extremists, pointing to growing inequalities and the corruption of the elite, called for a return to spiritual values. In Italy, thousands of artworks and books were burned, branded as irreverent. Across Europe, rising intolerance of scientists, intellectuals, foreigners and ethnic minorities became the norm, with religious wars and inquisitions playing out over the following centuries.

In my view, many parts of the world are now in the middle of a second Renaissance. This one is seeing even faster change than the last, and across the entire globe. History tells us that it will be disruptive. It will bring immense benefits and it will be highly destabilizing. We should expect more extremism and the rise of potentially catastrophic risks.

Innovation today is happening faster than ever, driven by the unlocking of individual and collective abilities in a booming population. On average, literacy levels, life expectancy and incomes have soared. Flows of goods, services, money, people and, most importantly, ideas across national borders — globalization — has unleashed unprecedented progress and a scientific and broader renaissance. They have also brought growing interdependence and new risks[1, 2].

The Internet helps to harness the global capacity for connectivity and innovation, but also brings us malware, cybercrime and the sacrifice of privacy. Airports are crucial to international integration of science and commerce, but they can also be super-spreaders of pandemics — just as explorers to the new world brought with them fatal diseases. Financial hubs create fresh opportunities for economies to prosper, but they simultaneously allow a financial crisis in one country to destroy jobs and pensions in distant parts of the world[3].

The tension between individual success and collective collapse is growing. As more people escape poverty and climb the energy curve, climate change and biodiversity loss accelerate. As more people benefit from better nutrition, ocean fisheries are at risk of collapse and forests are destroyed for cattle. Improvements in global health could soon be threatened by rapidly rising

antibiotic resistance.

Accelerating technological change will provide solutions for many challenges, from cancer to cleaner sources of energy. But our politics and our institutions are locked in past models that are increasingly unfit for purpose. Deep ethical issues arising from genomics research and the potential dangers of biological pathogens are not being adequately addressed. Improvements in computing and artificial intelligence will kill off many jobs. Breakthroughs in nanotechnology and materials science, augmented and virtual reality, 3D printing and other applications will also radically disrupt society. All are barely understood by politicians and most citizens.

Growing gap

Inequality is rising in almost all countries that are experiencing rapid change. The faster the pace of change, the more rapidly people are being left behind. The share of wealth enjoyed by the top 1% of citizens in the advanced economies has risen from an average of 17% in the late 1980s to more than 23% today (it is 39% in the United States). Countries starting from a more equal distribution of wealth, such as China and the nations of the former Soviet Union, have seen the most rapid rise in inequality[4].

John MacDougall/AFP/Getty

A robot sweeps food towards two dairy cows at an 'automated farm' exhibit at a food and agriculture fair.

Far from levelling the playing field and making the world more 'flat', as is alleged, globalization is making it more mountainous. Place matters more than ever. Cities hold a growing share of wealth and job opportunities, but it is increasingly difficult to afford to live in them. In dynamic ones, such as London, San Francisco, Paris, Berlin, Shanghai and Mumbai, house prices relative to average incomes are at an all-time high.

Technological change is already a key contributor to the growing inequality[5]. This is likely to be exacerbated as machine intelligence and automation take over a growing share of routine tasks in manufacturing and services, including retail, administration and call centres. Over the next 20 years, up to half of US jobs, one-third of jobs in the United Kingdom and the European Union and two-thirds of jobs in China and Mexico may be replaced by computers and robotics[6].

The future will bring new jobs, but their number will be small relative to those lost. And the quality of many of these new jobs will be inferior, in terms of the conditions of work and pay. Although it is tempting to imagine a world in which machines do dangerous and routine jobs, leaving more creative, stimulating and well-paid jobs for humans, this may not come to pass. The pace and scale of technological disruption, which far exceeds that of any previous industrial revolution, raises doubts about our capacity to keep up. We may not be able to redistribute enough funds from the wealthy, or come up with sufficiently creative changes to our systems of work and social safety, to prevent a further rise in inequality[6, 7]. Although this is a major issue for advanced economies, it is even more so for developing countries, because automation may remove key rungs of semi-skilled tasks from the development ladder.

Growing interdependence and complexity also mean that our politicians are increasingly unable to protect or shape our futures. Rather than pursue more cooperative politics, which enhance the benefits of connectivity and mitigate the risks, politicians increasingly blame foreigners and immigrants for the ills. This is profoundly misguided. Immigrants contribute disproportionately to the dynamism of our societies, as can be seen in the talent pool of leading universities, Silicon Valley firms, Nobel prizewinners and patent holders[8].

Those living in the fast-changing cosmopolitan cities of the world are embracing globalization and change: most Londoners did not support Britain's decision to exit from the European Union; people living in dynamic cities tended not to support US President Trump. The populist call for protectionism is driven by those in the United States who fear being left behind. This is not an irrational fear: as is evident from inequality, unemployment and health data, some people are being left behind. There is a correlation, for example, between those who voted for Trump and those whose jobs are vulnerable to having machines take over their jobs[9].

Alongside their anxieties about being left behind by globalization comes a deep mistrust of the 'experts' in charge of the global systems, and a rejection of evidence. Paradoxically, although we know more than ever, rising complexity and speed of change mean that experts are likely to be wrong more often. The financial system, for example, is home to numerous highly qualified experts, housed in a formidable array of powerful institutions, who are handsomely paid to secure economic stability. Yet, as the 2008 financial crisis demonstrated, they have proved dismally unequal to the task. Similarly, experts in the European Commission seem to have failed to control reporting of emissions from leading car manufacturers. Little wonder that trust in authority has been severely eroded. When the evidence threatens entrenched elites, scepticism regarding expertise becomes particularly poisonous. Trump's dismissal of the science of climate change is an egregious example of this trend.

The flourishing of science was contested in the original Renaissance, too. Printing presses provided the means for experts and intellects to share knowledge, but also allowed fake news to flourish. In Medici Florence, fundamentalist Italian preacher Girolamo Savonarola circumvented the authority of popes and princes with the mass production of one-page pamphlets — the equivalent of today's tweets. Both Savonarola and the clergy denied that Earth went around the Sun, and that the heart was a pump.

Although history does not repeat itself, it does rhyme. In the United Kingdom, campaigners successfully used social media to convince people to support Brexit even when it was against their interests, as in the case of farmers who receive subsidies from the European Union. In the United States, social media that propagated fears rather than facts played a key part in shaping the outcome of the 2016 presidential election[10].

Rapid response

As societies change more rapidly, flexibility becomes more important. For individuals, it becomes more necessary to move to where the jobs are and to reskill. For governments, it is crucial to renew infrastructure and social safety nets. Regulatory frameworks also need to evolve rapidly, to address a widening range of risks — from the genetic enhancement of humans to geoengineering.

Unfortunately, at a time when the need to renew and invest in the future is rising, the ability of governments to keep pace with change is being undermined. The use of off-shore tax havens — notably by companies at the frontier of technological change — as well as competition by governments to attract increasingly mobile individuals and companies by reducing taxes, together with austerity policies, have reduced the capacity of governments to invest in health, education, infrastructure, social security, research and other expenditures[11]. Lower investment leads to lower growth and political gridlock, as politicians fight over the allocation of fixed or diminishing resources.

Stronger safety nets are necessary to prevent poor and vulnerable individuals and families from being undermined by technological and other changes. If not, social cohesion will be eroded, fanning the flames of populist push-back against change and all things foreign.

Some Silicon Valley billionaires, fearing revolt against the growing wage gap, along with some social activists, have called for the introduction of a Universal Basic Income (UBI) for people working and not. But a UBI is not a panacea. The Organisation for Economic Co-operation and Development has shown that the policy could, perversely, increase inequality and poverty. And, because jobs are so important to our status and self-worth, having money alone does not protect against the increases in morbidity, criminal activity, opioid and alcohol abuse that have been associated with unemployment[12].

Instead, we need a broader change in attitudes towards work. We need to remove the stigmas associated with part-time employment, retirement and volunteer work. We should nurture a greater respect and pay for creative, caring and home-based activities.

There are reasons for optimism. There are more scientists alive today than all those who previously lived; citizen science adds millions more. As well as more minds at work, there are more-diverse collaborations, thanks to greater gender equality and the participation of more nations and peoples. The probability of unlocking mysteries and finding solutions to great challenges is rising, as is the global dissemination of the benefits. Cross-border collaborative projects, from the CERN particle-physics laboratory near Geneva, Switzerland, to the Human Genome Project, highlight the benefits of cooperative activity, in stark contrast to isolationist politics.

Now, more than ever, scientists must engage and communicate, to ensure that science is not overrun by politics. Renaissance moments are associated with an intensifying battle of ideas. Scientists need to engage in this struggle over the development and application of their expertise and inventions.

In the first Renaissance, extremists won; reason and evidence did not prevail. In our second Renaissance, knowledge and enquiry must find a way to conquer prejudice and ignorance. Scientists know that they can never progress through isolationism or ignorance. Nor can our societies.

Journal name:
Nature
Volume:
550,
Pages:
327–329
Date published:
(19 October 2017)
DOI:
doi:10.1038/550327a

Comments

4 comments

1. *Pentcho Valev* • 2017-10-19 06:50 AM
   "Look, my lad, I know a dead parrot when I see one, and I'm looking at one right now." https://www.youtube.com/watch?

v=RQhVLHu8HRk Physicists know a dead science when they see one, and they've been looking at one since January 2001: Joao Magueijo, Faster Than the Speed of Light, p. 250: "Lee [Smolin] and I discussed these paradoxes at great length for many months, starting in January 2001. We would meet in cafés in South Kensington or Holland Park to mull over the problem. THE ROOT OF ALL THE EVIL WAS CLEARLY SPECIAL RELATIVITY. All these paradoxes resulted from well known effects such as length contraction, time dilation, or E=mc^2, all basic predictions of special relativity. And all denied the possibility of establishing a well-defined border, common to all observers, capable of containing new quantum gravitational effects." http://www.amazon.com/Faster-Than-Speed-Light-Speculation/dp/0738205257 Neil Turok: "It's the ultimate catastrophe: that theoretical physics has led to this crazy situation where the physicists are utterly confused and seem not to have any predictions at all." http://www2.macleans.ca/2013/09/05/perimeter-institute-and-the-crisis-in-modern-physics/ Frank Close: "In recent years, however, many physicists have developed theories of great mathematical elegance, but which are beyond the reach of empirical falsification, even in principle. The uncomfortable question that arises is whether they can still be regarded as science. Some scientists are proposing that the definition of what is "scientific" be loosened, while others fear that to do so could open the door for pseudo-scientists or charlatans to mislead the public and claim equal space for their views." http://www.prospectmagazine.co.uk/features/what-happens-when-we-cant-test-scientific-theories Sabine Hossenfelder: "Many of my colleagues believe this forest of theories will eventually be chopped down by data. But in the foundations of physics it has become extremely rare for any model to be ruled out. The accepted practice is instead to adjust the model so that it continues to agree with the lack of empirical support." http://www.nature.com.proxy.readcube.com/nphys/journal/v13/n4/f Sabine Hossenfelder (Bee): "The criticism you raise that there are lots of speculative models that have no known relevance for the description of nature has very little to do with string theory but is a general disease of the research area. Lots of theorists produce lots of models that have no chance of ever being tested or ruled out because that's how they earn a living. The smaller the probability of the model being ruled out in their lifetime, the better. It's basic economics. Survival of the 'fittest' resulting in the natural selection of invincible models that can forever be amended." http://www.math.columbia.edu/~woit/wordpress/?p=9375 Peter Woit: "As far as this stuff goes, we're now not only at John Horgan's "End of Science", but gone past it already and deep into something different." http://www.math.columbia.edu/~woit/wordpress/?p=7266 "But instead of celebrating, physicists are in mourning after a report showed a dramatic decline in the number of pupils studying physics at school. The number taking A-level physics has dropped by 38% over the past 15 years, a catastrophic meltdown that is set to continue over the next few years. The report warns that a shortage of physics teachers and a lack of interest from pupils could mean the end of physics in state schools. Thereafter, physics would be restricted to only those students who could afford to go to posh schools. Britain was the home of Isaac Newton, Michael Faraday and Paul Dirac, and Brits made world-class contributions to understanding gravity, quantum physics and electromagnetism - and yet the British physicist is now facing extinction. But so what? Physicists are not as cuddly as pandas, so who cares if we disappear?" http://www.guardian.co.uk/science/2005/nov/22/schools.g2 Peter Woit: "If, as seems increasingly all too possible, we're now at an endpoint of fundamental physics, with the field killed off by a pseudo-scientific argument..." http://www.math.columbia.edu/~woit/wordpress/?p=9444 Peter Woit: "I think the worst thing that has happened to theoretical physics over the past 25 years is this descent into ideology, something that has accelerated with the multiverse mania of the last 10-15 years." http://www.math.columbia.edu/~woit/wordpress/?p=9375 The last quotation is correct, except for the number 25 - it should be replaced by 112 (note the "embarrassing question" that will have to be answered soon): "This paper investigates an alternative possibility: that the critics were right and that the success of Einstein's theory in overcoming them was due to its strengths as an ideology rather than as a science. The clock paradox illustrates how relativity theory does indeed contain inconsistencies that make it scientifically problematic. These same inconsistencies, however, make the theory ideologically powerful. [...] The gatekeepers of professional physics in the universities and research institutes are disinclined to support or employ anyone who raises problems over the elementary inconsistencies of relativity. A winnowing out process has made it very difficult for critics of Einstein to achieve or maintain professional status. Relativists are then able to use the argument of authority to discredit these critics. Were relativists to admit that Einstein may have made a series of elementary logical errors, they would be faced with the embarrassing question of why this had not been noticed earlier. Under these circumstances the marginalisation of antirelativists, unjustified on scientific grounds, is eminently justifiable on grounds of realpolitik. Supporters of relativity theory have protected both the theory and their own reputations by shutting their opponents out of professional discourse. [...] The triumph of relativity theory represents the triumph of ideology not only in the profession of physics bur also in the philosophy of science." Peter Hayes, The Ideology of Relativity: The Case of the Clock Paradox http://www.informaworld.com/smpp/content~content=a909857880 And when ideology replaces science, bureaucrats replace scientists of course: Mike Alder: "It is easy to see the consequences of the takeover by the bureaucrats. Bureaucrats favour uniformity, it simplifies their lives. They want rules to follow. They prefer the dead to the living. They have taken over religions, the universities and now they are taking over Science. And they are killing it in the process. The forms and rituals remain, but the spirit is dead. The cold frozen corpse is so much more appealing to the bureaucratic mind-set than the living spirit of the quest for insight. Bureaucracies put a premium on the old being in charge, which puts a stop to innovation. Something perhaps will remain, but it will no longer attract the best minds. This, essentially, is the Smolin position. He gives details and examples of the death of Physics, although he, being American, is optimistic that it can be reversed. I am not. [...] Developing ideas and applying them is done by a certain kind of temperament in a certain kind of setting, one where there is a good deal of personal freedom and a willingness to take risks. No doubt we still have the people. But the setting is gone and will not come back. Science is a product of the renaissance and an entrepreneurial spirit. It will not survive the triumph of bureacracy. Despite having the infrastructure, China never developed Science. And soon the West won't have it either." https://www.highbeam.com/doc/1G1-172684821.html Pentcho Valev

2. *Pentcho Valev* • 2017-10-18 04:30 PM

   Fundamental physics is paralyzed, even killed, by blind faith in false principles. The falsehood of Einstein's constant-speed-of-light postulate is easy to prove but I'm not going to do this here. Let me just call the attention, by quoting Joao Magueijo, to the validity of the following conditional: If Einstein's constant-speed-of-light postulate is false, fundamental physics is dead. "The speaker Joao Magueijo, is a Reader in Theoretical Physics at Imperial College, London and author of Faster Than the Speed of Light: The Story of a Scientific Speculation. He opened by explaining how Einstein's theory of relativity is the foundation of every other theory in modern physics and that the assumption that the speed of light is constant is the foundation of that theory. Thus a constant speed of light is embedded in all of modern physics and to propose a varying speed of light (VSL) is worse than swearing! It is like proposing a language without vowels." http://www.thegreatdebate.org.uk/VSLRevPrnt.html "...Dr. Magueijo said. "We need to drop a postulate, perhaps the constancy of the speed of light." http://www.nytimes.com/2002/12/31/science/e-and-mc2-equality-it-seems-is-relative.html "But the researchers said they spent a lot of time working on a theory that wouldn't destabilise our understanding of physics. "The whole of physics is predicated on the constancy of the speed of light," Joao Magueijo told Motherboard. "So we had to find ways to change the speed of light without wrecking the whole thing too much."

http://www.telegraph.co.uk/technology/2016/12/06/speed-light-discovered/ Joao Magueijo, Faster Than the Speed of Light, p. 250: "Lee [Smolin] and I discussed these paradoxes at great length for many months, starting in January 2001. We would meet in cafés in South Kensington or Holland Park to mull over the problem. THE ROOT OF ALL THE EVIL WAS CLEARLY SPECIAL RELATIVITY. All these paradoxes resulted from well known effects such as length contraction, time dilation, or E=mc^2, all basic predictions of special relativity. And all denied the possibility of establishing a well-defined border, common to all observers, capable of containing new quantum gravitational effects." http://www.amazon.com/Faster-Than-Speed-Light-Speculation/dp/0738205257 Pentcho Valev

3. *Pentcho Valev* • 2017-10-18 05:19 PM

   Another science killer is the false second law of thermodynamics. Systems violating the second law are commonplace but scientists always turn the blind spot of the eye to them. Here is vigorous motion of water in an electric field, obviously able to produce work - e.g. by rotating a waterwheel: "The Formation of the Floating Water Bridge including electric breakdowns" https://www.youtube.com/watch?v=17UD1goTFhQ "The water movement is bidirectional, i.e., it simultaneously flows in both directions." https://www.wetsus.nl/home/wetsus-news/more-than-just-a-party-trick-the-floating-water-bridge-holds-insight-into-nature-and-human-innovation/1 The work (rotating a waterwheel) will be done at the expense of what energy? The first hypothesis that comes to mind is: At the expense of electric energy. The system is, essentially, an electric motor. However close inspection would suggest that the hypothesis is untenable. Scientists use triply distilled water to reduce the conductivity and the electric current passing through the system to minimum. If, for some reason, the current is increased, the motion stops - such system cannot be an electric motor. If the system is not an electric motor, then it is a heat engine violating the second law of thermodynamics. Here arguments describing such heat engines as impossible, idiotic, etc. are irrelevant - the following conditional is valid: IF THE SYSTEM IS NOT AN ELECTRIC MOTOR, then it is a a heat engine violating the second law of thermodynamics. In other words, if the work is not done at the expense of electric energy, it is done at the expense of ambient heat. No third source of energy is conceivable. In the electric field between the plates of a capacitor, the same turbulent motion can be seen: " Liquid Dielectric Capacitor" http://www.youtube.com/watch?v=T6KAH1JpdPg In the capacitor system the rising water can repeatedly do work, e.g. by lifting floating weights. The crucial question is: The work (lifting floating weights) will be done at the expense of what energy? Obviously "electric energy" is not the correct answer - the capacitor is not an electric motor. Then the only possible answer remains "ambient heat". The system is a heat engine violating the second law of thermodynamics! Pentcho Valev

4. *Pentcho Valev* • 2017-10-19 07:03 AM

   Why scientists are unable to see the obvious violations of the second law of thermodynamics: Clifford Truesdell, The Tragicomical History of Thermodynamics, 1822-1854, p. 6: "Finally, I confess to a heartfelt hope - very slender but tough - that even some thermodynamicists of the old tribe will study this book, master the contents, and so share in my discovery: Thermodynamics need never have been the Dismal Swamp of Obscurity that from the first it was and that today in common instruction it is; in consequence, it need not so remain." [...] p. 333: "Clausius' verbal statement of the "Second Law" makes no sense, for "some other change connected therewith" introduces two new and unexplained concepts: "other change" and "connection" of changes. Neither of these finds any place in Clausius' formal structure. All that remains is a Mosaic prohibition. A century of philosophers and journalists have acclaimed this commandment; a century of mathematicians have shuddered and averted their eyes from the unclean." https://www.amazon.com/Tragicomical-Thermodynamics-1822-1854-Mathematics-Physical/dp/1461394465 Jos Uffink, Bluff your way in the Second Law of Thermodynamics: "I therefore argue for the view that the second law has nothing to do with the arrow of time. [...] Before one can claim that acquaintance with the Second Law is as indispensable to a cultural education as Macbeth or Hamlet, it should obviously be clear what this law states. This question is surprisingly difficult. The Second Law made its appearance in physics around 1850, but a half century later it was already surrounded by so much confusion that the British Association for the Advancement of Science decided to appoint a special committee with the task of providing clarity about the meaning of this law. However, its final report (Bryan 1891) did not settle the issue. Half a century later, the physicist/philosopher Bridgman still complained that there are almost as many formulations of the second law as there have been discussions of it. And even today, the Second Law remains so obscure that it continues to attract new efforts at clarification." http://philsci-archive.pitt.edu/313/1/engtot.pdf Pentcho Valev

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Brazilian Amazon still plagued by illegal use of natural resources

Practices such as poaching and illegal logging are concentrated near inhabited areas and along rivers, study finds.

17 October 2017

Jeff Hutchens/Getty

An official with Brazil's environmental enforcement agency arrests poachers caught near Manaus.

Despite Brazil’s efforts to safeguard the Amazon rainforest by establishing protected areas and boosting law enforcement, illegal use of the region’s natural resources is still widespread, according to a study[1] published on 10

October in *PeerJ*.

The researchers looked at 4,243 law-enforcement records from between 2010 and 2015, across 118 federally protected areas of the Brazilian Amazon. Although the overall number of citations decreased over those five years, illegal activities still occurred in nearly every protected area. The analysis highlighted the need for improved monitoring and enforcement, says study co-author Érico Kauano, a conservation biologist at the Chico Mendes Institute for Biodiversity Conservation (ICMBio), the Brazilian agency responsible for the management of the federal protected areas.

Kauano and his colleagues grouped illegal activities into ten categories, and found that 37% of the infractions fell into the "suppression and degradation of vegetation" group, which included deforestation, logging of endangered tree species and the unauthorized use of fire. Illegal fishing was the next most common citation at 27%, followed by hunting at 18%. Most of the illegal activity occured in more accessible and densely populated areas.

Roads have a major role in opening up the tropics to colonization and exploitation[2]. Deforestation of the Brazilian Amazon increased after the construction of the Belém–Brasília Highway in the 1960s, and continued with the opening of the Trans-Amazonian Highway in 1970s. A 2014 study[2] using satellite images found that around 95% of the deforestation in Brazil's Amazon occurred within 5.5 kilometres of a road and within 1 kilometre of a navigable river.

Caught in the act

The availability and use of government data are what sets this study apart from others, says Emilio Bruna, a tropical ecologist at the University of Florida in Gainesville, who was not involved in the study. Past studies, including a paper[3] published last month in *Biotropica* (where Bruna is editor-in-chief), struggled to obtain even the most basic information, such as how many staff members were employed by the agency that manages protected areas, and how much they were paid, Bruna says.

Data from efforts on the ground are important because, although remote-sensing instruments such as satellites can detect deforestation, for example, they fail to identify threats present beneath the forest canopy. Law-enforcement records, when available, can complement remote-sensing data sets, the study authors say.

“You can actually tell what it is they’re writing infractions for, and that’s valuable,” says Bruna. But he points out that, without knowing where law-enforcement efforts are being allocated, it’s only a partial picture. “It could be that the reason certain protected areas have the most infractions is because those are the places that are under the greatest threat,” he says. “Or it could be because that’s where the greatest enforcement is being focused.”

Greater enforcement

“We are still far from having adequate staff in the protected areas,” Kauano says. In 2014, a local news outlet reported that the Brazilian Institute of Environment and Renewable Natural Resources had only 47 agents to monitor environmental crimes in Amazonas, the country’s largest state in the Amazon region, which covers an area of about 1.6 million square kilometres.

Hiring more enforcement officials looks unlikely in the short term, however, owing to Brazil’s ongoing political and economic crisis, says Kauano. “What ICMBio seeks to do to overcome this is to prioritize some regions with greater problems.”

Bruna cautions against jumping to conclusions from the study’s results, however. “Not all infractions are created equal,” he says. It’s important to differentiate between a resident fishing out of season and a fishing charter operator. Bruna worries that some may look at this study and think that the people living near protected areas are the problem. But they aren’t the only ones breaking the law, he says. And the demand for the fruits of this illegal labour comes from all over the world.

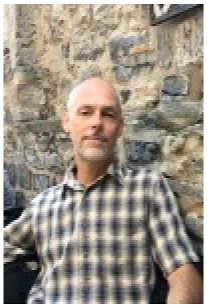
Local people can, in fact, be part of the solution. There is some evidence that people living in or near protected areas are helping with conservation, says

Kauano. But he adds that the government needs to make a greater effort to work with local communities.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22830

Comments

Commenting is currently unavailable.



Ellie R.
Martinson

Give researchers a lifetime word limit

Brian C. Martinson[1] imagines how rationing the number of publications a scientist could put out might improve the scientific literature.

17 October 2017

A dirty truth pervades academic publishing: we write papers to gain credit in an academic marketplace. Almost a quarter of a century ago, academic worthies lamented that scholarly publications had become “the coins academics must use to get through the tollgates on their way to academic promotion” (D. Rennie and A. Flanagin *J. Am. Med. Assoc.* **271**, 469–471; 1994). In some cases, papers in flashy journals truly do bring in hard cash — reportedly more than US$40,000 at some universities in China. And plenty of people reading this will have felt they’d better squeeze a paper or two out soon to have any chance of getting their next grant proposal funded.

The purpose of authorship has shifted. Once, its primary role was to share knowledge. Now it is to get a publication — ‘pubcoin’ if you will. Authorship has become a valuable commodity. And as with all valuable commodities, it is bought, sold, traded and stolen. Marketplaces allow

unscrupulous researchers to purchase authorship on a paper they had nothing to do with, or even to commission a paper on the topic of their choice. ‘Predatory publishers’ strive to collect fees without ensuring quality.

I have spent much of my career studying how academic and clinical workplaces influence how carefully researchers conduct their studies. The commodification of authorship encourages all manner of corner-cutting, sloppiness in research, and other degradations in the quality of publications, not to mention an obvious motive for plagiarism. A quest for high-profile papers leads researchers to favour a spectacular result, even if it is specious. Authors cite themselves to boost the impact of publications, and cite colleagues to curry favour.

At this point, it is hard even to envisage a world in which the communication of knowledge could return to its rightful place as the focus of academic authorship. But if we cannot imagine something, we cannot attain it. So let me try. Imagine a world in which each scientist is allotted a fixed number of words that they can publish over her or his career. I’m not the first person to suggest this: the Australian writer Michael McGirr has proposed a word limit for every person.

What would happen? Might authorship regain its original purpose?

Lifetime limits would create a natural incentive to do research that matters. Researchers would have to ask themselves, “Is this project I’m pursuing worth the words it will cost me?” I see several articles in my own CV that did not contribute much knowledge to the world. I cannot help but think that I might have pursued better questions had a word limit been in place.

Ideally, limits would encourage researchers to ensure that research is conducted with the utmost care. (Imagine losing part of your allotment of words to a paper that is discredited or even retracted.) This would provide a counterweight to the pressure to publish quickly for priority. It would also lead to increased value being placed on concision and clarity, improving readability and efficiency. Honorary authorship would become much less attractive.

With less time needing to be spent on papers of low quality or containing

little new information, readers and editors would be able to give the smaller number of articles more attention. Editorial workload would be reduced by virtue of the lower volume and the higher quality of material. This might reduce editorial costs, enhance quality, and quite possibly enhance the job satisfaction and quality of life of editors and readers. Predatory publishers would vanish.

With a boost in the quality of scientific papers, the communal work of peer review would get easier. Individual researchers would be asked to carry out fewer reviews. Reviewing invitations would be for work of higher quality, making the job more enjoyable and less aggravating. And knowing the stakes for the authors in expending their precious words, reviewers themselves might be inclined to put more time and effort into their reviews, further improving quality.

The task of evaluating candidates for jobs, advancement and prizes would become less scattershot. With fewer publications per candidate, promotion and tenure committees could become less reliant on tallying counts of first-authored publications, and devote time to reading and critiquing the published work. This, in turn, should reduce their use of journal impact factors as proxies for quality.

Limits would of course bring a new set of problems: if we don't also address our own cognitive biases and penchant for compelling narratives, word limits could exacerbate tendencies to publish only positive findings, leading researchers to explore blind alleys that others' negative results could have illuminated. Researchers might skimp on a full description of caveats, previous work and methods. Some subjects and pursuits might be inherently wordier than others. Exceptions might have to be made for experts such as statisticians and bioinformaticians whose skills are required on many papers — but perhaps this would boost the quality of collaborations. Perhaps researchers could apply for word bonuses for careful reproductions, cautious interpretations and meticulously described methods.

Would these drawbacks be worse than the current incentives to publish as much as you can? We have lost sight of information sharing as the primary reason for publishing. Perhaps my flight of fancy is a rose-tinted remembrance of times past. Or perhaps it can serve as a guide to restore the

exchange of ideas to its rightful, pithy, place.

Journal name:
Nature
Volume:
550,
Pages:
303
Date published:
(19 October 2017)
DOI:
doi:10.1038/550303a

Comments

Commenting is currently unavailable.

Japanese research leaders warn about national science decline

Concern mounts over budget cuts and other changes that undermine basic science.

17 October 2017

Toru Hanai/Reuters

People gather for a rally in Fukushima, Japan, for Prime Minister Shinzo Abe and the Liberal Democratic Party.

As Japan heads towards a national election on 22 October, scientific leaders worry that the outcome will do little to address long-standing concerns about

the country’s deteriorating research landscape. They say that a decline in funding and a shift away from basic research has undermined Japan’s capacity to compete against both established scientific powerhouses and emerging ones such as China.

Since 25 September, when Prime Minister Shinzo Abe called for a snap election, science has barely featured in the campaign. Debate has focused on the government’s plan to amend the constitution and increase taxes. The latest polls suggest that Abe’s conservative Liberal Democratic Party could lose some seats, but will retain enough to lead a coalition government.

If Abe is re-elected, he says, his government will pursue an innovation agenda. At a meeting of global science leaders in Kyoto on 1 October, Abe reaffirmed his pledge to turn Japan into “a cradle of innovation” by cutting regulations that impede new technologies.

Despite Abe’s lofty ambitions, the ruling party coalition has decreased the science and technology budget by more than 5% overall since it came to power in 2012. And the budget for universities has dropped by about 1% a year for a decade. “This has been pointed out as the major cause of the deterioration of research performance and, eventually, the global rank of Japanese universities,” says Takashi Onishi, president of Toyohashi University of Technology and a former president of the Science Council of Japan, which advises the government. In the past two decades, the country’s share of highly cited papers has stagnated, whereas those of many other leading nations are rising, according to publisher Elsevier’s Scopus database.

In an attempt to elevate Japan’s top research universities, the government has introduced reforms that categorize institutions according to their research or teaching focus, and that allocate funding on the basis of performance. The government wants leading research institutions to compete globally for the best students and faculty.

Atsushi Sunami, a science-policy specialist at the National Graduate Institute for Policy Studies (GRIPS) in Tokyo, agrees with this aim, but says that to succeed, the government will need to increase its research funding. And money alone will not be enough, says Hiroshi Nagano, also a science-policy specialist at GRIPS. For universities to become world class, they need

autonomy to decide their research and teaching focus, he says. “The current policy is oriented in the opposite direction.”

Basic research left behind

Changes to the university system implemented by Abe’s government are designed to make academia more responsive to the needs of society and industry, in the hope that it will boost low private-sector investment in research. Although scientists broadly encourage this increased collaboration, some say that it has compromised support for basic research. “The government should focus on the development of basic research to supply seeds or ideas to applied sciences,” says Onishi.

Science leaders point to other big concerns about the future of Japanese research. Minicharini Hamaguchi, head of the Japan Science and Technology Agency in Kawaguchi, says that the domestic workforce will be insufficient to keep up with changes in science, technology and innovation, given the country’s rapidly ageing population. He says that policies are urgently needed to encourage more women and foreigners into science and to boost the number of students in doctoral courses, which has dropped by 18% since 2003.

Students who pursue research careers are finding it harder to get jobs. Budget cuts have depleted permanent research positions at universities, and fewer younger researchers are securing permanent posts: the number of research associates on short-term contracts more than doubled from 2007 to 2013.

Biologist and 2016 Nobel prizewinner Yoshinori Ohsumi has warned that the situation for young researchers will jeopardize the country’s chances of winning future Nobel prizes. Japan has the second-highest number of science laureates in the twenty-first century after the United States — but, Ohsumi says, that record is unlikely to hold.

Journal name:
Nature
Volume:

550,
Pages:
310–311
Date published:
(19 October 2017)
DOI:
doi:10.1038/550310a

Comments

Comments

There are currently no comments.

Reboot for the AI revolution

17 October 2017

As artificial intelligence puts many out of work, we must forge new economic, social and educational systems, argues Yuval Noah Harari.

Laura Lezza/Getty

A robot conducts the Orchestra Filarmonica di Lucca at Teatro Verdi in Pisa, Italy, this September.

The ongoing artificial-intelligence revolution will change almost every line of work, creating enormous social and economic opportunities — and challenges. Some believe that intelligent computers will push humans out of the job market and create a new 'useless class'; others maintain that

automation will generate a wide range of new human jobs and greater prosperity for all. Almost everybody agrees that we should take action to prevent the worst-case scenarios.

The automation revolution is emerging from the confluence of two scientific tidal waves. Computer scientists are developing artificial intelligence (AI) algorithms that can learn, analyse massive amounts of data and recognize patterns with superhuman efficiency. At the same time, biologists and social scientists are deciphering human emotions, desires and intuitions. The merger of infotech and biotech is giving rise to algorithms that can successfully analyse us and communicate with us, and that may soon outperform human doctors, drivers, soldiers and bankers in such tasks. These algorithms could eventually push hundreds of millions out of the job market.

Governments might decide to deliberately slow down the pace of automation, to lessen the resulting shocks and allow time for readjustments. But it will probably be both impossible and undesirable to prevent automation and job loss completely. That would mean giving up the immense positive potential of AI and robotics. If self-driving vehicles drive more safely and cheaply than humans, it would be counterproductive to ban them just to protect the jobs of taxi and lorry drivers.

A more sensible strategy is to create new jobs. In particular, as routine jobs are automated, opportunities for new non-routine jobs will mushroom. For example, general physicians who focus on diagnosing known diseases and administering familiar treatments will probably be replaced by AI doctors. Precisely because of that, there will be more money to pay human experts to do groundbreaking medical research, develop new medications and pioneer innovative surgical techniques.

This calls for economic entrepreneurship and legal dexterity. Above all, it necessitates a revolution in education.

Lifelong learning

To make use of the new opportunities, people will need radical, lifelong

retraining. The AI revolution won't be a single event after which the job market and the educational system will settle into a new equilibrium. Rather, it will be a cascade of ever-bigger disruptions. Even today, few employees expect to work in the same job for their entire life (see go.nature.com/2ymdvjs). By 2050, not just the idea of 'a job for life', but even the idea of 'a profession for life' might seem antediluvian. It will become increasingly difficult to know what to teach schoolchildren and university students.

Predicting the future was never easy. If you lived in China 1,000 years ago, there were many things you didn't know: the empire might collapse in 50 years; the Khitans might invade, or a new plague might kill millions. Nevertheless, you did know that most people would still work as farmers and weavers, rulers would still need men to fight in their armies and administer their taxes, women would still have few opportunities beyond marriage and life expectancy would still be about 40 years.

LISTEN

Reporter Benjamin Thompson finds out how lessons from the past can help explore the future of work.

You may need a more recent browser or to install the latest version of the Adobe Flash Plugin.

Hence, in 1017, poor Chinese parents taught their children how to plant rice or weave silk, and wealthier parents taught their boys how to read and write, or to fight on horseback, and their girls to be modest and obedient housewives. It was obvious that these skills would still be needed. In 2017, by contrast, we have no such certainties about the future of jobs, gender, economics or even death.

Human psychology, too, might turn out to be a key hurdle. Change is always stressful. Already we face an epidemic of stress and anxiety (see go.nature.com/2z96s57). As the volatility of the job market and of individual careers increases, we may wonder whether everyone will have the emotional

stamina necessary for a life of constant flux. We may need more-effective stress-reduction techniques — ranging from drugs through neurofeedback to meditation — to cope.

Creating new jobs might prove easier than retraining people to fill them. A huge useless class might appear, owing to both an absolute lack of jobs and a lack of relevant education and mental flexibility.

Test cases

It is particularly important to identify as early as possible the potential winners and losers from new technologies. Rosy overall statistics can hide growing gaps between disparate groups. Automation might have a very different impact on men and women, on 40-somethings and 20-somethings, on the university-educated and the illiterate.

The winners and losers are not the usual suspects. In the clinic, for example, automation might prove more of a threat to doctors than to nurses. Many physicians focus almost exclusively on processing information: they absorb medical data, analyse them and produce a diagnosis. Nurses also need good motor and emotional skills, to give a painful injection, replace a bandage and listen with care. We will probably have an AI family doctor on our smartphone years before we have a reliable nurse robot[1].

Exploring the relationship between intelligence and consciousness will also be crucial to understanding the economic, professional and ethical rapport between future computers and humans. We are seeing a tremendous development in computer intelligence, but zero development in computer consciousness. Just as aeroplanes fly faster than birds without ever developing feathers, so computers could come to solve problems and even to analyse human feelings much better than humans, without ever developing feelings. Studying these differences will help us to predict what AI can and cannot do, and to decide what should be kept out of its control.

There are a few areas in which AI has already made significant strides that, in my view, offer test cases for the impact of modern automation on the world

of work.

In chess, it has been 20 years since IBM's Deep Blue computer thrashed Gary Kasparov. Yet humans still play chess, and 'centaur' teams of humans-plus-AIs can outperform both. This seems at first to bode well for the future: the job market could nurture people who can leverage, rather than compete with, AI. Yet the balance of power in centaur teams is constantly shifting. Computers are becoming so good at chess that the humans are gradually losing value, and could soon become irrelevant. The same thing might happen in other human–AI teams[2].

Laura Lezza/Getty

A woman with a robot at an Italian nursing home in 2015.

Self-driving vehicles are another important test case. The race to produce self-driving vehicles now pits old steel giants such as Mercedes-Benz against new silicon giants such as Google. Transport leverages one of the core advantages of AI: connectivity. Even if a single computer-driven car is less

competent than a good human driver, a network of computer-driven cars is still likely to be much safer and more efficient than the chaos of fallible human drivers that currently dominates the roads.

Today, about 1.25 million people are killed annually in car accidents[3], more than 90% of which are estimated to be caused by human errors[4]. When two human drivers approach the same junction, they might miscommunicate and collide. But computer-driven vehicles can be connected — the chances that they might miscommunicate and collide are therefore much smaller. Similarly, it is easier to ensure that automated vehicles comply with rules such as speed limits (not to mention the ban on drink driving), even as those rules change[5, 6, 7].

Self-driving vehicles illustrate two important points. First, that in some fields it might make sense to replace all humans with robots and computers, even if individually some humans do a better job. Second, that when change comes to some realms, it might do so suddenly, not step-wise.

The military is another important bellwether, because armies are early adopters of much technology. Human soldiers carry a very high economic and political price tag, so replacing people with computers on the battlefield has proved attractive. The most advanced armies now increasingly rely on relatively small numbers of experts coupled with sophisticated and autonomous technologies, such as drones, robots, smart bombs, cyberworms and algorithms that sift through a mass of data[8, 9].

This shift has produced new classes of military jobs in maintenance, remote control, programming and cybersecurity. The US armed forces need 30 people to operate every Predator or Reaper drone flying over Syria, and analysing the harvest of information occupies at least 80 more. A careful study of the military job market might tell us a lot about potential future developments in the civilian economy.

New order

With insights gleaned from early warning signs and test cases, scholars

should strive to develop new socio-economic models. The old ones no longer hold. For example, twentieth-century socialism assumed that the working class was crucial to the economy, and socialist thinkers tried to teach the proletariat how to translate its immense economic power into political clout. In the twenty-first century, if the masses lose their economic value they might have to struggle against irrelevance rather than exploitation.

One new model has been gaining increasing attention and popularity: universal basic income (UBI). UBI suggests that the government should tax the rich and big corporations to provide every person with a stipend covering his or her basic needs. This will cushion the poor against job loss and economic dislocation, and protect the rich from populist rage. It will also free the masses to engage in more creative forms of work that might not currently have economic value, or to pursue further education.

In January 2017, Finland began a 2-year experiment, providing 2,000 unemployed citizens with €560 (US$657) per month, irrespective of whether they work. Similar experiments are under way in the Canadian province of Ontario, in the Italian city of Livorno and in several Dutch cities[10].

Of course, such national and municipal schemes might not solve the worst problems. Globalization has made people in one country utterly dependent on markets in others, and automation might unravel large parts of this global trade network with disastrous consequences for the weakest links. AI might generate immense wealth in hi-tech hubs such as Silicon Valley and Bangalore, while devastating the economies of underdeveloped countries that rely on cheap labour, such as Honduras and Bangladesh.

US voters might conceivably agree that taxes paid by tech giants Amazon and Google for their US business should be used to give stipends to unemployed coalminers in Pennsylvania or jobless taxi-drivers in New York. But they are unlikely to send their taxes to Honduras. We are still far from having any feasible models for a post-work economy, society or political system, and we don't have much time to formulate them.

In the nineteenth century, the Industrial Revolution created new conditions and problems that none of the existing social, economic and political models could cope with. Consequently, humankind had to develop completely new

models — liberal democracies, communist dictatorships and fascist regimes. It took more than a century of terrible wars and revolutions to experiment with these, separate the wheat from the chaff and implement the best solutions.

The challenges posed in the twenty-first century by the merger of infotech and biotech are arguably bigger than those thrown up by steam engines, railways, electricity and fossil fuels. Given the immense destructive power of our modern civilization, we cannot afford more failed models, world wars and bloody revolutions. We have to do better this time.

Journal name:
Nature
Volume:
550,
Pages:
324–327
Date published:
(19 October 2017)
DOI:
doi:10.1038/550324a

Comments

Comments

There are currently no comments.

Eye in the sky offers clearest vision of Earth

The world’s latest carbon-monitoring satellite has advanced our understanding of how the planet functions. US politicians should take note.

16 October 2017

Bill Ingalls/NASA

Launched in 2014, the OCO-2 satellite has offered unprecedented views of carbon flow on Earth.

When a rocket failure saw NASA’s first carbon-monitoring satellite plunge into the ocean in 2009, it was a major blow for climate scientists. Space-based greenhouse-gas monitoring was a promising new frontier — and perhaps an eventual tool for monitoring international climate commitments. It took several years to get a replacement into space, but the Orbiting Carbon Observatory-2 (OCO-2) began taking measurements in 2014. The first major scientific results were published last week in *Science*[1–5], and there can be no doubt that the mission is delivering. No doubts, either, that the US government should launch a successor.

The results give an unprecedented insight into one of the most important planetary phenomena: El Niño, the subtle but massively influential gathering of warm waters in the tropical Pacific Ocean. The 2015–16 El Niño was a monster, changing weather patterns and driving the largest and longest coral-reef-bleaching event on record. Through it all, scientists used OCO-2 to watch carbon move through oceans and ecosystems.

The overall trend came as little surprise — a massive increase in global atmospheric carbon levels. Scientists have measured similar rises in carbon dioxide during past El Niños. But the precise mechanism was elusive. OCO-2 helped clarify the matter by producing detailed maps. Researchers saw an initial decrease in the amount of CO_2 coming out of the tropical Pacific Ocean, a dip later swamped by CO_2 originating from Africa, South America and southeast Asia as the event wore on.

Tracking carbon is just the first step. Those data feed into atmospheric models that can provide a more comprehensive explanation for the origin — and destination — of any given CO_2 molecule. Fortunately, sensors on board OCO-2 can assess the amount of photosynthesis using methods other than measuring carbon flux. They detect a photosynthesis-linked signal called solar-induced chlorophyll fluorescence, which gives an independent measure of how much CO_2 plants are taking up.

With this suite of tools, scientists have managed to paint a finer picture of how the 2015–16 El Niño affected individual regions. Heat and drought set the stage for the massive wildfires that ravaged Indonesia during the event, whereas drought-stricken trees in the Amazon rainforest took up less carbon than usual. In Africa, the higher temperatures probably boosted plant respiration. All three mechanisms for increasing atmospheric CO_2 have been proposed in the past, but it was a surprise to see all play out on different continents simultaneously.

Plenty of questions remain. The satellite measurements are not as precise as scientists would like, and they don’t always align perfectly with data from the ground. And getting the models right is a never-ending challenge. It will be some time before satellites are able to provide the precision needed to quantify the natural carbon cycle, let alone to separate out human emissions with enough confidence to verify whether countries are meeting their obligations to cut greenhouse-gas emissions. But OCO-2 is further validation that the effort is worth pursuing.

US politicians should take note. President Donald Trump has proposed scrapping a follow-on mission, OCO-3, presumably because it falls under the rubric of climate — a topic that is anathema to this administration. That would be a self-defeating and damaging move. The bulk of the budget for

OCO-3 — which was built from the spare parts of its predecessor — has already been spent; all that's left is the expense of launch and operation. Killing the mission now would waste time and money. But more importantly, as these latest studies show, humanity can learn from the measurements that it will make.

OCO-2 is an affirmation of climate science that everybody should be able to appreciate, regardless of political leanings. Trump might not like talking about climate. But surely his administration — and the lawmakers on Capitol Hill who will decide whether OCO-3 survives — cares about the weather.

El Niño has an impact on weather systems around the world. It raises the likelihood of heavy rainfall from California to the Gulf of Mexico, while increasing the chances of drought and extreme heat in areas farther north. El Niño and its opposite sister system La Niña factor heavily in longer-term seasonal forecasts, which can help governments prepare for fires like those tearing through California at the moment. The more we understand this system, the better we will be at forecasting changes in the weather, the climate — and the economy. A 2014 report from the International Monetary Fund argued that effects of El Niño should be taken into account when nations plan their finances. This has nothing to do with politics, and everything to do with understanding the world in which we live.

Journal name:
Nature
Volume:
550,
Pages:
301
Date published:
(19 October 2017)
DOI:
doi:10.1038/550301a

Comments

Comments

There are currently no comments.

Colliding stars spark rush to solve cosmic mysteries

Stellar collision confirms theoretical predictions about the periodic table.

16 October 2017

Cosmic furnace

A simulation of the merger of two neutron stars, leading to the formation of a black hole. About 2% of the stars' mass gets ejected at high speed, producing radioactive, heavy atoms.

Credit: W. Kastaun/T. Kawamura/B. Giacomazzo/R. Ciolfi/A. Endrizzi via Caltech

Gold, platinum, uranium and many of the rare-earth elements that are crucial to today’s high-tech gadgets are generated during the formation of black holes, astronomers have said. The collision of two small but dense stars simultaneously solved several cosmic mysteries, researchers announced at a press conference in Washington DC on 16 October. More than 30 papers have been published so far in five journals — *Physical Review Letters, Science*, *Nature*, *Nature Astronomy* and *Astrophysical Journal Letters*.

Astronomers watched as two neutron stars — small but very dense objects formed after the collapse of stars bigger than the Sun — collided and merged, forming a black hole, in a galaxy 40 million parsecs (130 million light years) away, according to two dozen researchers interviewed by *Nature*’s News team.

The collision generated the strongest and longest-lasting gravitational-wave signal ever seen on Earth. And the visible-light signal generated during the

collision closely matches predictions made in recent years by theoretical astrophysicists, who hold that many elements of the periodic table that are heavier than iron are formed as a result of such stellar collisions.

Neutron-star mergers are also thought to trigger previously mysterious short γ-ray bursts, a hypothesis that now also seems to have been confirmed.

Astronomers have good reasons to believe that they are looking at the same source of both the gravitational waves and the short γ-ray bursts, says Cole Miller, an astronomer at the University of Maryland in College Park, who was not involved in the research but who has seen some of the papers ahead of their publication.

Bright object

The event was detected on Earth on 17 August, and triggered weeks of febrile, round-the-clock activity on all 7 continents, as more than 70 teams of researchers scrambled to observe the aftermath.

The collision was felt first as a space-time tremor by the Laser Interferometer Gravitational-wave Observatory (LIGO) in the United States and by its Italy-based counterpart Virgo, and seen seconds afterwards as a smattering of high-energy photons by NASA's Fermi Gamma-ray Space Telescope.

Alerted by the LIGO–Virgo team, astronomers then raced to find and study what was seen as a bright object in the sky using telescopes big and small, famous and obscure, on land and in orbit, and spanning the spectrum of electromagnetic radiation, from radio waves to X-rays.

Cody Messick was at his home at 08:41 local time (12:41 UT) on 17 August when he first found out about the event. "I remember standing on my stairs and looking at my phone, thinking: 'Wow!" he says. Messick, who is a physicist at Pennsylvania State University in University Park, belongs to a small team of LIGO first-responders who receive frequent automated alerts from the two interferometers, which are based in Livingston, Louisiana, and Hanford, Washington. Normally, LIGO's algorithms flag a potential signal in real time only if both interferometers detect it. Messick was surprised,

because the message on his smartphone mentioned a strong signal — but one seen only at the Hanford site.

Messick quickly got on a conference call with his team leader, Chad Hanna, also at Pennsylvania State, and other colleagues. Together, they examined the data online. The Hanford signal looked like a textbook example of the waveform of the gravitational waves emitted by two compact objects, each slightly more massive than the Sun, as they spiral into each other, he says. In particular, the waves lasted much longer — about 100 seconds — and had a higher pitch than the signals from the much more massive black-hole mergers that LIGO had previously detected.

When they looked at the data stream coming from Livingston, the LIGO researchers found a similar signal there as well, but one with a loud, spurious glitch towards the end. It was that anomaly that had caused the real-time-analysis software to ignore the signal, says David Shoemaker, a physicist at the Massachusetts Institute of Technology in Cambridge who is LIGO's spokesperson.

Meanwhile, researchers received another alert: Fermi had detected a short γ-ray burst that had occurred 1.7 seconds after the gravitational waves had ended. Called GRB170817A, it was unusually faint for such a burst.

Second signal

In Italy, another technical glitch had suspended the continuous stream of data normally sent out by Virgo. So it took another 40 minutes for researchers to realize that they, too, had a signal — albeit a faint one. It transpired that the waves had travelled close to one of the interferometer's four blind spots, says Jo van den Brand, a physicist at the Vrije Universiteit Amsterdam and spokesperson for the Virgo Collaboration.

By 13:21 UT, 40 minutes after the event, the LIGO–Virgo team had decided to notify its roughly 70 follow-up partners — teams of astronomers on standby to look for related events using conventional telescopes.

Four and a half hours later, the team sent a second, much more useful alert.

The timing of Virgo's feeble signal had been sufficient for the LIGO-Virgo team to identify the source of the waves. It pointed to a region of the sky spanning an angle of just a few degrees, in the southern sky. They called the event GW170817, after the date it was detected.

Virgo had joined LIGO's observation campaign only on 1 August, after a five-year shutdown for upgrades. And just three days before the event's detection, on 14 August, LIGO and Virgo had made their first joint detection. It enabled them to rehearse the more precise identification of the patch of sky of interest. The event on 17 August enabled them to narrow it down even further. And the estimated distance was ten times closer to Earth than in the previous events. They could tell this because of how loud and persistent the waves were: it was the strongest signal LIGO had ever sensed. After the fact, Hanna's team was able to extract a signal that lasted a full six minutes.

Together, the alerts from LIGO–Virgo and Fermi sent astronomers into a frenzied rush. Each team wanted to be first to spot the fireworks produced by a neutron-star merger. It was daytime on most of the world's land mass, so teams began to formulate strategies for their nocturnal observations. They knew that, at that time of the year, the region to search was not far from the Sun. That left a window of observation of a couple of hours after dusk, before the region of sky would set below the horizon.

"We had a complicated, choreographed dance of telescopes that night," says Iair Arcavi, an astrophysicist at the University of California, Santa Barbara, whose team made non-stop observations using the Las Cumbres Observatory, a worldwide network of robotic telescopes. It began by activating a number of telescopes in Chile.

Three messengers

The first person to see the event may have been Charles Kilpatrick, an astronomer at the University of California, Santa Cruz. He was part of a team that was scanning the sky with the more modest means of the single one-metre Swope Telescope in Chile. Like his competitors, Kilpatrick was closely watching the exposures one by one as they came out, comparing them with

archival images of the same patch of sky. By the ninth exposure, he saw something very conspicuous in a galaxy called NGC 4993. “It looked exactly like a point source in this image that wasn’t in the reference image,” Kilpatrick says. The team named it SSS17a.

At least two other groups say they spotted the bright dot independently. They and other teams also made sure that there were no other plausible candidates within the search region. GW170817, GRB170817A and SSS17a really seemed to be three different messengers from the same source.

LIGO and Virgo lacked a sufficiently detailed signal of the final instants of the collision to be certain that the objects were neutron stars, Shoemaker says. From gravitational-wave data alone, they could have been two unusually small black holes. But the presence of visible light strongly suggested that at least one of the objects in the merger was a neutron star, he and other researchers say.

The group at the University of California, Santa Cruz, was also the first to measure the optical spectrum of SSS17a. On the first night, the dot was bright blue, says astronomer Ryan Foley, who led that effort. NASA’s Swift telescope also detected blue, as well as ultraviolet, light. But during the next few nights of observation, those colours faded away, and the object became more red, according to multiple teams.

Colliding neutron stars should spread debris — a mix of neutrons, but also some protons — in three ways, says Brian Metzger, a theoretical astrophysicist at Columbia University in New York City. First, they fling matter out from their outer layers during the final orbits. Then some matter gets squeezed out in the actual collision. Finally, as the two stars begin to collapse into a black hole, it forms an accretion disk of matter, some of which flies out instead of falling in.

Over the past decade or so, astrophysicists had come to believe that this was the most plausible mechanism to explain the abundance of the heavier elements of the periodic table[1]. The theory held that, overall, about 2% of the combined mass of the stars would escape the fate of the rest. Within one second of the collision, this material would have expanded to become a cloud tens of thousands of kilometres across, but still about as dense as the Sun. In

this cauldron, protons and neutrons would immediately clump together to form neutron-heavy nuclei, which would then begin to decay radioactively. This radioactivity would keep the cloud glowing hot for several days, even as it reached the size of the Solar System. Within a million years, it would spread across an entire galaxy.

As predicted

Metzger says that the switch from blue to red was just what he expected to see. His models suggest that nuclei in this early cloud would reach the masses of many of the elements beyond iron, although not the heaviest ones. This chemical composition would cause the cloud to glow blue.

But the real smoking gun for this model, the signatures of the formation of the heaviest elements, would be a cloud that glowed in the red and infrared. These would be elements forged in a separate wave of the explosion, probably the one coming from the accretion disk, says Metzger.

“We had predicted exactly what kind of red,” says Daniel Kasen, a theoretical astrophysicist at the University of California in Berkeley. Jennifer Barnes, another theorist then in Kasen’s team who is now at Columbia University, had run the supercomputer simulations that predicted the experimental signatures in 2013[2]. “I had just finished my PhD thesis predicting what these things would look like,” she says.

Eleonora Troja, an astronomer at NASA Goddard Space Flight Center in Greenbelt, Maryland, was part of one of the first teams to use the Hubble Space Telescope to view the event. “The spectra were phenomenal,” she adds, and almost indistinguishable from the theoretical predictions. “You could clearly see the fingerprints of the metals that had formed.”

But Troja and other observers were also puzzled, because they couldn't find any signal in the X-ray and radio regions of the spectrum. These would be expected during the formation of a black hole, which is thought to shoot jets of out of its poles at close to the speed of light. Nine days later, Troja’s team was the first to find the X-rays.

Alessandra Corsi, an astronomer at Texas Tech University in Lubbock, and her collaborators kept looking for radio emissions using the Very Large Array in New Mexico. Day after day, the dishes recorded nothing. “It turned out we had to wait 16 very long days in order to see the first radio glow,” she says.

The late onset of the radio and X-ray signals, together with the weakness of the initial γ-rays, suggest that the jets were pointed away from the line of sight to Earth. Gamma-ray bursts that happen to be pointed in the right direction can look very bright even from billions of parsecs away.

After a few weeks, most observatories had to stop looking at the object, because that part of the sky had got too close to the Sun. But radio telescopes are still tracking it to this day, Corsi says. More discoveries might yet be made.

“The idea that all this stuff has happened, it’s too much. It is just hard to process,” says Daniel Holz at the University of Chicago in Illinois. “It’s unreasonable that we have done so much with just one event of its kind.”

“All our hopes and dreams have basically come true,” says Jocelyn Read, an astrophysicist at California State University, Fullerton. “All this time we have been saying, look at this amazing thing we are going to be able to see. And it is still hard to believe when it actually happens.”

Journal name:
    Nature
Volume:
    550,
Pages:
    309–310
Date published:
    (19 October 2017)
DOI:
    doi:10.1038/550309a

Comments

Commenting is currently unavailable.

Prepare for larger, longer wildfires

Climate change makes land management more urgent than ever, says Kathie Dello[1].

13 October 2017

Neighbourhoods burned this week in northern California, with more than 30 people reported dead and 2,000 buildings destroyed. Downtown San Francisco is hazy with smoke from wildfires covering 465 square kilometres, more than 30 kilometres north of the Golden Gate Bridge.

Whatever the proximate cause, these should serve as reminders that climate change is not a future problem, nor a hazard just for tiny island nations. It is a problem now, and our land-management plans need to do a better job of incorporating it.

Scientists must walk a careful line when attributing specific events to climate change. Wildfires are part of a healthy ecosystem and a fact of life in the western United States. Many aspects of a landscape affect them, including past fire suppression, land use and human carelessness.

But climate change increases the threat: fires that do start are larger and last longer. Warmer summer temperatures mean more evaporation. Overall, that means drier forests during the fire season. Ironically, California's past wet winter ended a long drought, but meant that there was more vegetation to become tinder. A 2016 study showed that the fire area attributed to human-

caused climate change has doubled since 1984, largely because vegetation has dried out more. Another 2016 study found that the average area of burnt forest in the northwest United States each year from 2003 to 2012 was almost 5,000% larger than in the years 1972 to 1983, and that the fire season grew from an average of 23 days to 116 days over the same periods. Four other forest areas studied — the Northern Rockies, Southern Rockies, Sierra Nevada and Southwest — also saw increases in both the area burnt and the length of the fire seasons.

Talk about climate change can focus exclusively on avoiding temperature increases in the vague future. The US government's moves to pull out of the Paris climate accord and the home-grown Clean Power Plan are short-sighted, and states' and municipalities' efforts to cut their own emissions are laudable. But it's not enough. We have to manage the effects of climate change that are already here. That means recognizing that threats are increasing.

The cost of fighting US wildfires this year exceeded a staggering US$2 billion, more than half the US Forest Service's budget. The agency has to use funds to fight fires that would otherwise go towards prevention and forest management. It needs more resources so that plans for prevention can become bolder and more expansive.

In fact, the Forest Service is incorporating some climatic adaptation into its regional plans. These include planting seedlings less densely, for instance. But we need many more plans in place, and we need to make sure that goals are met.

What does adaptation mean for wildfires? We have to manage risk even more aggressively than we have done, and incorporate greater uncertainty. We are likely to need an expansion of the areas considered to be at risk. We should avoid building in the urban–wildland interface and mandate the use of materials that are less likely to catch fire. We can boost attempts to thin woody growth and remove brush.

A public-education component is needed as well. At the end of August, a wildfire ravaged the breathtakingly beautiful Columbia River Gorge near Corvallis, Oregon, where I live. It was probably caused by a teenager

throwing a firework off a cliff during one of the hottest summers on record in the Pacific Northwest. Everyone has to realize that the consequences of foolish behaviour or bad luck (many wildfires are started by lightning) are getting worse, so prevention and mitigation are even more important.

Let’s face it — adapting to a changing climate makes the already difficult task of land management even tougher. The aspects we need to manage aren’t isolated — for instance, the burn scars left by the fires will be prone to landslides in the rainy season and dust storms in the summer.

Those living far from fire hazards also need to adapt. The 2014 US National Climate Assessment counts only 15 states with climate-adaptation plans, mainly concerned with flooding and saltwater hazards. The Georgetown Climate Center in Washington DC, which has been tracking progress, says that most states have completed only a few of their goals, many set nearly a decade ago, although work on others is in progress.

The irony is that catastrophes can make for better planning. We should not be afraid to talk about them. Recent events — such as the fires this summer, and the crippling five-year drought that ended in 2015 — motivate us to account for more of these events in the future. Part of my job is talking to policymakers, natural-resource managers and the general public about climate change. Contrary to stereotypes, people in rural areas in the US West are ready to discuss it.

Approaches to climate change that start off in an atmosphere of blame and aggressive policy proposals rarely stick. Instead, discussions about the land that people know provide a common ground that images of lonely polar bears on ice floes do not. There’s always an entry point, and it’s around shared values and solutions. That’s as true in Pocatello, Idaho, as it is in Portland, Oregon.

The wildfires in northern California are horrendous. There is much to mourn. And we can bet that these and other disasters will get worse. Our planning needs to take that into account. We need to protect our livelihoods now, to help ensure better prospects for future generations.

Journal name:

Nature
DOI:
doi:10.1038/nature.2017.22821

Comments

Commenting is currently unavailable.

Global networks of small telescopes will chase companion signals of gravitational waves

Seeing cosmic events is one thing, but what if you could hear them and taste them, too?

13 October 2017

Krzysztof Ulaczyk/University of Warwick

The Gravitational-wave Optical Transient Observer (GOTO) in La Palma, Spain, will look for flares of light coming from the same spot as any gravitational waves.

A cottage industry of small observatories is springing up around the globe to take advantage of astronomers' new ability to capture the gravitational waves from major cosmic events. These new facilities will enable researchers to match up those gravitational waves with electromagnetic signals and perhaps one day even particles of matter from some of the cataclysms that send measurable ripples through space-time.

The main goal is to look for flares of light originating from the same spot as any gravitational waves detected by the US-based Advanced Laser Interferometer Gravitational-Wave Observatory (LIGO), or the Virgo observatory near Pisa, Italy. These smaller telescopes, often built on a shoestring budget, will serve as first-line responders, filling the gap between gravitational-wave detectors and the major facilities of conventional astronomy. “Once you know where to look, you can swing the whole world’s telescopes at it,” says Danny Steeghs, an astronomer at the University of Warwick, UK.

Moving quickly is key. It’s tricky to pinpoint the source of gravitational waves — astronomers can typically narrow it down to a region of the Universe that could contain thousands of galaxies — and observatories may have only a few days before any promising flares of light dissipate. “You need to look at a lot of sky,” says Steeghs, “and you don’t have a lot of time for it.”

Robots of the sky

Steeghs leads a small UK–Australian collaboration that built the Gravitational wave Optical Transient Observer (GOTO) in La Palma, Spain. It is an array of four small robotic telescopes that will eventually grow to 8 telescopes, and perhaps 16. So far, it has cost just £800,000 (around US$1 million).

Alan Watson of the National Autonomous University of Mexico (UNAM) in Mexico City and his collaborators spent even less. They built the Deca-Degree Optical Transient Imager (DDOTI), currently consisting of a pair of robotic telescopes at Sierra San Pedro Martir, Mexico, for a mere

US$350,000, largely by using off-the-shelf components, he says. They plan eventually to have six telescopes, perhaps followed by more facilities in France and Australia.

Some of the facilities, including GOTO, are being designed and built specifically to follow up on gravitational-wave signals. Most of these will be robotic, using machine-learning algorithms to alert each other to point at particular regions of sky and search for interesting flares without the need for human intervention.

Other projects have grown out of existing collaborations that are familiar with looking for visible-light counterparts to the γ-ray bursts spotted by space observatories, or tracking other transient phenomena, such as supernovae explosions or asteroids that are potentially Earth-bound. And some venerable telescopes, including one of those once used by Edwin Hubble in Palomar, California, have been retrofitted. The 1.2-metre telescope is now part of GROWTH (Global Relay of Observatories Watching Transients Happen), a network of 17 facilities around the globe that can track an object seamlessly as the Earth spins. “The idea is, basically, to beat sunrise,” says Mansi Kasliwal, an astronomer at the California Institute of Technology in Pasadena, who is part of GROWTH.

Twan Bekkers

Engineers install a prototype of the BlackGEM telescopes at the South African Astronomical Observatory in Sutherland.

Astrophysicist Paul Groot of Radboud University in Nijmegen, the Netherlands, whose group is part of the Virgo collaboration itself, is leading a Dutch-funded project called BlackGEM. It will initially consist of three telescopes in La Silla, Chile, costing about €6 million (US$7.1 million), that will continuously map the southern sky to build up a database of archived images. If news of a gravitational-wave detection arrives, BlackGEM will scan the relevant patch of sky within hours, and automatically compare that to its archived images to search for anything new.

Neutrino chasers

Similar efforts are already following up on detections of notable particles from space, such as unusually energetic neutrinos or cosmic rays. The

Astrophysical Multimessenger Observatory Network (AMON), started in 2016, got its first interesting hint on 22 September, when it responded to a high-energy neutrino detected by IceCube, the world's largest neutrino observatory, at the South Pole.

When AMON researchers looked towards the source of the neutrino, they saw that a known quasar — an entity consisting of heated matter orbiting a supermassive black hole at the centre of a distant galaxy — was flaring up. This is the type of heightened activity that theorists think could produce an excess of neutrinos, but so far, no high-energy neutrinos have been traced conclusively back to their sources.

In the future, researchers hope that they might detect all three types of emission together: electromagnetic radiation, gravitational waves and particles of matter. Some compare that to seeing, hearing and tasting an astrophysical event at once.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22828

Comments

Commenting is currently unavailable.

Nature News

周五, 27 10月 2017

Nature News

[周五, 27 10月 2017]

- **Nature News**

Nature News

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- **China announces plans to fast-track drug approval** [周四, 26 10月 08:00]
  Policies are expected to speed up access to medicines and boost the country’s pharmaceutical industry.
- **Bitter CRISPR patent war intensifies** [周四, 26 10月 08:00]
  Gene-editing pioneers prepare for next stage of intellectual-property disputes in the United States and Europe.
- **First living human cells added to brain database** [周三, 25 10月 08:00]
  Measurements show how neurons behave in healthy living tissue.
- **Many junior scientists need to take a hard look at their job prospects** [周三, 25 10月 08:00]
  Permanent jobs in academia are scarce, and someone needs to let PhD students know.
- **Data science can improve aid distribution** [周三, 25 10月 08:00]
  Online platforms can help to steer emergency response and ensure money is well spent.
- **A death sentence, Hawking's thesis and China's ambitions** [周三, 25 10月 08:00]
  The week in science: 20–26 October 2017.
- **CRISPR hacks enable pinpoint repairs to genome** [周三, 25 10月 08:00]
  Precision tools expand the number of ‘base editors’ available for manipulating DNA and RNA.
- **Out of the Syrian crisis, a data revolution takes shape** [周三, 25 10月 08:00]
  Aid organizations have been piloting a nimble approach to cut through the fog of war.
- **History: Science and the Reformation** [周三, 25 10月 08:00]
  The scientific and religious revolutions that began 500 years ago were not causally related, but were both stimulated by printing, argues David Wootton.
- **Disaster preparedness: Risk, rout and ruination** [周三, 25 10月 08:00]
  Anthony King navigates a show on catastrophe, from nuclear apocalypse to γ-ray bursts.
- **Public engagement: Young scientists welcome at IPBES** [周三, 25 10月 08:00]
- **Poaching: Is snow leopard tally underestimated?** [周三, 25 10月 08:00]

- **Construction: limit China's sand mining** [周三, 25 10月 08:00]
- **Construction: use waste for building** [周三, 25 10月 08:00]
- **Science writing: On what's neither clear nor obvious** [周三, 25 10月 08:00]
- **Nicolaas Bloembergen (1920–2017)** [周三, 25 10月 08:00]
  Laser and optics pioneer whose work led to magnetic resonance imaging.
- **The Everywhere Bus** [周三, 25 10月 08:00]
  It's the latest in travel technology.
- **French scientists in uproar over changes to medical-research clusters** [周二, 24 10月 08:00]
  Biomedical-research agency accused of attempting to undermine autonomy of university–hospital groups.
- **Wait for Trump's science adviser breaks modern-era record** [周二, 24 10月 08:00]
  Top White House science job stays empty more than nine months after president took office.
- **Reclassify waste to shift the nuclear landscape** [周二, 24 10月 08:00]
  The US Department of Energy should classify and dispose of nuclear rubbish according to risk.
- **Cancer biology still needs physicists** [周二, 24 10月 08:00]
  Considering game theory and the role of physical forces could lead to better treatments for cancer, says Robert Austin.
- **India gears up for second Moon mission** [周二, 24 10月 08:00]
  The Chandrayaan-2 orbiter, lander and rover will track how lunar dust might scupper settlement.
- **To stay young, kill zombie cells** [周二, 24 10月 08:00]
  Killing off cells that refuse to die on their own has proved a powerful anti-ageing strategy in mice. Now it's about to be tested in humans.
- **Shrew skulls shrink for winter survival** [周一, 23 10月 08:00]
  Getting smaller by absorbing bone tissue may help animals to save energy when food is scarce.
- **Iranian scholar sentenced to death** [周一, 23 10月 08:00]
  Ahmadreza Djalali, a researcher in disaster medicine, has 20 days to appeal against his death sentence.
- **Photons pair up like superconducting electrons** [周五, 20 10月 08:00]
  Discovery raises questions about how a light 'supercurrent' might behave.

China announces plans to fast-track drug approval

Policies are expected to speed up access to medicines and boost the country’s pharmaceutical industry.

26 October 2017

Xue Jun/Xinhua via ZUMAPRESS

China is aiming to cut the amount of time people have to wait for new medicines.

China is overhauling its drug-approval system to let companies bring their treatments to market quicker and more easily. On 9 October, the Communist Party of China and the State Council, two of the country’s most authoritative

bodies, announced plans to reduce the backlog of medicines awaiting approval by the China Food and Drug Administration (CFDA). Policies will also be introduced to boost the productivity of Chinese drugmakers and spur innovation in health care.

Details of the plans are only just starting to emerge, but industry observers expect them to be in place by the end of 2017. One proposal, released for public comment on 20 October, states that companies will be allowed to use data from clinical trials conducted in other countries when applying for drug approval in China. Currently, companies have to perform extra trials in China to test a drug's efficacy. Under the new guidelines, they will instead need to provide data that show that a drug works in all human populations.

The changes will significantly reduce the time Chinese people have to wait for new medicines, and will save multinational companies time and money, says Angela Yan, senior director of science and regulatory affairs at the R&D-based; Pharmaceutical Association Committee in Beijing, which represents the interests of foreign companies in China**.** A vaccine against the human papillomavirus, for example, was approved in China only in 2016, a decade after it was given the green light in the United States. More than 20 years of efforts to reduce delays are now paying off, says Yan. "This is very positive."

Unblocking the pipeline

The shake-up is the latest in a series of measures to accelerate China's drug-regulation process and make it more rigorous, in line with international standards. In the past two years, the government has dramatically increased the number of application inspectors at the CFDA to reduce the backlog of medicines awaiting approval. It has also threatened to jail manufacturers or researchers caught submitting fraudulent applications.

And in June, China became a member of the International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use, which requires a nation's drug-approval agency to adhere to international standards and guidelines.

As well as reducing the administrative burden of drug registration, the government is eager to expand its pharmaceutical industry, given that China is the world's second largest drug market. Between 2001 and 2016, China approved just over 100 new drugs, whereas developed countries approved 433.

Far-reaching policies

Su Ling, director of the Institute of Drug Regulatory Science at Shenyang Pharmaceutical University and a venture partner for the investment fund Lilly Asia Ventures in Shanghai, says the government will introduce a range of policies that will have broad effects on the industry. "Overall they are in the right direction to become more aligned with international norms and to promote new drug R&D; and access," says Su. "This is really important."

Another policy, announced by the CFDA on 10 October, will end the restriction that prohibits pharmaceutical companies from starting phase I safety trials for a drug in China until its safety has been proved in another country. The ban was designed to protect Chinese people from exploitation by drug companies during early experiments.

Yan says loosening the restriction could plug crucial holes in China's drug-development pipeline, which has lost capacity to translate research from animals to humans. "Now they can do global phase I trials and learn and improve their capabilities," she says.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22888

Comments

Comments

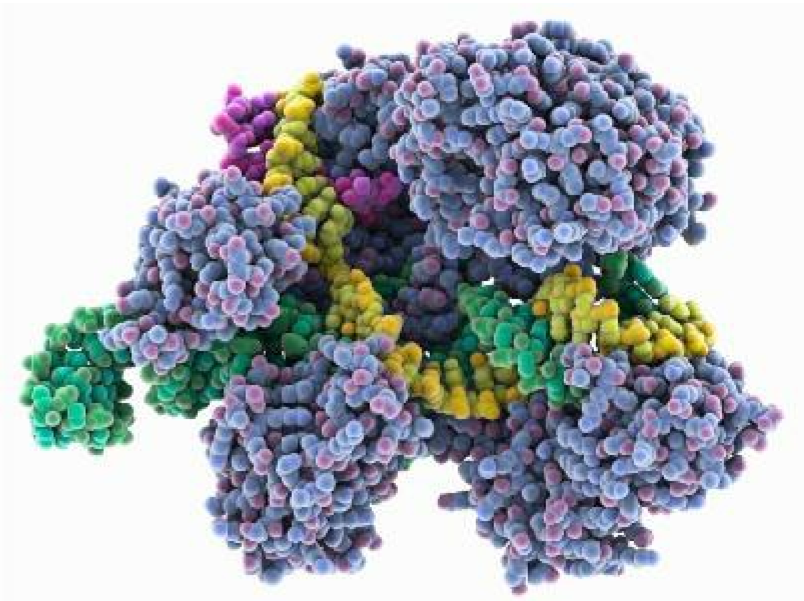
There are currently no comments.

| 章节菜单 | 主菜单 |

Bitter CRISPR patent war intensifies

Gene-editing pioneers prepare for next stage of intellectual-property disputes in the United States and Europe.

26 October 2017



Laguna Design/SPL

The CRISPR–Cas9 system acts as molecular scissors to precisely cut and edit genetic code.

The long-running battle over US patents for CRISPR–Cas9 gene editing continues. On 25 October, the Broad Institute of Cambridge, Massachusetts, filed a fresh set of arguments with the US government to defend a key patent.

That action helps to set the stage for a second round of oral arguments in the unusually vitriolic case, which observers expect to take place in early 2018.

A decision is anticipated to follow shortly thereafter.

In the filing, lawyers for the Broad and its collaborators argued that its opponent, a team that includes the University of California, Berkeley, has failed to provide new evidence that would undermine the legitimacy of the Broad's patent. The lawyers also used the University of California's own press releases as a sign that the case should be thrown out.

At stake are intellectual-property rights to the use of CRISPR–Cas9 gene-editing tools in eukaryotes, organisms such as plants and animals. This would include applications of the technique to treat human genetic diseases — an approach that has recently entered cancer clinical trials in China, and is potentially the most lucrative application of gene editing.

Although non-profit research institutes often reach settlements over such patent disputes, both sides in the CRISPR case have invested heavily in a prolonged patent fight, says Kevin Noonan, a partner at the law firm McDonnell Boehnen Hulbert & Berghoff in Chicago, Illinois. "They really went after each other so vigorously," he says. "You want to say, 'Hey, let's take a breath.'"

Novelty seeking

The fight began when the US patent office granted the Broad a patent covering the use of CRISPR–Cas9 in eukaryotic cells. The California team had filed its patent earlier, but the Broad opted for an expedited review that got its application granted first. The University of California then argued that the Broad's patent interfered with the granting of its own patent, and launched an official proceeding before a board of specialized patent judges.

Throughout that proceeding, the University of California team argued that its patent — which explicitly describes the use of CRISPR–Cas9 gene editing only in non-eukaryotes such as bacteria — rendered applications in eukaryotic cells "obvious" and therefore unpatentable. The Broad countered that the University of California's invention needed significant and non-obvious tweaks before it could be used in eukaryotes.

In February, the patent office sided with the Broad. The University of California team soon filed an appeal to the US Court of Appeals for the Federal Circuit, claiming that the patent board had made "fundamental errors of law" that would allow the Broad to unfairly claim rights to the most important and valuable applications of CRISPR–Cas9 gene editing.

Despite that argument, Noonan expects the court — which generally defers to the patent office — to uphold the patent board's decision. "For Berkeley to prevail, the Federal Circuit is going to have to say, 'Yeah, the board got it wrong,'" he says. "I think it's unlikely that they'll do that."

Counter arguments

In the 25 October filing, lawyers for the Broad also pointed to press releases issued by the University of California in the wake of the patent board's February decision. Those press releases argued that the University of California had come out ahead in the decision, because people who wanted to use CRISPR–Cas9 gene editing in any system — eukaryotic or not — would still need to license its patents. If so, the Broad argued, then the University of California was not harmed by the patent board's decision and therefore lacks legal standing to appeal it.

Upholding that previous decision could spell trouble for the University of California, notes Jacob Sherkow, a legal scholar at New York Law School. The university's patent would go back to the patent office for examination. But in May, the patent office issued another key CRISPR patent to Vilnius University in Lithuania. That application was filed earlier than the University of California's, so patent law could dictate that it takes precedence. The California patent could be crowded out, Sherkow says: "This is a dramatic turn."

The CRISPR patent landscape elsewhere is also uncertain. In Europe, the Broad has been granted ten patents but is in danger of losing as many as eight of them, notes Catherine Coombes, a patent attorney at intellectual-property specialists HGF in York, UK. In April, the European Patent Office issued a preliminary ruling that threw out the Broad's earliest filing date for its first

patent, because the institute had later removed an inventor from the patent application.

If that decision — which will be discussed during oral arguments in mid-January — becomes final, it will push the Broad's patent date to a time after the institute's team published its findings in a scientific article[1]. And that would invalidate the patent application altogether.

Overall, there are more than 1,880 families of CRISPR patent, according to IPStudies, a consulting firm near Lausanne, Switzerland. More than 100 new families — each a group of related intellectual-property claims — are published each month.

With those numbers in mind, people looking to commercialize CRISPR–Cas9 gene editing will probably continue to face a daunting patent landscape, notes Coombes. "The situation is going to get a lot more complicated before it gets better."

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22892

Comments

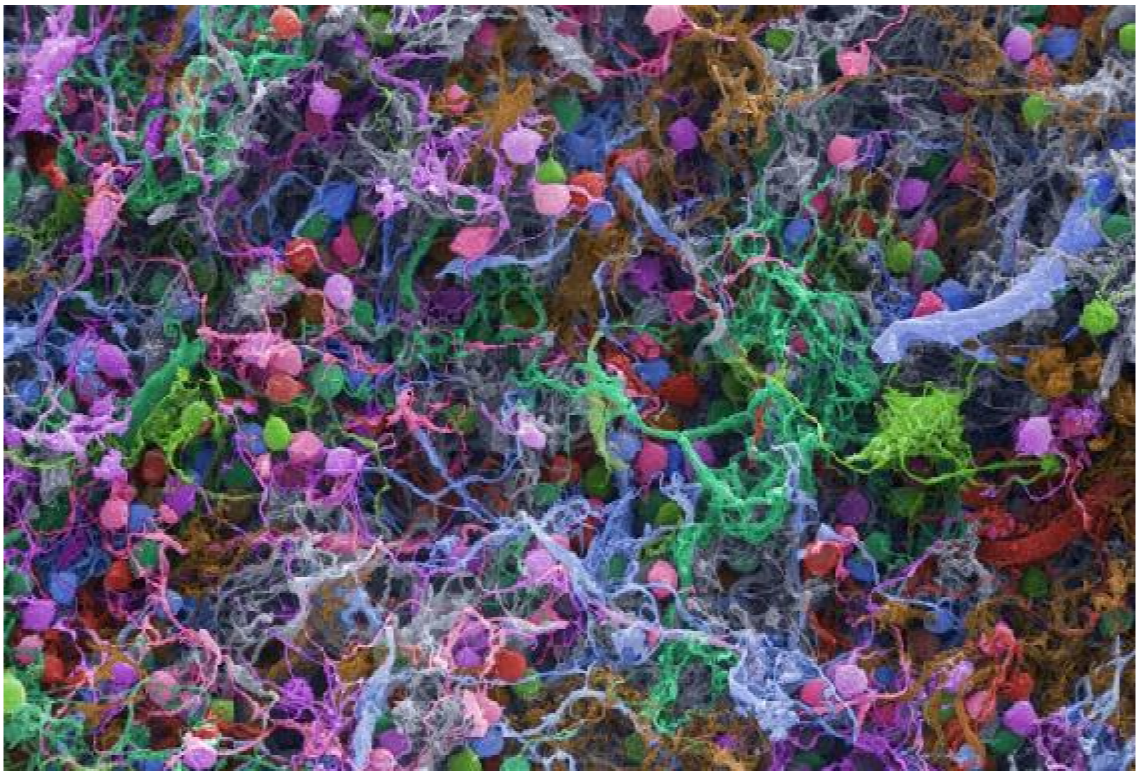
Comments

There are currently no comments.

First living human cells added to brain database

Measurements show how neurons behave in healthy living tissue.

25 October 2017



Ted Kinsman/SPL

Scanning electron micrograph of human brain cells.

Fresh human brain tissue is a vanishingly rare resource for neuroscientists. Now, data on small bits of live human brain tissue that normally get discarded during surgery are being added to a publicly available database that could help to unravel how cognition works. On 25 October, researchers at the

Allen Institute for Brain Science in Seattle, Washington, who compile neuroscience tools including large-scale databases and brain maps, announced that they had published their first data from living human brain cells.

Most human-brain studies use either images of functioning brains obtained by scanning volunteers or slices of dead organs from cadavers. The images and information now added to the database will let researchers analyse the molecular content of individual living cells, or neurons, and, ultimately, identify the biological basis of their behaviour. Until now, the database had contained information only about mouse brains.

Small studies using surgical human brain samples began very tentatively in the 1970s but the large amount of human data now published by the Allen Institute — the most extensive and systematic effort so far — has been welcomed as a major aid to identifying the uniqueness of the human brain.

Uniquely human

With their patients’ consent, neurosurgeons in the Seattle region donated small pieces of brain that they would otherwise have discarded during surgery. The pieces are bits of the outer layer called the cerebral cortex that they needed to snip out to access diseased tissue deeper in the brain.

The cortex processes higher-level activities, including the deep introspection and abstract reasoning that is thought to be specifically human. “Finding out what the detailed differences are between the mouse and human brain will help us understand what makes us unique among species,” says Christof Koch, president and chief scientific officer of the Allen Institute.

The first slew of human data includes the electrical properties of 300 different types of neuron from 36 people, along with 3D reconstructions of the spidery shapes of some of them, and computer models that simulate their electrical behaviour. It also includes gene-expression profiles of 16,000 individual cells from the brains of another 3 people. Scientists around the world may now compare these data with those from mice to generate hypotheses about where

key differences lie.

“This database is a major service to the scientific community,” says Huib Mansvelder, a neuroscientist at the Free University of Amsterdam and an early pioneer of research on fresh human brain cells. He and his colleagues have shown[1], for example, that human neurons have a lower capacitance than mouse neurons, which makes them quicker to start firing and quicker to transfer information. They also have more intricate shapes. “But the Allen’s industrial approach takes the endeavour to a whole new level,” he says.

Living tissue

The lumps of donated tissue are each about the size of a sugar lump — typically the same volume as an entire mouse brain. Cut into slices 300–350 micrometres thick, the cells remain alive and active for three days, giving scientists ample time to take measurements. Mouse neurons, by contrast, tend to degenerate within hours.

Only a few research centres worldwide study fresh human brain tissue, partly because until recently few brain surgeons had been inspired to work with it. But rapid developments in biological research tools have increased the scientific rewards for doing so.

The Allen Institute now plans to increase the number of human brain cells in its database and the amount of information available from each of them. It aims eventually to include full RNA profiles to indicate which genes are active in the tissue. The next phase will also analyse the connections between the cells. However, the work cannot be as comprehensive as studies of mouse brains, because only small pieces of living human brains can be removed, whereas the whole brains of mice can be examined.

Cell integrity

There is another concern about the human tissue. Although apparently healthy, the cells come from surgery to remove tumours or treat severe

epilepsy, which provokes concerns that their properties might have been altered by their pathological environment. However, Mansvelder has compared cortical tissue from people with cancer with that from people with epilepsy, and found them to be very similar. The Allen Institute has confirmed these results.

There is another advantage to using human cortical tissue. Neurosurgical teams collect vast information about the brain functions of their patients before and after operations. With appropriate anonymization, this can be correlated with cellular properties. At a meeting of the Federation of European Neuroscience Societies in Pécs, Hungary, on 20–23 September, Mansvelder presented data showing that IQ correlates with the threshold of firing of cells — the higher the IQ, the lower the threshold.

Mansvelder, along with fellow neuroscience pioneer Gábor Tamás of the University of Szeged in Hungary and groups from Israel and Sweden, will collaborate with the Allen Institute to develop the human-brain database further, thanks to a US$19.4-million grant from the US National Institutes of Health, announced on 23 October.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22889

Comments

Comments

There are currently no comments.

Many junior scientists need to take a hard look at their job prospects

Permanent jobs in academia are scarce, and someone needs to let PhD students know.

25 October 2017

David Williams/Corbis/Getty

Most PhD students will have to look beyond academia for a career.

For his 2012 PhD thesis, the sociologist Chris Platts surveyed and interviewed more than 300 young footballers — aged 17 and 18 — at UK club academies who were hoping to pursue a career in the game. He told the newspaper *The Guardian* this month that just four of them currently have

gained a professional contract. That’s a drop-out rate of 99%.

For our Careers section this week, *Nature* surveyed more than 5,700 early-career scientists worldwide who are working on PhDs. Three-quarters of them, they told us, think it’s likely that they will pursue an academic career when they graduate, just like Platts — now a senior lecturer in sport development and sport business management at Sheffield Hallam University, UK. How many will succeed?

Statistics say these young researchers will have a better chance of pursuing their chosen job than the young footballers. But not by much. Global figures are hard to come by, but only three or four in every hundred PhD students in the United Kingdom will land a permanent staff position at a university. It’s only a little better in the United States.

Simply put, most PhD students need to make plans for a life outside academic science. And more universities and PhD supervisors must make this clear.

That might sound like an alarmist and negative attitude for the International Weekly Journal of Science. But it has been evident for years that international science is training many more PhD students than the academic system can support. Most of the keen and talented young scientists who responded to our survey will probably never get a foot in the door. Of those who do, a sizeable number are likely to drift from short-term contract to short-term contract until they become disillusioned and look elsewhere.

As *Nature* has said before, it is good for PhD students and postdocs to pursue careers outside academia. Many will find similar challenges and rewards in industry. And it is surely of benefit to science and society at large that a sizeable number of well-educated and well-trained scientists spread to other sectors, and take with them healthy scepticism and respect for evidence. It is certainly better for young scientists to take a realistic view early in their career path, when they still have time to adjust their ambitions. So why do people in science still see this reality as a dirty secret?

Our survey, for example, shows that one-third of respondents do not have useful conversations about careers with their PhD supervisors. And non-

academic jobs are low on the agenda when future options are discussed. Almost one-third of the students disagreed or strongly disagreed with the statement that their supervisor has useful advice for non-academic careers. That's about the same as was reported in *Nature*'s previous PhD survey, in 2015. If you supervise a PhD student or know someone who does, then please help to shrink that number by the time the next survey goes out, in 2019. Supervisors are busy people but they are often the face of the university and the academic system for students, and so the most obvious place to seek guidance. At the very least, they should be willing to point students towards the university careers service, which should also focus more on options outside academia. It's not just undergraduates who benefit from a variety of possibilities. Indeed, postgraduates arguably need more attention and advice because so many people — including themselves — believe that they are now on a path to a professorship.

Another major point worth making from the 2017 survey is about mental health. More than one-quarter of the students who responded listed mental health as an area of concern, and 45% of those said they had sought help for anxiety or depression caused by their PhD. One-third of those got useful help from their institution (which of course means that two-thirds did not). Still, just 5% said no help was available there or elsewhere, which, given the general difficulty in accessing mental-health support in many countries, suggests that young people in the education system are perhaps better served than many outside it.

If the outlook for junior scientists in academia is mixed, then, luckily for science, most don't seem to let it put them off. Indeed, it's striking to note that nearly eight in ten of the young scientists surveyed said they were satisfied with their decision to start a PhD. That reflects well on the excellent opportunities, facilities and supervision that many receive. Just like the footballers, some will succeed, and they will find a career in academic science to be as thrilling, rewarding and satisfying as they hope. But someone needs to tell the rest what happens next.

Journal name:
Nature
Volume:

550,
Pages:
429
Date published:
(26 October 2017)
DOI:
doi:10.1038/550429a

Comments

Commenting is currently unavailable.

Data science can improve aid distribution

Online platforms can help to steer emergency response and ensure money is well spent.

25 October 2017

Delil Souleiman/AFP/Getty

Better data tools could help coordinate aid and relief efforts.

Over the past decade, non-profit organizations have sent millions of small stoves to families in the developing world. These appliances are intended to stop people from cooking over open flames indoors — an activity linked to four million deaths per year, attributable to household air pollution.

But economists and public-health researchers have published studies that question the benefits of this effort. One randomized controlled trial (RCT), reported in 2012 and involving 15,000 households in rural India, found no evidence of improved lung function in women in the first four years after they received a stove (see go.nature.com/2zjgwny).

The RCT suggests that these efforts might be revised. But as useful as RCTs are in development economics and global health, they have limits. Findings in one place might be wildly different in another. And in a crisis, first responders are typically too busy trying to provide shelter, health care and bare necessities to design and carry out a controlled set-up.

But humanitarian groups can still improve their efforts in the short and long term through evidence obtained with new technology. A *Nature* News Feature this week highlights software called the Dharma Platform, which enables workers on the front line of hurricanes, outbreaks or other crises to record, share and analyse useful data — for example, the spread of disease in rural villages. Dharma is being tested by Médecins Sans Frontières (or Doctors Without Borders), the World Health Organization and other groups combating crises in the Middle East. And it is just one of many new technologies that will make data faster to collect and easier to exchange.

The rush to provide food, shelter and health care can be as chaotic as the disaster itself. Hundreds of millions of dollars flood into the world's largest agencies and non-governmental organizations, which often sub-contract delivery to dozens of smaller groups. In such a system, the best source of data is a person on the ground — often someone low in an organization's chain of command. It's this aid worker who listens as a mother describes how she's received four sacks of rice, yet her babies have nothing to eat. This essential feedback is typically recorded on paper. If it makes it into a report, weeks or months will pass by the time it gets to headquarters, where managers then adjust the system.

Platforms such as Dharma that collate real-time data could quicken this response time by informing groups of what people need, and help to reassure donors that their money is being spent wisely. After an acute crisis, researchers can use data collected in the heat of the moment to answer big-picture questions. For example, how might assistance better prevent tragedies

that follow disasters, such as the cholera epidemic in the wake of Haiti's 2010 earthquake, or blindness in survivors of Ebola? As long as data collection is organized, consistent and secure, researchers distanced from those delivering aid can evaluate projects objectively.

Requesting more data and analysing them coldly will make failures more evident. In turn, philanthropists, taxpayers and governments that donate money should evaluate each inefficiency sensibly, and not be unforgiving. For example, a tiny fraction of donated insecticide-treated bednets may be used as fishing nets — but that fact should not negate an intervention that has been shown to reduce cases of malaria caused by *Plasmodium falciparum* by up to 62% (C. Lengeler *Cochrane Database Syst. Rev.* http://doi.org/c4f9c7; 2004). Failures at all scales must be upheld as lessons in the continuing struggle to do what's right — and not as arguments to abandon aid completely.

Journal name:
Nature
Volume:
550,
Pages:
430
Date published:
(26 October 2017)
DOI:
doi:10.1038/550430a

Comments

Comments

There are currently no comments.

A death sentence, Hawking's thesis and China's ambitions

The week in science: 20–26 October 2017.

25 October 2017

Events | Facilities | Politics | Space | Research | Business | Energy | Trend watch

EVENTS

Death sentence for Iranian scientist A judge in Tehran sentenced to death an Iranian researcher accused of “collaboration with a hostile government” on 21 October, according to the researcher’s wife and diplomatic sources in Italy. Ahmadreza Djalali, a disaster-medicine researcher who is affiliated with institutions in Sweden and Italy, was arrested in April 2016 while on an academic visit to Tehran and convicted of espionage following a trial in Iran’s revolutionary court. Close contacts of Djalali’s say he believes that he was arrested for refusing to spy for the Iranian intelligence service and was forced to make false confessions. They say Djalali has 20 days to appeal against the sentence.

Dirk Waem/AFP/Getty

A flyer photographed during a protest outside the Iranian embassy in Brussels for Ahmadreza Djalali.

Hawking's thesis The PhD thesis of physicist Stephen Hawking has been made freely available online for the first time. The University of Cambridge, UK, where Hawking completed his PhD in 1966, posted the work on 23 October to mark Open Access Week 2017. The physicist was 24 years old when he wrote up his thesis, entitled 'Properties of expanding universes'. Demand to view the document temporarily crashed Apollo, the open-access repository on which it was posted. Hawking said that he hoped to inspire people by making his work available.

FACILITIES

Hungary university The US-registered Central European University (CEU) in Budapest faces another year of uncertainty over whether it can continue to

operate in Hungary. In April, the Hungarian government amended its higher-education law to require that all foreign-accredited universities there had to operate as higher-education institutes in their countries of origin. The CEU took steps to comply with the law, but on 17 October the country's parliament voted to delay a decision that would allow the CEU to keep operating. See 'Efforts to save leading Hungarian university hit hurdle' for more.

POLITICS

Travel ban blocked Two federal judges temporarily blocked much of US President Donald Trump's latest iteration of a travel ban that affects eight countries — most of which are Muslim-majority nations — citing unconstitutional religious discrimination. The decisions, announced on 17 and 18 October, allow visa processing to resume as usual for all countries named in the ban, with the exception of Venezuela and North Korea. Eighty-four scientific societies and a university submitted a letter on 17 October contesting the most recent version of the ban, which Trump introduced in late September. The letter says that the ban weakens US science, and cites "serious implications for diplomatic, humanitarian, and national security interests" as motivation for the organizations' disapproval.

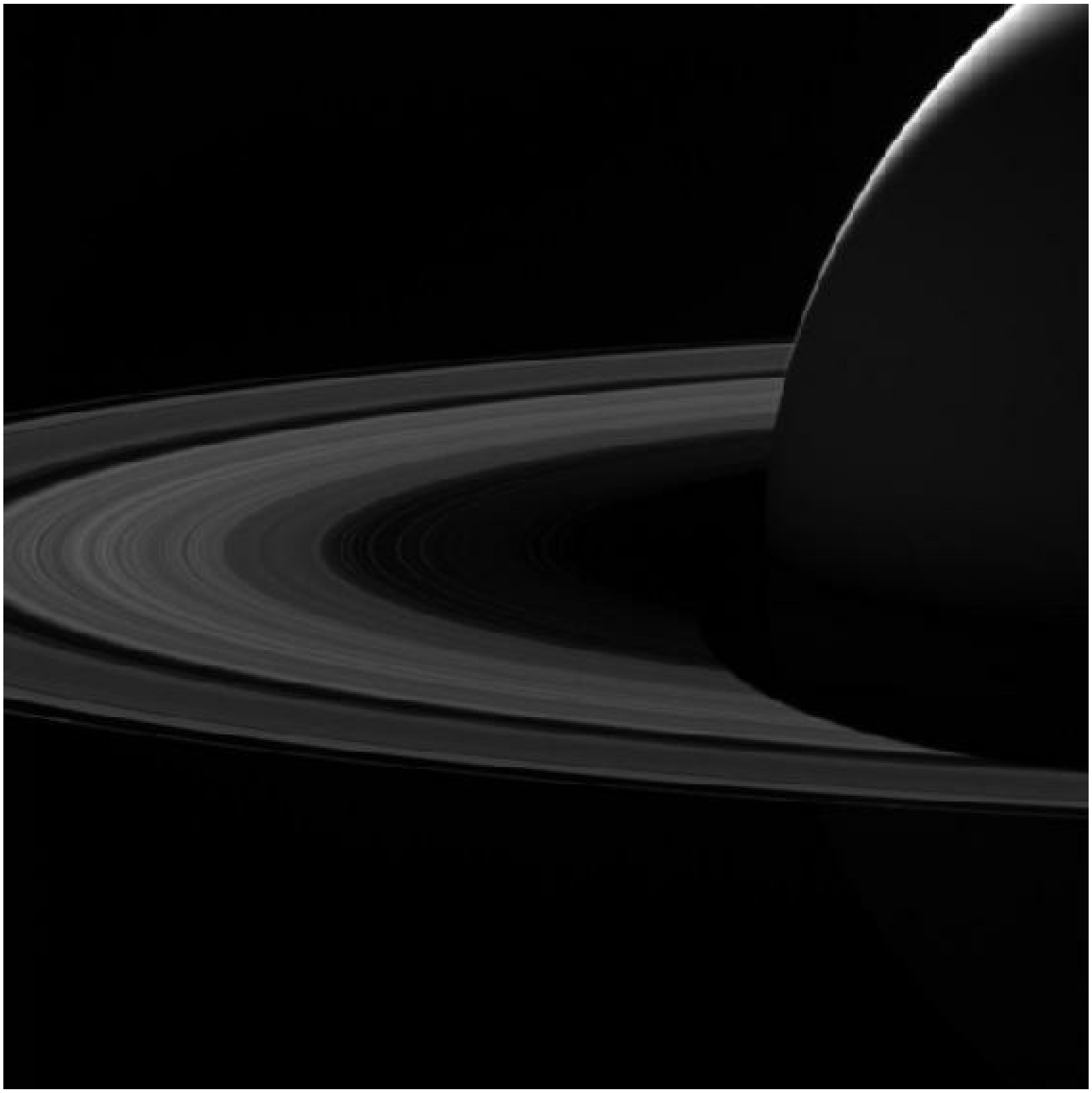
New Zealand leader Jacinda Ardern, New Zealand's newly elected prime minister, has promised to prioritize a number of science-related issues, including climate change and the environment. After a close-run election in which no party won an outright majority, it was announced on 19 October that Ardern would lead a coalition government made up of her own Labour Party and the New Zealand First party. During campaigning, both parties committed to boosting science funding, with New Zealand First saying it would increase investment in research and development (R&D;) to 2% of gross domestic product. The current figure is around 1.2%. The Labour Party plans to introduce tax breaks for companies that invest in R&D;, and to establish an independent climate commission to advise the government on reducing carbon emissions.

Chinese science China will become "a nation of innovators", according to a

speech by the country’s president Xi Jinping on 18 October. Xi laid out the vision as he opened the 19th National Congress of the Chinese Communist Party, an event held every 5 years at which the party shuffles its leadership. It was also a chance for Xi to consolidate his power after five years of heading the party. His support for science and technological innovation, which he says is necessary to build the industrial system needed for “socialism with Chinese characteristics”, has been welcomed by scientists. Xi also boasted of China’s success on environmental issues, and promised to put the country at the forefront of global efforts to combat climate change.

SPACE

Saturn surprise New data from NASA’s Cassini probe suggest that Saturn’s majestic rings are showering tiny dust particles into the planet’s upper atmosphere, where they form a complicated and unexpected chemical mix. The findings were presented on 17 October at a meeting of the American Astronomical Society’s Division for Planetary Sciences in Provo, Utah. A mass spectrometer aboard Cassini detected the strange chemistry during the probe’s final five months, as it looped between Saturn and its rings. Cassini’s mission ended in September, when it burnt up on a controlled dive into Saturn.



NASA/JPL-Caltech/SSI

Telescope cut-back NASA will assess what it can strip off from the planned Wide Field Infrared Survey Telescope (WFIRST), its next major astrophysics mission for the 2020s, to keep the mission's cost below US$3.2 billion. On 19 October, following input from an independent panel of experts, NASA science chief Thomas Zurbuchen directed the agency to consider downsizing the capabilities of WFIRST's coronagraph, an instrument that studies exoplanets, and its wide-field camera. Even with these reductions, NASA says, WFIRST will still enable cutting-edge research into dark energy, exoplanets and other areas of astrophysics. The mission was the top priority

in the most recent US astrophysics decadal survey, but its cost has been creeping up. WFIRST's current price tag is $3.6 billion.

Euclid delay Officials overseeing the European Space Agency's (ESA's) Euclid space telescope will assess whether they need to delay its scheduled 2020 launch because of a problem with infrared detectors developed by NASA. The detectors' electronics have been failing during tests at cold temperatures, NASA astrophysics head Paul Hertz told an advisory panel on 18 October. Fixing the problem could take 12–18 months. NASA is providing 16 detectors for Euclid, which will study dark energy and dark matter. ESA is trying to minimize the impact of the NASA delay by reshuffling its schedule for integrating parts into the telescope.

RESEARCH

Nuclear-decay hunt On 23 October, physicists in Italy inaugurated a search for a type of nuclear decay that could explain why the Universe seems to contain almost no antimatter. The Cryogenic Underground Observatory for Rare Events (CUORE) at the Gran Sasso underground laboratories in the Apennine Mountains is one of several experiments worldwide that are looking for neutrinoless double-beta decay, a hypothetical reaction that would reveal whether neutrinos are their own antiparticles. In early cosmic history, this reaction could have led to matter becoming prevalent over antimatter. CUORE looks for the reaction in 760 kilograms of tellurium dioxide crystals kept at 10 millikelvin and shielded in part with lead recovered from a Roman shipwreck.

BUSINESS

CRISPR patents Key US patents on a gene-editing tool called CRISPR–Cas9 can be bundled together and licensed for agricultural applications, thanks to an 18 October agreement. The patents are held by the Broad Institute of MIT and Harvard in Cambridge, Massachusetts, and DuPont Pioneer, an agricultural biotechnology company in Johnston, Iowa, which had licensed the patents from the University of California, Berkeley, and

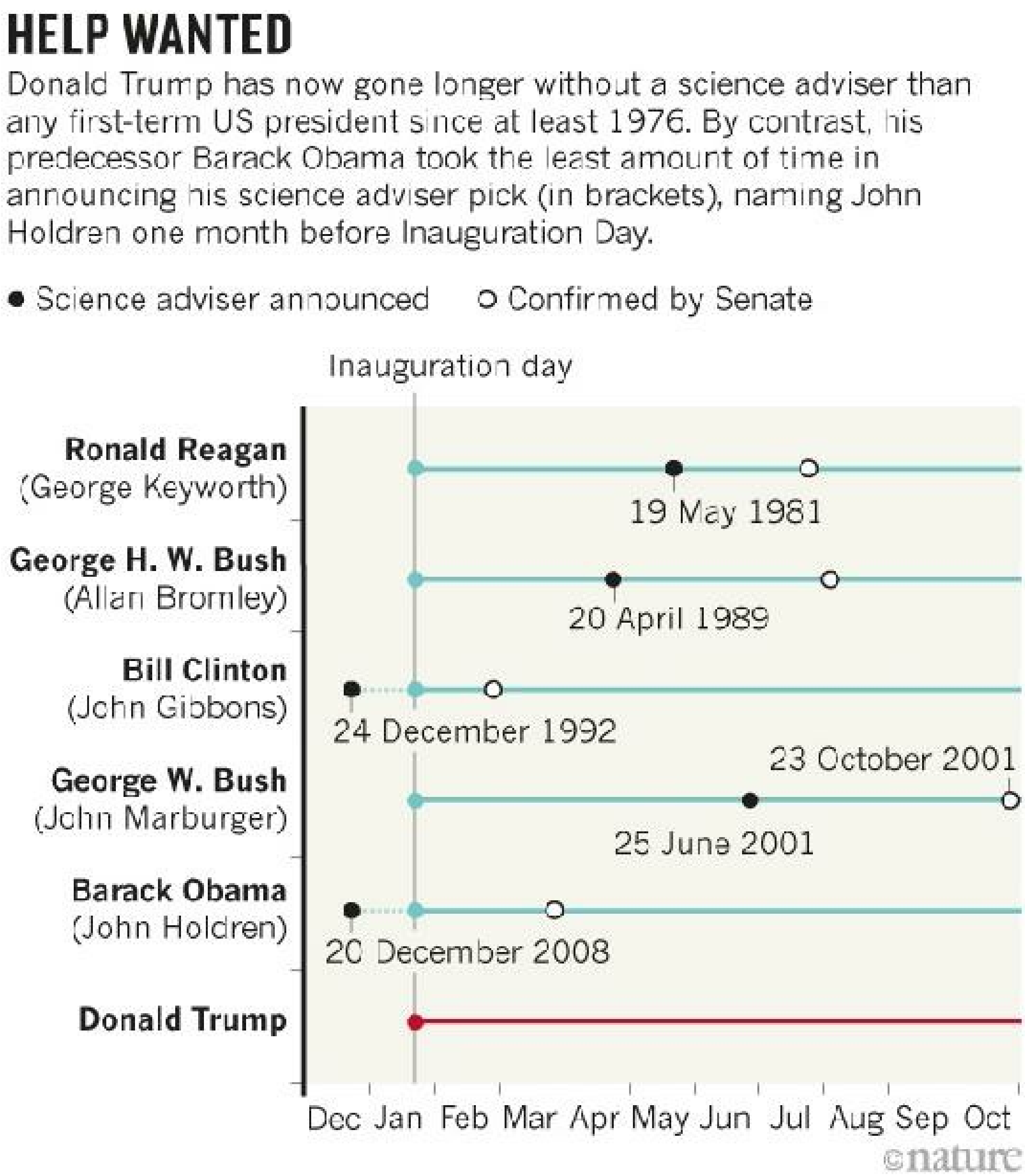
other institutions. Although the Berkeley team is embroiled in a fight with the Broad Institute over CRISPR–Cas9 patents, the new agreement will allow companies to obtain a non-exclusive licence for the patents from the Broad and DuPont. The CRISPR–Cas9 intellectual property will be free for universities and non-profit organizations.

ENERGY

Korean reactors South Korea will resume building two nuclear power plants following the recommendation of a citizens' jury. Although President Moon Jae-in had pledged to cancel construction of the plants when he was elected earlier this year, he agreed to a three-month public debate after his party took power. On 20 October, the government announced that it would accept the jury's decision. Composed of 471 citizens, the jury also recommended that nuclear power eventually be phased out. Moon, who has shut down one old reactor, vowed to continue to pivot the nation towards renewable energy and natural gas. An earthquake last year in the country's southern region has raised fears of possible damage to its nuclear reactors.

TREND WATCH

Donald Trump has now gone longer without a science adviser in place than any first-term US president since at least 1976. On 23 October, Trump broke the record set by former president George W. Bush, whose science adviser was confirmed by the Senate on 23 October 2001 — 276 days after Bush took office, and 120 days after he announced his pick. Trump has yet to name an adviser. By contrast, Barack Obama took the least time of any first-term president in naming his science adviser.



Journal name:
Nature
Volume:
550,
Pages:
434–435
Date published:
(26 October 2017)

DOI:
doi:10.1038/550434a

Comments

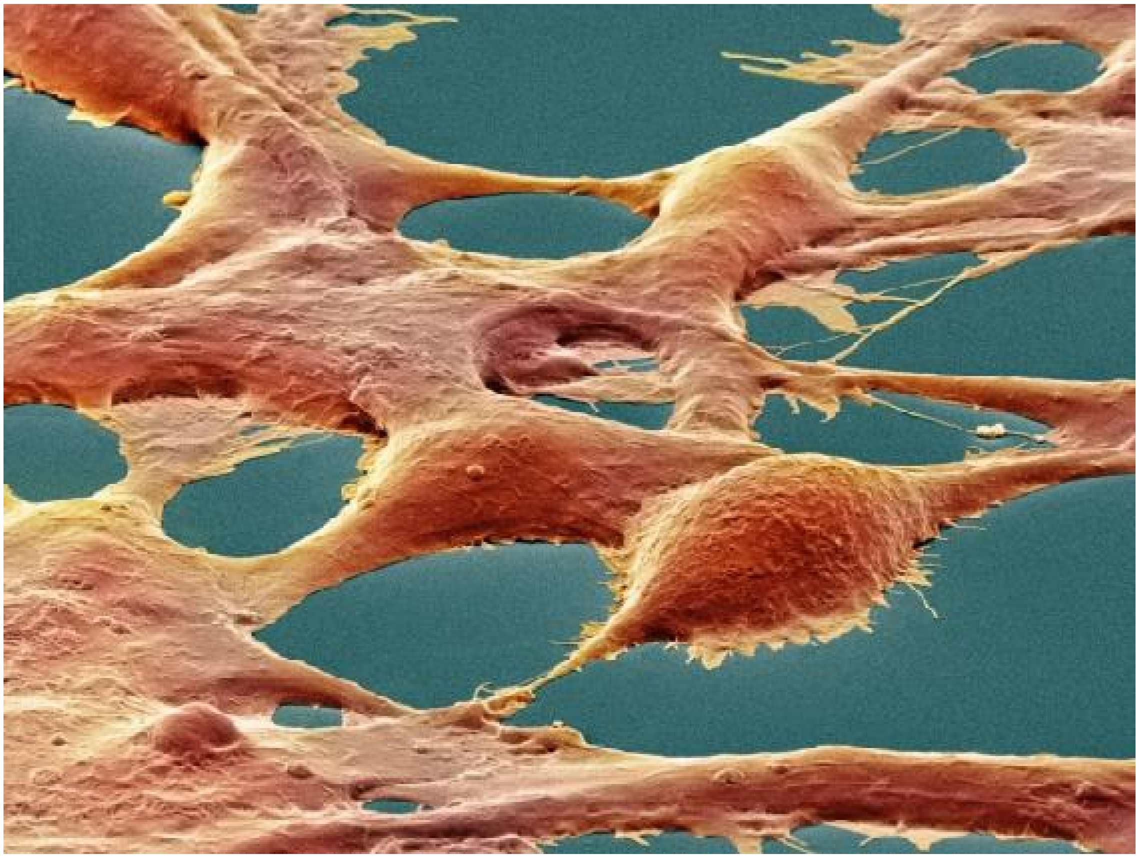
Comments

There are currently no comments.

CRISPR hacks enable pinpoint repairs to genome

Precision tools expand the number of 'base editors' available for manipulating DNA and RNA.

25 October 2017



David McCarthy/SPL

Using human embryonic kidney cells, researchers have come up with a way to edit specific letters in the genome.

The toolbox for editing genes expanded this week, as two research groups

announced techniques that enable researchers to make targeted alterations to DNA and RNA. Unlike the original CRISPR gene-editing system — a relatively unpredictable and blunt form of molecular scissors that cut sizeable sections of DNA — the new systems rewrite individual letters, or genetic bases. The ability to alter single bases means that researchers can now attempt to correct more than half of all human genetic diseases[1, 2].

The tools, developed by separate teams at the Broad Institute of MIT and Harvard in Cambridge, Massachusetts, are adaptations of the CRISPR system. Whereas most past attempts to use CRISPR-based methods to fix individual bases have been crude affairs — akin to using a machete to remove a wart — the new techniques are more like “precision chemical surgery”, says David Liu, a chemical biologist at the Broad Institute who led one of the studies.

Last year, his group reported[3] the first ‘base editing’ method for converting one target DNA letter into another without needing to cleave the genome’s double helix. It has since been used around the world to correct genes in fungi, plants, fish and mice, and even in human embryos harbouring a defective gene that can cause a blood disorder. But that base editor could achieve only two kinds of chemical conversions: a cytosine (C) into a thymine (T) or a guanine (G) into an adenine (A).

The new base editor — described in a paper published on 25 October in *Nature*[1] — works in the other direction, converting T to C or A to G. It can therefore undo the most common types of ‘point mutation’, which involve single aberrant bases.

In human embryonic kidney cells and bone-cancer cells, the technique made the desired corrections with about 50% efficiency and almost no detectable by-products. By comparison, a more conventional CRISPR-based method, in which scientists insert a strand of DNA containing the desired base change, fixed the same single-base differences with less than 5% efficiency and often caused undesired insertions or deletions of large chunks of DNA.

“This is a major breakthrough in the field of genome editing,” says Jin-Soo Kim, a molecular geneticist at Seoul National University.

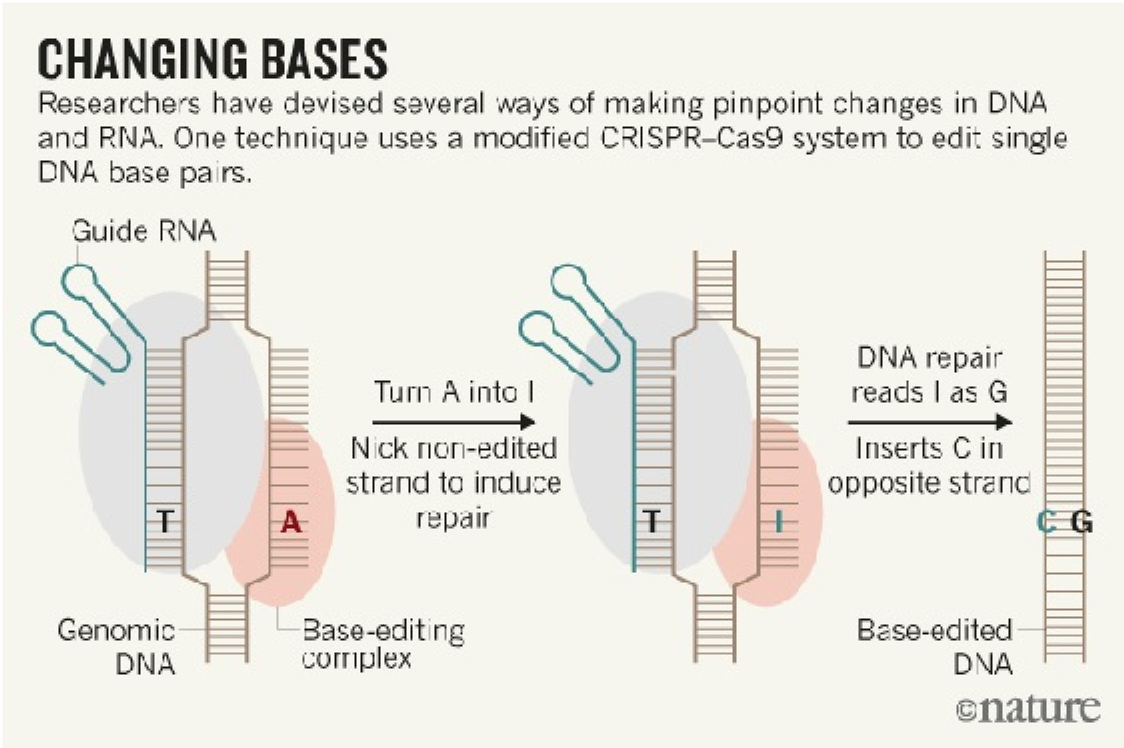
Tricks of the trade

Another method, described in a study published on 25 October in *Science*[2] and led by Broad Institute bioengineer Feng Zhang, performs a similar conversion, but for RNA instead of DNA. It turns an A into inosine (I), which is read as a G by the cell's protein-building machinery. This allows for a temporary correction of a disease-causing mutation without permanent alteration to the genome — a potentially safer option when it comes to gene-fixing therapeutics, although the treatment would need to be administered repeatedly. It would also mean that researchers could alter a treatment as they gain a better understanding of the disease. "If you use RNA therapy," Zhang says, "you can upgrade."

His team's RNA editor is based on a naturally occurring enzyme that rearranges the atoms in A to resemble I instead. The researchers fused the enzyme to a disabled version of the CRISPR system — one involving an RNA-targeted enzyme called Cas13, instead of the usual DNA-binding Cas9. With the help of a sequence-specific guide RNA molecule, they successfully corrected disease-causing mutations 23–35% of the time, with low incidences of off-target activity.

In the base-editing method pioneered by Liu's team last year, the researchers engineered a naturally occurring enzyme and tethered it to a dud Cas9, which allowed them to convert C to T. But there is no equivalent enzyme found in nature for the opposite conversion in DNA. So the researchers started with an RNA-editing enzyme similar to the one Zhang's group used.

The team guided the evolution of bacterial cells through seven generations, and used some protein engineering in the lab, to produce an enzyme that would recognize and manipulate DNA. The enzyme was able to rearrange atoms in adenine to change it into an inosine, which the cell reads as a guanine. The system then tricked the cell into inserting a cytosine into the unmodified DNA strand (see 'Changing bases').



SOURCE: REF. 1

Gutsy move

"It represents a heroic effort," says Dana Carroll, a genome-engineering researcher at the University of Utah in Salt Lake City, noting that the directed-evolution approach was something of a shot in the dark. "I wouldn't have had the guts to try what they did," Carroll says. "My hat's off to David Liu."

The ability to make four types of single-base conversion — A to G, G to A, C to T and T to C — "will be extremely valuable for precise therapeutic and agronomic editing", says Caixia Gao, a plant geneticist at the Chinese Academy of Sciences' Institute of Genetics and Developmental Biology in Beijing.

It could also prove useful in drug discovery and for DNA-based data storage, says Marcello Maresca, a gene-editing researcher at AstraZeneca in

Gothenburg, Sweden.

The development of any other base editors will require enzymes that do not occur in nature, even for conversions in RNA. But that kind of obstacle has not stopped Liu before. “We’ll keep trying until the community has developed all possible base editors,” he says.

Journal name:
Nature
Volume:
550,
Pages:
439–440
Date published:
(26 October 2017)
DOI:
doi:10.1038/550439a

Comments

Comments

There are currently no comments.

Out of the Syrian crisis, a data revolution takes shape

Aid organizations have been piloting a nimble approach to cut through the fog of war.

25 October 2017

Neil Brandvold for Nature

A doctor and technicians record health data on a Syrian refugee in Jordan.

Shadows shroud Issam Salim's face as he recounts the operations he's performed. Yesterday, he tended to fractures, mangled limbs and intestinal injuries caused by an explosion from an unknown source. “The situation was very tense,” he says. Today, there have been no war-wounded patients, so he

saw people with bladder stones and hernias instead. Salim is deputy director of a hospital in southern Syria, and he's talking to an Iraqi surgeon, Ghassan Aziz, through a flickering Skype video call.

Aziz is not far away — just two hours south by car, in Jordan's capital, Amman. It is from here that the organization Aziz works for, Médecins Sans Frontières (MSF), has been providing medical aid to clinics in southern Syria during a conflict that has become one of the world's worst ongoing humanitarian crises. But Aziz and his colleagues dare not get much closer. After 13 MSF staff members were kidnapped in January 2014, the organization, also known as Doctors without Borders, pulled its international staff out of the country.

Text messages and calls such as the one with Salim provide a glimpse of what is going on, but it is hardly enough to let MSF staff predict what Syrian doctors and nurses will need most to help their communities. An increase in severe burns might mean that C-4 plastic explosives are in heavy rotation, for example, and therefore medics will require extra antibiotics, intravenous lines and surgical equipment, because they won't have time to sterilize between operations. Or an increase in kidney failures could mean that people with diabetes have lost access to regular care. But the fog of war makes tracking such trends next to impossible.

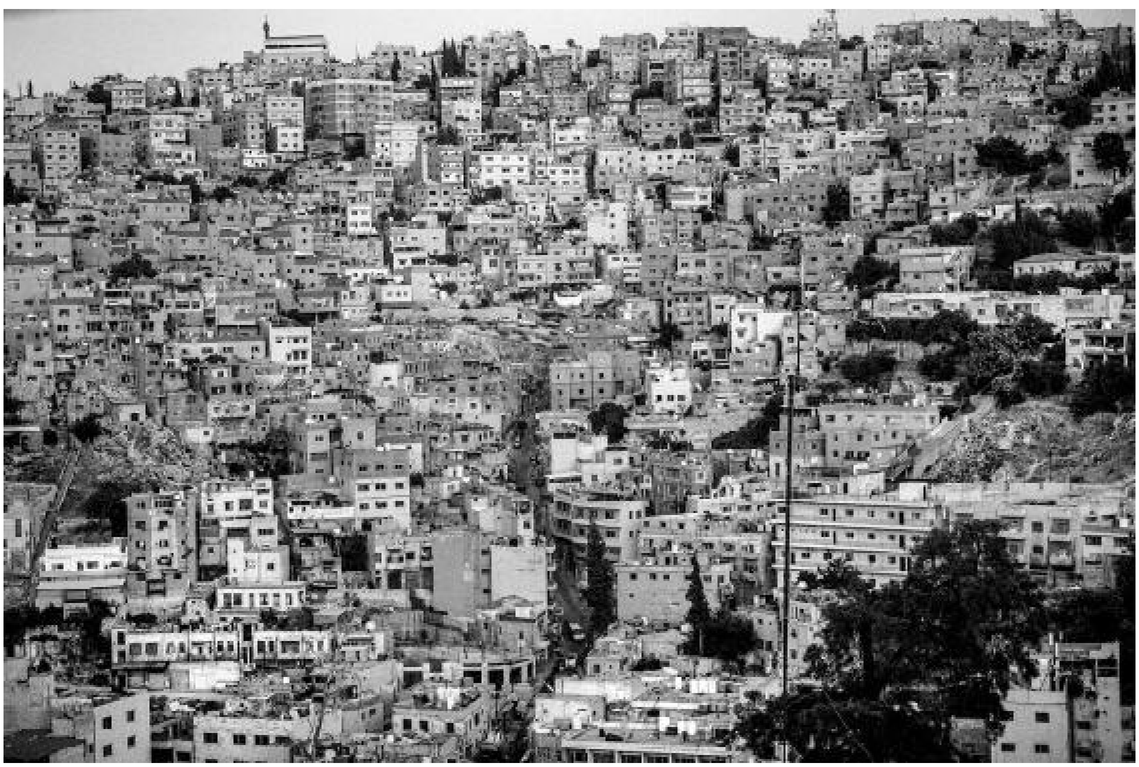
Whenever war, hurricanes or other disasters ravage part of the globe, one of the biggest problems for aid organizations is a lack of reliable data. People die because front-line responders don't have the information they need to act efficiently. Doctors and epidemiologists plod along with paper surveys and rigid databases in crisis situations, watching with envy as tech companies expertly mine big data for comparatively mundane purposes.

Three years ago, one frustrated first-responder decided to do something about it. The result is an innovative piece of software called the Dharma Platform, which almost anyone can use to rapidly collect information and share, analyse and visualize it so that they can act quickly. And although public-health veterans tend to be sceptical of technological fixes, Dharma is winning fans. MSF and other organizations now use it in 22 countries. And so far, the Rise Fund, a 'global impact fund' whose board boasts U2 lead singer Bono, has invested US$14.3 million in the company behind it.

“I think Dharma is special because it has been developed by people who have worked in these chaotic situations,” says Jeremy Farrar, director of biomedical-funding charity the Wellcome Trust in London, “and it's been road-tested and improved in the midst of reality.”

Now, the ultimate trial is in Syria: Salim, whose name has been changed in this story to protect him, started entering patient records into the Dharma Platform in March, and he is looking at health trends even as he shares his data securely with MSF staff in Amman.

It's too soon to say that Dharma has transformed his hospital. And some aid organizations and governments may be reluctant to adopt it. But Aziz, who has deployed Dharma in Iraq, Syria, Jordan and Turkey, is confident that it will usher in a wave of platforms that accelerate evidence-based responses in emergencies, or even in health care generally. “This is like the first version of the iPhone or Yahoo! Messenger,” he says. “Maybe something better will come along, but this is the direction we're going in.”



Neil Brandvold for Nature

Overlooking Amman, where Médecins Sans Frontières remotely supports clinics in southern Syria.

Born of frustration

Jesse Berns dreamt up Dharma after years of first-hand experience with the injured and ill, first as a helicopter paramedic, and then as a field epidemiologist embedded in some of the world's worst disaster zones. “I've worked in pretty much every conflict since 2006,” she says. She became disheartened by the inability to base decisions on data. In 2013, for example, she was surveying the health condition of refugees at the Iraq–Syria border with the World Health Organization. She entered her own hand-written data into an Excel spreadsheet, merged the information with other data, analysed it and generated a report. But the process took five months, and at that point, the results were too old to act on.

In 2015, she worked with MSF during the Ebola crisis in West Africa as the group tried to find a way to track and transmit data on the vital signs of dying patients without a Wi-Fi connection. Berns watched as incredible sums of money were spent. But the outbreak was over before a solution materialized.

She felt broken. “I got burned out after seeing colossal wastes of money and time,” she says. “I'd come home and have Uber and Slack, but in the field I had paper and Excel and it was just the ultimate shitshow for data.”

Berns complained to her friend Michael Roytman, a data scientist working in Chicago, Illinois, and California's Silicon Valley. Roytman suggested that the two join forces and create software to allow an emergency responder to fill the gap in a flash, without having to ask Excel experts, information-technology departments or consultants for help. The platform also had to work offline, store data securely in the cloud and be able to pass information through Bluetooth connections in case bombs, power failures or computer viruses interrupted service. So the pair started a company based in Washington DC to build what was needed in the field.

When they are asked to describe Dharma, Berns and Roytman struggle

because there aren't yet many things like it. “It's not a database,” says Roytman. “It's a platform or framework that lets people with no technical background create the tool they need.”

An early iteration of Dharma caught the attention of Pablo Marco, the head of MSF's Middle East operations, based in Amman, in 2015. His team had been struggling with the complexities of health in the region, which presented challenges MSF was unaccustomed to. For refugees in Africa, he says, the approach is generally straightforward because needs are fairly uniform: provide clean water, food, shelter, antibiotics and vaccines. “We have a checklist,” Marco says, “so we can act fast, fast, fast,” But refugees from Iraq and Syria have a range of different requirements. They might be managing depression, hypertension or diabetes instead of malnutrition. And their needs are in flux as they move and lose assets, and as access to medicine comes and goes.

Marco wanted to see whether new technology could provide faster feedback. So he asked Berns to meet Aziz, who was preparing to survey some 200,000 Iraqis who had fled south from the Islamist terrorist group ISIS in Mosul. Having completed his medical residency in Baghdad amid sectarian violence in 2007, Aziz understood the depth of the challenge before him. Acute traumas would be obvious, but not festering chronic maladies. He readied himself for the undertaking: “You need to train a large number of people to go out to households and fill out paper forms. Then it takes tonnes of time to transfer those forms into Excel, then transfer the data to an analyst and three months go by before they send back findings.”

Aziz, a programme manager at MSF's Center for the Advancement of Humanitarian Medicine in Amman, resembles a Silicon Valley techie with his backpack and worn T-shirt, but he has no computer-science background. Sceptical, but willing to give Dharma a try, he downloaded it onto a tablet and built a form with 145 questions. The survey was designed to move fast, asking only questions made relevant by previous responses. Each person would answer a total of about 25. Women of child-bearing age, for example, were asked whether they were pregnant, and children were asked if they had had diarrhoea or asthma attacks in the past two weeks. Iraqi medical students asking the questions sped through the surveys.

By day 5, the students had collected information from 6,455 people. Then Aziz did something he never could have done before. He merged the information from their devices onto his own and he began to interrogate the data, simply by typing in questions: for example, who identifies as head of household (husband, wife, son-in-law, and so on), and what are the chronic illnesses among these household heads? The answers came back instantly, in graph form.

“Even though I had been up since 5 a.m. that day, I stayed awake until 4 a.m. since it was so interesting,” he says. In one view, a pie chart revealed that people of various ages and backgrounds were complaining of skin irritation. Within minutes, it was obvious that the burrowing mites that cause scabies had infested mosques, motels and flats in which refugees were living. Aziz shared the data with MSF and in less than six weeks the organization was treating people with scabies and their contacts, and spraying shelters to eradicate the pests. A follow-up survey showed that the rate of scabies had dropped from 72% to 23%. Without Dharma, Aziz says, it would have taken several months to realize that something so easily fixed needed attention.

He was sold, and went on to use Dharma to survey refugee health in Turkey and Syria. All the while, he kept in touch with Berns, who tweaked the product in response to feedback. The same evolution occurred as the World Health Organization applied Dharma in Iraq, and as the Paris-based aid agency Médecins du Monde piloted it in Lebanon to assess the mental health of Syrian refugees. Preliminary data from that test suggest that refugee women with children have a lower incidence of suicidal thoughts than those without. Now the group is exploring the connection in a larger survey.

As Dharma's use has spread, public-health experts have taken notice. In April, Farrar told Larry Brilliant to check it out. Brilliant is an epidemiologist and former Google executive who now chairs the Skoll Global Threats Fund, a group in San Francisco, California, that identifies solutions to problems imperilling humanity. He was flabbergasted by how simple it was to use. “I am pitched lots and lots of systems that mechanize emergency and public-health responses, but they take so damn long to learn,” he says. “That is not true for Dharma.” In July, he joined the company's board.

Broken records

In Syria, MSF has been anxious to get access to patients' medical records, which would provide a long-term view of how people are faring and what support Syrian hospitals need. But that has been next to impossible because hospitals have been targeted by the Syrian regime and terrorist groups. Since March 2011, the non-profit group Physicians for Human Rights in New York City has documented 826 deaths of health-care workers in Syria from targeted bombs, assassinations and torture — more than 90% by the government.

Although MSF officially withdrew from the country in 2014, it had avoided some dangerous regions since 2011. One afternoon in 2012, Khalid Ahmad, a tropical-medicine doctor with the charity, got an idea about how the group could provide aid in areas that it was unable to reach itself. He was at an MSF office in Turkey, just across the northern Syrian border, when a young Syrian couple approached him. They showed him videos on their phones of people mangled under rubble. “They were finding the wounded and bringing them to clandestine hospitals,” Ahmad says. “They weren't even doctors, but they were organized, and I was so touched by their commitment.” He gave the couple first-aid kits and training on how to stop bleeding and move the wounded. Then he set out to find doctors said to be operating out of basements, in living rooms and under trees. Underground practices were “mushrooming up everywhere”, he recalls.

In 2015, MSF forged a connection with a hospital serving a large population in southern Syria — the one where Salim now works. At first, MSF asked hospital employees to enter patient data into an electronic database that the organization has long deployed around the world. But the Syrians didn't use it. They did not work for MSF, and they had little to gain from entering data into an unfamiliar system. Trying to get meaningful analyses out of it would take training and time, which the overwhelmed hospital staff didn't have. Plus, MSF's internal system is rigid. Requests for changes have to go through technology departments in European cities, a fact that stood out as a bottleneck.

Early this year, Aziz got the green light to try Dharma at the hospital. He

designed questionnaires on the platform that mimicked the format of the hand-written record books that hospital staff were accustomed to keeping. Two tablets with the program arrived at the hospital on 1 March, and every day since then, hospital staff have transferred data from hard copies into the devices. Anyone with access to the system can use it to search for trends.

For example, in April, Aziz noticed an unusually high number of infections among women who came for post-natal visits. Looking more closely, he saw that these women had not given birth at the hospital, so their infections probably came from stitches administered by midwives after slight rips during birth. “That means the midwife is doing this without sterile tools or in non-sterile conditions,” he says. “By knowing this, we can start to think about how to fix it.”

As of 15 October, the hospital has shared details from 29,469 patient visits. It's an exponential boost in information. “This is the only eye we have,” says Anja Braune, project coordinator for MSF's south Syria operation. “This is the only way we can try to forecast the coming period.” Still, Braune says that Dharma has not suddenly solved an extraordinarily difficult situation. In 2016 alone, MSF-supported facilities in the country were bombed or shelled on 71 separate occasions.

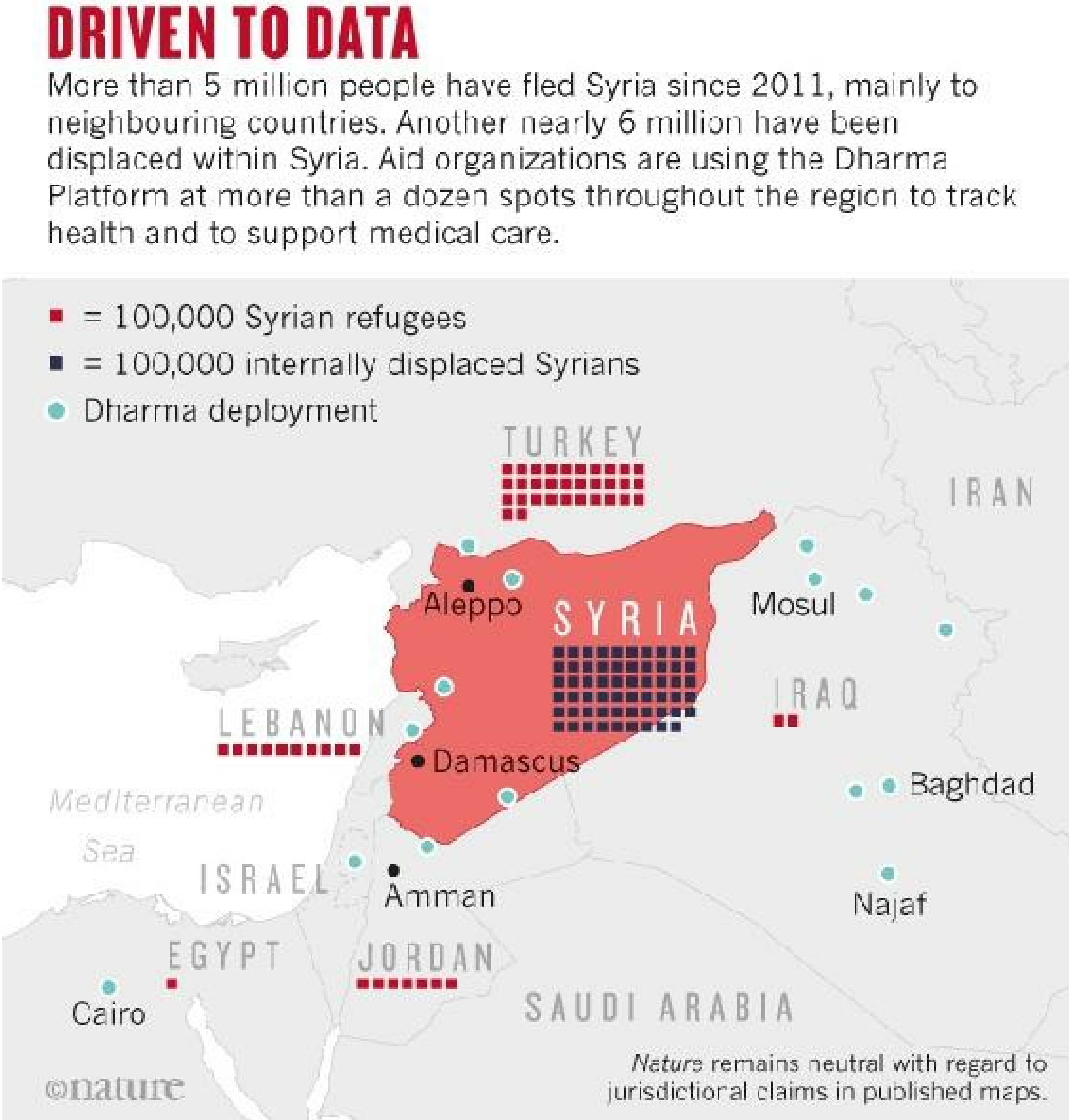
Data diaspora

But the data gap in the Syrian crisis extends outside the country's borders. Since 2011, about 5.3 million Syrians have fled the country, 92% of them to Turkey, Lebanon and Jordan (see 'Driven to data'). Although they are no longer in imminent danger, many continue to deteriorate from chronic health conditions, despite medical care. To understand how to help them, doctors need information.

One sweltering morning in July, Mohammed Manasrah carries a device loaded with Dharma to the houses of his bed-bound patients in Ar Ramtha — a northern district of Jordan where roughly 68,000 Syrian refugees have settled in concrete flats. Manasrah is a physician at an MSF hospital in Ar Ramtha specializing in non-communicable disease. Forms created on Dharma

can be easily amended, and Manasrah inserts variables that might help him discover patterns. “I want to see if some medication we are giving them correlates with depression or if that's tied to refugee status,” he says. “I want to see if we can convince women who cannot walk in the street to exercise in their homes, and to see if this leads to better medical outcomes.” Some answers may lie in patient records maintained by the hospital, but analysing the information requires more expertise and time than he has. On Dharma, he could search for correlations in minutes.

Doctors and other crisis responders have never had access to technology like this before: something that lets them design the tool they need for a job, and that puts analytics at their fingertips. The hope is that this will make them want to participate further and collect more information. That kind of buy-in is important, says Matthew Gee, a data scientist at the University of Chicago. “Whether you are a clinician trying to treat an illness or an academic wanting to understand the propagation of an infection, you rely on the data collector,” Gee says. The same data that help crisis responders react day-to-day can later be used by academics doing long-term research.



Source: UNHCR

Dharma makes it technically easier to share data, too. If a sudden disaster occurs, information obtained on the platform can (pending permission) be passed on to researchers more easily than before. Berns and Roytman have designed the platform to adhere to the security and formatting standards that many scientific-review boards and government agencies recommend. That's a key reason that Dharma is being piloted by scientists monitoring Middle East respiratory syndrome, or MERS, as part of the International Severe Acute

Respiratory and Emerging Infection Consortium. In this way, researchers who arrive at an outbreak much later than first-responders can make use of information gathered at its unpredictable start.

Still, Dharma could fail, like most start-ups. At the moment, many aid groups and governments prefer open-source tools, such as Open Data Kit, says Dykki Settle, director of digital health at PATH, a global-health organization based in Seattle, Washington. Settle explains that cost is not the reason: although open source means that the raw software is free, consultants still charge fees to maintain and modify it, or to link it with other systems for storage or analytics.

Rather, open source has some of the appeal of a vintage car: tinkering is an expectation. Someone who can program computers can alter the code, and weave one component with another. But as with vintage cars, that's unlikely to be the most reliable approach in a crisis. “In an emergency, you may not have the time and money to invest in the extra labour that open source requires,” Settle says.

Berns argues that Dharma is just as useful for long-term health management as for emergencies. And although its code is not accessible, she says, the ease of customization has allowed humanitarian groups to assess data ranging from medical needs to housing damage in Hurricane Harvey. These attributes have caught the attention of powerful players in global health. The US Centers for Disease Control and Prevention (CDC) is planning to pilot Dharma and several other new or updated systems for data management in emergencies. Richard Garfield, an epidemiologist involved with the effort, says that the agency plans to publish a sort of “consumer report” listing the pros and cons of each. New technology and analytics, he hopes, will force aid agencies to base their actions on evidence. “Everyone gets by with good intentions, and that's a serious frustration for those of us who are really concerned about improving people's lives,” Garfield says.

Neil Brandvold for Nature

A Dharma representative shows staff how to use the platform at a Médecins Sans Frontières clinic in Ar Ramtha, Jordan.

With or without Dharma, technological barriers to information exchange are falling. Still, data sharing may remain an aspirational ideal. Organizations often keep information to themselves to save face when their programmes don't deliver; researchers keep it private because they want credit; and many governments like to control access. In this respect, says Farrar, “the technical side is not the challenge; it is a political one”.

Despite being surrounded by war, Salim pushes for data sharing as well. He would like scientists and doctors around the world to learn the details of his cases. “Many websites talk about the war in Syria, but it's very general,” he says. “We need more specialized people talking about our situation so that it can improve — because the situation is bad.” For example, he says, what types of nerve damage are caused by chemical weapons and how do you treat those affected?

Salim admits that he often considers fleeing Syria, but feels responsible

because he knows too well all he leaves behind. “When it's the worst,” he says, “I weigh the risks and the benefits of the services I provide.” And then he decides to stay. At the very least, the world could pay attention.

Journal name:
Nature
Volume:
550,
Pages:
444–447
Date published:
(26 October 2017)
DOI:
doi:10.1038/550444a

Comments

Comments

There are currently no comments.

French scientists in uproar over changes to medical-research clusters

Biomedical-research agency accused of attempting to undermine autonomy of university–hospital groups.

24 October 2017

IRCAD

The Research Institute Against Digestive Cancer is part of a university–hospital research cluster (IHU) in Strasbourg, France.

A group of French scientists is due to meet government officials on 27 October in a bid to resolve a row that has left many of the country's leading biomedical researchers furious.

Scientists were shocked earlier this month when the government

unexpectedly postponed a call for applications to create a new crop of medical-research clusters just days before the closing date, and said that it would slash the budget earmarked for the project.

Government ministers said that they were delaying the project because they wanted to change the way these autonomous clusters are governed. But scientists contacted by *Nature* say they suspect that behind the decision is an effort by INSERM, France’s biomedical-research agency, to exert control over the institutes.

The idea of creating the clusters, known as Instituts Hospitalo-Universitaires (IHUs), was introduced in 2009 to boost translational medical research, bringing together universities, teaching hospitals, research agencies and industry.

Based on public–private partnerships, they enjoy much autonomy and are mostly free from government and research-agency bureaucracy. The first six IHUs — in Paris, Bordeaux, Marseilles and Strasbourg — were approved in 2010 and received total funding of €850 million (US$1 billion). The clusters have been widely hailed as a successful model, and a second call for applications — open to any group of institutions that wanted to apply — was due to close on 12 October.

But in a press release on 2 October, the government announced that the deadline for the call would be postponed to an unspecified date. It also said that only two new IHUs would be funded, instead of the three initially planned, and that the total budget would be halved to €100 million. Nineteen applications had been made.

In letters sent to the government last week, and to President Emmanuel Macron on 23 October, 14 applicants said they were “appalled” or “bewildered” by the sudden and drastic changes to the funding and to the terms of the selection process. The health minister and higher-education ministers have invited applicants to discuss the issue this week.

Furious reaction

“None of the changes were discussed with us,” says Richard Frackowiak, who was chair of the international panel that would have assessed the IHU applications, but who resigned from the post on 6 October in protest. “The IHUs are the biggest French medical-research success of the past 10 years.”

The delay “is incomprehensible”, says Jacques Marescaux, a surgeon and chairman of the IHU Institute of Image-Guided Surgery of Strasbourg. The clusters are admired worldwide for their flexibility in being able to raise funds rapidly, and to recruit well-paid, top-flight researchers, says Marescaux. “The model has already been copied in Taiwan and Brazil.”

Despite the clusters' autonomy, INSERM seems to have weighed in on the latest call. In a 9 September letter to the IHU applicants, seen by *Nature*, the agency recommends that the candidate clusters alter their proposed structures to a ‘contract’ or ‘consortium’ model. This would give the agency a direct say in IHU affairs. The ministers’ desire to change the governance models seems to directly reflect INSERM’s recommendations, which were not solicited, say applicants. INSERM did not respond to a request for comment from *Nature*’s news team.

The change of strategy suggests that INSERM wants to get its hands on all the clusters, says Didier Raoult, who heads the infectious-diseases IHU in Marseilles. The institutes largely — or, in some cases, completely — escape the control of the research agencies, he adds, as do the patents that come out of them. “To quarrel with leading French and other medical researchers is very bad news for France and its image in the scientific community.”

A joint report by two French inspectorate agencies — of social affairs, and of education and research — was completed before the latest call was opened, and said that the IHUs were “promising”. The institutes had filed 183 patents and spun out 28 start-up companies. Although the report called for improved IHU governance, including closer researcher involvement, “it said the autonomous foundations should be maintained and strengthened”, notes Philippe Froguel, who is leading an IHU application and is an endocrinology researcher at Lille University Hospital.

Froguel is concerned that at the upcoming meeting, applicants will simply be again told what has been already decided. But he hopes that it will provide an

opportunity for negotiation and some clarity: “They will have to give us a new date for the tender and be more precise about the question of governance, which will be positive,” he says.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22877

Comments

Comments

There are currently no comments.

Wait for Trump's science adviser breaks modern-era record

Top White House science job stays empty more than nine months after president took office.

24 October 2017 Corrected:

1. 24 October 2017

Kevin Lamarque/Reuters

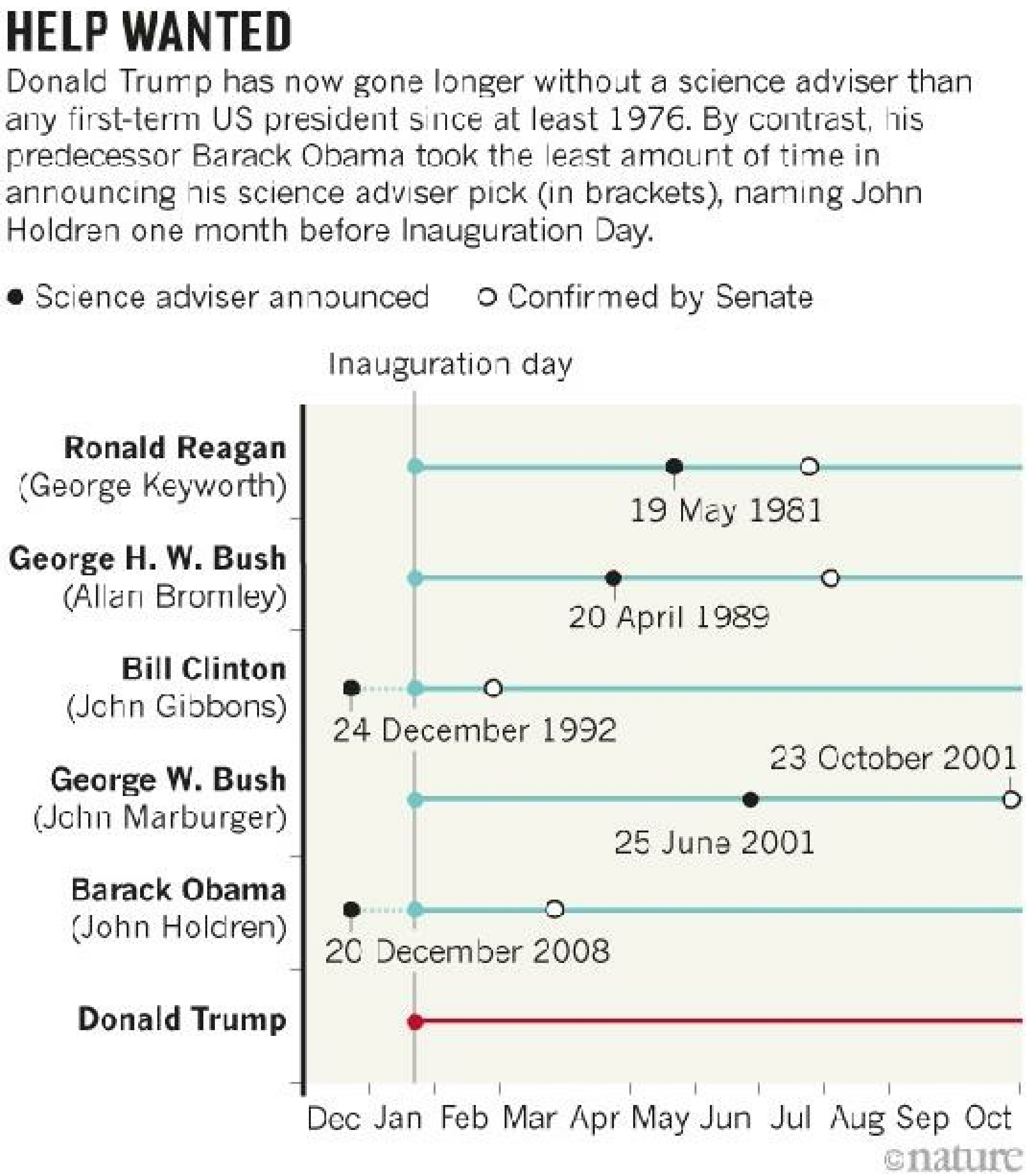
US President Donald Trump still hasn't chosen a White House science adviser

Donald Trump has now gone longer without a science adviser in place than any recent first-term US president — by any measure.

On 23 October, Trump broke the record set by former President George W. Bush. Bush's science adviser, physicist John Marburger, was confirmed by the Senate on 23 October 2001. That was 276 days after Bush took office, and 120 days after he announced that Marburger was his pick for the job.

Trump has also waited longer than any president since at least 1976, when the White House Office of Science and Technology Policy was created, to name his choice for the science-adviser job (see 'Help wanted'). Although rumours have surfaced periodically about scientists who may be in the president's sights, the White House has not made any official announcement.

By contrast, Trump's predecessor Barack Obama took the least time of any first-term president in naming his science adviser. Obama revealed his choice of physicist John Holdren on 20 December 2008 — just 47 days after he won the presidency, and exactly one month before he was sworn in. (Holdren was confirmed by the US Senate three months later, on 19 March 2009.)



Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22878

Corrections

Corrected:

> An earlier version of the graphic gave the wrong year for the date that John Marburger was confirmed by the Senate as the science adviser.

Comments

Commenting is currently unavailable.

Reclassify waste to shift the nuclear landscape

The US Department of Energy should classify and dispose of nuclear rubbish according to risk.

24 October 2017

Brian Vander Brug/Los Angeles Times/Getty

Reclassification of nuclear waste could make disposal simpler and cheaper.

The United States has a single deep geological repository for nuclear waste. Since 1999, the Waste Isolation Pilot Plant (WIPP), 655 metres down in a massive salt formation near Carlsbad, New Mexico, has received 12,000-odd shipments of what it calls transuranic waste. This is clothing, tools and other

detritus from the nuclear-weapons programme that are contaminated by elements heavier than uranium. It’s more hazardous than low-level waste, which can be buried closer to the surface, but not as dangerous as high-level waste, for which a disposal site has yet to be found.

WIPP was closed for three years after radiation escaped from a ruptured drum in 2014. It was given the all-clear to reopen only in January; an enquiry determined that the drum had been packed improperly before shipment from the Los Alamos National Laboratory in northern New Mexico. Concerns remain about safety, as well as the long-term risk of human intrusion into a facility that will remain dangerous for thousands of years after its eventual closure. But by and large, WIPP has functioned as designed, and it could do even more to help the US Department of Energy (DOE) address the fallout from the country’s nuclear-weapons programme.

Much high-level waste — produced during the reprocessing of spent nuclear fuel into plutonium — is highly radioactive and dangerous. But the evidence suggests that some of the waste that is labelled ‘high level’ technically qualifies as transuranic. This material is still barred from direct disposal at WIPP, purely because of how it was produced. But labels can be changed. If wastes that meet the transuranic criteria could be shipped to WIPP, it would save considerable time and effort as the DOE continues to struggle with the country’s radioactive legacy.

At present, the high-level waste is scheduled to be encased in glass logs for disposal in a separate repository at Yucca Mountain in Nevada. Despite decades of delays and controversies, there are signs of progress at the DOE’s flagship vitrification facility at the Hanford Site in Washington. But even if current plans hold, that facility will not begin processing high-level waste until 2032. Nor is it clear where the logs will actually go. Yucca Mountain was shut down by former president Barack Obama, only to be revived by President Donald Trump. Its long-term prospects are far from certain.

Reclassifying some high-level waste at Hanford, as well as at two facilities in Idaho and South Carolina, offers an alternative path for some of that waste, and one that would reduce an ongoing threat to workers and the environment. More than one-third of the 177 underground storage tanks at Hanford have leaked and contaminated groundwater.

The problem is inertia, compounded by fear, distrust and politics. The DOE is operating under a complex web of rules, regulations and legal agreements, and shifting course isn't easy. Although the agency has the authority to look through its nuclear-waste inventory and reclassify wastes that meet the WIPP transuranic criteria, it has resisted such a move because it fears that this would spark political uproar — and quite probably legal challenges.

Washington state, which has in place a court-ordered clean-up agreement for Hanford, has been particularly resistant to change. And New Mexico has tied the DOE's hands at WIPP by banning the disposal of tank wastes and any other materials managed as high-level waste — even if they meet the WIPP criteria. Watchdog groups, meanwhile, are concerned that nuclear-waste reclassification is simply a way of changing the rules and lowering the bar for public and environmental safety.

The proposal briefly bubbled up to the surface several years ago, but political attention shifted after the leak at WIPP. Now a coalition of local governments from communities across the nuclear-weapons industry is reviving the idea. In a white paper published last month, the Energy Communities Alliance urged a two-pronged approach involving the DOE as well as Congress, which could clarify the definition of high-level waste legislatively. The alliance estimated that the DOE could save at least US$40 billion over the lifetime of its clean-up programme — more than 15% of the estimated $257-billion price tag.

After spending some $11 billion on the as-yet-unfinished vitrification plant over the past two decades at Hanford, some may hesitate to change course. But as former DOE secretary Steven Chu said, the worst thing you can do in a multi-decade project such as nuclear-waste clean-up is to close the door to alternatives. In this case, the solution is simple enough: nuclear waste should be managed on the basis of the risk it poses and not the process that produced it.

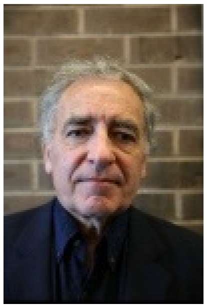
Journal name:
Nature
Volume:
550,
Pages:

429–430
Date published:
(26 October 2017)
DOI:
doi:10.1038/550429b

Comments

Comments

There are currently no comments.



Ted Lewis
III

Cancer biology still needs physicists

Considering game theory and the role of physical forces could lead to better treatments for cancer, says Robert Austin[1].

24 October 2017

Cancer is close to surpassing heart disease as the leading cause of death in the United States. The World Health Organization estimates that worldwide, new cases will rise by 70% in the next two decades. In concert, treatment costs are skyrocketing and could reach US$156 billion by 2020 in the United States alone, according to the US National Cancer Institute (NCI). A modest decline in US cancer mortality rates has been attributed to prevention, such as lower smoking rates, rather than better treatment. Yet, more than 150,000 papers on cancer have been published each year since 2013.

This month, application deadlines closed for several programmes in the US$1.8-billion Cancer Moonshot authorized by the US Congress in 2016. The extra funds to study cancer are badly needed, but we do not have a sufficient fundamental understanding of the disease for these investments to make a near-term difference in treatment.

Comparison of the cancer initiative to former US president John F. Kennedy’s lunar challenge is misleading. When, in 1961, Kennedy declared

the goal of landing on the Moon, we understood gravity well enough to be reasonably confident that if we built rockets powerful enough, we could do it. We could predict distant planetary orbits with startling precision. Getting an astronaut to a nearby satellite was an engineering feat. No new basic principles needed to be discovered.

This is not true for cancer. The deepest puzzle we must solve is how groups of cells behave, which networking theories developed in the physical sciences are well equipped to address. Cancer can move from a localized tumour to remote locations — a process called metastasis. Once that happens, individuals with cancer have a poor prognosis. Metastasis drives the costs of treatment skyward, but these therapies are, tragically, largely futile. Without a better way to explain and treat metastases, new clinical methods will do little to improve the situation.

To be sure, there has been progress. A growing appreciation of how the immune system keeps cancer in check has brought a new class of therapies. Patient-specific chemotherapy and more-precise radiotherapy have also led to advances. But cancer needs more big ideas — and those of scientists from other disciplines should be taken more seriously.

In 2008, I attended a series of workshops organized by the NCI in Bethesda, Maryland, to bring together physicists, engineers, mathematicians and computer scientists to look for new ways of tackling the disease. These led to the creation in 2009 of a dozen designated physical-sciences oncology centres; I led the Princeton Physical Sciences–Oncology Center, based in New Jersey, from 2009 to 2015.

Over that time, large cancer-genome sequencing projects revealed millions of cancer-related mutations. The numbers found in individual tumours and types of cancer range widely. Exactly what causes this variation is unclear. In any case, genetically targeted treatments generally buy affected individuals, at most, a few more months of life.

Since the centres launched, there has been greater recognition of the potential contributions of physical forces to cancer-cell responses, such as the number and location of metastases, or how cells stick together. Networking and game theories — mathematical analyses of social and economic interactions that

represent how humans do or don’t cooperate to minimize costs and maximize gains — have also been adapted to model how cells behave during cancer growth and invasion. Particularly promising, in my view, are theories of the evolution of multicellularity, when cells had to develop mechanisms for living in communities — possibly at the cost of their own selfish, local goals of reproduction. I argue that these approaches have not yet had time to show their potential.

The cancer community has been unenthusiastic about the contributions of physical oncologists. When, several years ago, we proposed a special section on the physics of cancer for a high-profile journal, oncology referees were dismissive. One admitted: “I am not a big fan of the topic.” Another reviewer rejected the proposal because genetics “is the Rosetta Stone with respect to treatment”. Wrote another: “I did not recognize any of the proposed authors.”

Too often, biologists see physicists as human calculators. The big ideas, they think, belong to them, with physicists filling in the details by performing quantitative analyses. To counter this attitude, the Francis Crick Institute in London, for instance, is actively searching for physicists with transformative ideas. We need to do more than hire ‘quants’ to crunch ‘big data’.

To develop new conceptual approaches to cancer, scientists of all stripes must reach out. I have sometimes antagonized biologists by saying that their advice stifles creativity. But I am now working, along with medical physicist Robert Jeraj of the University of Wisconsin–Madison, to form groups within the American Physical Society that focus on oncology. These scientists have strong collaborations with biomedical researchers, but have historically been restricted to advancing imaging technologies — important, but far removed from bringing in ideas about the origins and progression of disease. I also serve on the editorial board of two journals designed as outlets for this sort of work. *Convergent Science Physical Oncology* was launched in 2015, by the Institute of Physics in Bristol, UK, and *Cancer Convergence* (published by Springer Nature, which also publishes *Nature*) will publish its first articles in the next few months.

We need to expand our questions — or risk remaining Earth-bound.

Journal name:

Nature
Volume:
550,
Pages:
431
Date published:
(26 October 2017)
DOI:
doi:10.1038/550431a

Comments

Commenting is currently unavailable.

India gears up for second Moon mission

The Chandrayaan-2 orbiter, lander and rover will track how lunar dust might scupper settlement.

24 October 2017

Xinhua/Alamy

India's Chandrayaan-2 moon mission is scheduled to launch next March from the spaceport of Sriharikota.

In a large shed near the headquarters of the Indian Space Research Organisation (ISRO) in Bangalore, a six-wheeled rover rumbles over dark grey rubble in a landscape designed to mimic the Moon's rocky surface. This test and others scheduled for the next few weeks are crucial steps in India's

quest to launch a second mission to the Moon next March.

The country's much anticipated Chandrayaan-2 comes almost a decade after India began its first journey to the Moon, in 2008. "It is logically an extension of the Chandrayaan-1 mission," says Mylswamy Annadurai, director of the project at ISRO. The spacecraft comprises an orbiter that will travel around the Moon, a lander that will touch down in a as-yet undecided location near the Moon's south pole and a rover.

India's maiden Moon trip was a significant achievement for its space programme, but ended prematurely when ISRO lost contact with the orbiter ten months into the planned two-year mission. However, an instrument on a probe that reached the Moon's surface did gather enough data for scientists to confirm the presence of traces of water.

Chandrayaan-2 will attempt more ambitious technical manoeuvres that will put Indian space technology to the test. For the first time, ISRO will attempt to give a craft a controlled, or soft, landing. The agency has had to develop advanced systems that can guide the lander to a touch down and successfully deploy the rover.

Lunar conditions

Lunar missions are also being planned by China, Japan and other countries, among others. Like these, India's explorations are partly driven by the need to improve understanding of the Moon's environment in the event that governments or private entities decide to establish a human settlement there. One poorly understood phenomenon is floating lunar dust. Without an atmosphere like Earth's, the surface of the Moon is buffeted by solar wind and ultraviolet radiation, creating a layer of charged ions called a plasma sheath in which dust particles can levitate.

If humans colonize the Moon, this dust will be a significant challenge, says planetary scientist Penny King of the Australian National University (ANU) in Canberra. It gets into everything, from astronauts' suits to machinery and equipment, where it causes damage, she says. "Understanding how it moves

around is pretty critical.” ISRO says the Chandrayaan-2 orbiter and lander will carry a first of its kind instrument, called the Radio Anatomy of Moon Bound Hypersensitive ionosphere and Atmosphere (RAMBHA), to measure the density of the near-surface plasma and how it changes over time.

Evolving environment

The rest of the spacecraft’s suite of instruments will collect data to help scientists study other aspects of the Moon’s present environment and how it has evolved. Chandrayaan-2’s lander will take the first on-site thermal measurements on the lunar surface near a polar region. The mission “is expected to further consolidate the findings from the first mission and add new ones with *in situ* analysis of the lunar surface and ionosphere,” says Annadurai, who is also director of ISRO’s Satellite Centre in Bangalore.

ISRO plans to execute its mission on shoestring budget of just 6.03 billion rupees (US$93 million), including the cost of the rocket and launch. Chandrayaan-2 will be carried into space on one of the agency’s three-stage rockets, a Geosynchronous Satellite Launch Vehicle Mark II, taking off from a spaceport on the island of Sriharikota in the Bay of Bengal. “A nice part of the Indian space programme is that they manage to do things so cheaply,” says ANU astrobiologist Charles Lineweaver. “If it succeeds, maybe everyone else will see that their mission didn’t really need that extra bell or whistle.”

In three to four weeks**,** ISRO will begin one of the final and most complex testing phases for Chandrayaan-2, integrating all of its components. With one Moon mission under its belt, ISRO is settling into its role as a moon-faring organisation. “Maybe we were extra anxious with the first child, as parents. But we relax a bit as more children come along,” he jokes.

Journal name:
Nature
Volume:
550,
Pages:

440
Date published:
(26 October 2017)
DOI:
doi:10.1038/nature.2017.22870

Comments

Commenting is currently unavailable.

To stay young, kill zombie cells

Killing off cells that refuse to die on their own has proved a powerful anti-ageing strategy in mice. Now it's about to be tested in humans.

24 October 2017 Corrected:

1. 25 October 2017

Illustration by Paweł Jońca

Jan van Deursen was baffled by the decrepit-looking transgenic mice he created in 2000. Instead of developing tumours as expected, the mice experienced a stranger malady. By the time they were three months old, their fur had grown thin and their eyes were glazed with cataracts. It took him years to work out why: the mice were ageing rapidly, their bodies clogged

with a strange type of cell that did not divide, but that wouldn't die[1].

That gave van Deursen and his colleagues at Mayo Clinic in Rochester, Minnesota, an idea: could killing off these 'zombie' cells in the mice delay their premature descent into old age? The answer was yes. In a 2011 study[2], the team found that eliminating these 'senescent' cells forestalled many of the ravages of age. The discovery set off a spate of similar findings. In the seven years since, dozens of experiments have confirmed that senescent cells accumulate in ageing organs, and that eliminating them can alleviate, or even prevent, certain illnesses (see 'Becoming undead'). This year alone, clearing the cells in mice has been shown to restore fitness, fur density and kidney function[3]. It has also improved lung disease[4] and even mended damaged cartilage[5]. And in a 2016 study, it seemed to extend the lifespan of normally ageing mice[6].

“Just by removing senescent cells, you could stimulate new tissue production,” says Jennifer Elisseeff, senior author of the cartilage paper and a biomedical engineer at Johns Hopkins University in Baltimore, Maryland. It jump-starts some of the tissue's natural repair mechanisms, she says.

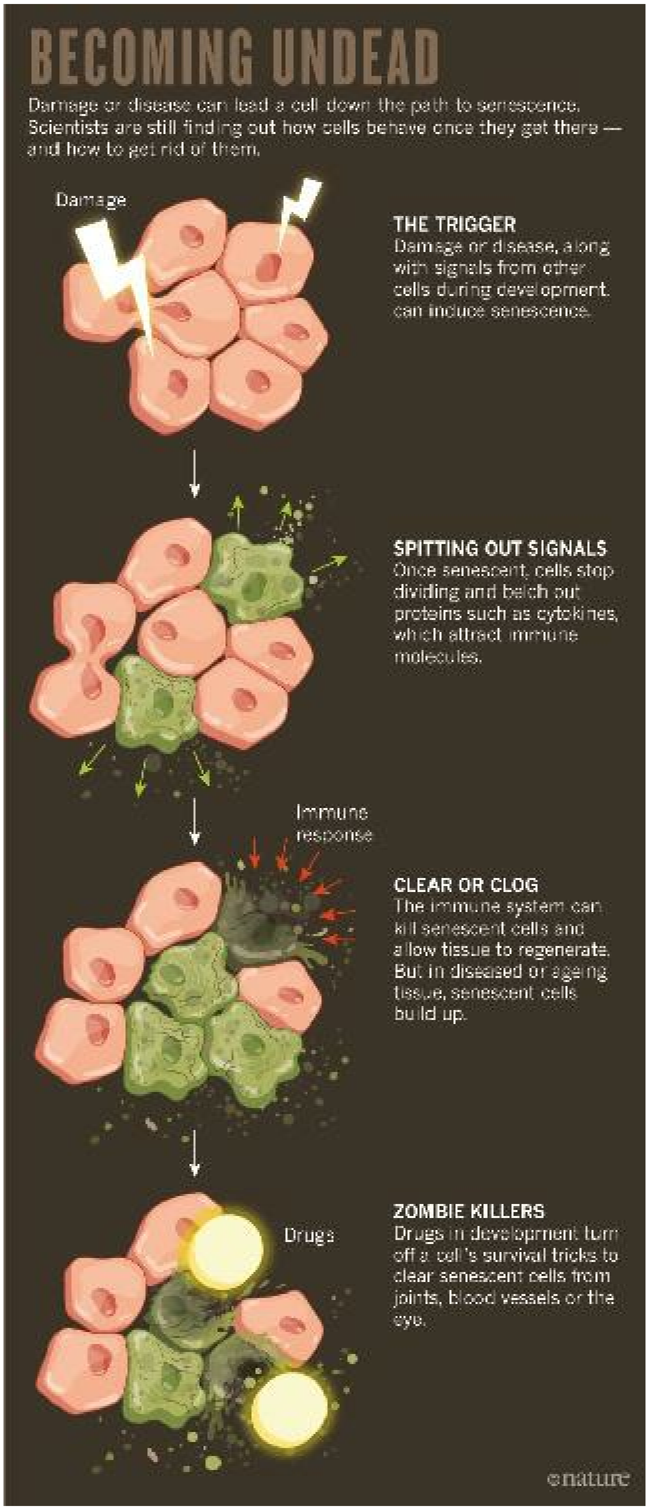
This anti-ageing phenomenon has been an unexpected twist in the study of senescent cells, a common, non-dividing cell type first described more than five decades ago. When a cell enters senescence — and almost all cells have the potential to do so — it stops producing copies of itself, begins to belch out hundreds of proteins, and cranks up anti-death pathways full blast. A senescent cell is in its twilight: not quite dead, but not dividing as it did at its peak.

Now biotechnology and pharmaceutical companies are keen to test drugs — known as senolytics — that kill senescent cells in the hope of rolling back, or at least forestalling, the ravages of age. Unity Biotechnology in San Francisco, California, co-founded by van Deursen, plans to conduct multiple clinical trials over the next two-and-a-half years, treating people with osteoarthritis, eye diseases and pulmonary diseases. At Mayo, gerontologist James Kirkland, who took part in the 2011 study, is cautiously beginning a handful of small, proof-of-concept trials that pit senolytic drugs against a range of age-related ailments. “I lose sleep at night because these things

always look good in mice or rats, but when you get to people you hit a brick wall," says Kirkland.

No other anti-ageing elixir has yet cleared that wall, and for a few good reasons. It's next to impossible to get funding for clinical trials that measure an increase in healthy lifespan. And even as a concept, ageing is slippery. The US Food and Drug Administration has not labelled it a condition in need of treatment.

Still, if any of the trials offer "a whiff of human efficacy", says Unity's president, Ned David, there will be a massive push to develop treatments and to better understand the fundamental process of ageing. Other researchers who study the process are watching closely. Senolytics are "absolutely ready" for clinical trials, says Nir Barzilai, director of the Institute for Aging Research at the Albert Einstein College of Medicine in New York City. "I think senolytics are drugs that could come soon and be effective in the elderly now, even in the next few years."



The dark side

When microbiologists Leonard Hayflick and Paul Moorhead coined the term senescence in 1961, they suggested that it represented ageing on a cellular level. But very little research was done on ageing at the time, and Hayflick recalls people calling him an idiot for making the observation. The idea was ignored for decades.

Although many cells do die on their own, all somatic cells (those other than reproductive ones) that divide have the ability to undergo senescence. But, for a long time, these twilight cells were simply a curiosity, says Manuel Serrano of the Institute for Research in Biomedicine in Barcelona, Spain, who has studied senescence for more than 25 years. “We were not sure if they were doing something important.” Despite self-disabling the ability to replicate, senescent cells stay metabolically active, often continuing to perform basic cellular functions.

By the mid-2000s, senescence was chiefly understood as a way of arresting the growth of damaged cells to suppress tumours. Today, researchers continue to study how senescence arises in development and disease. They know that when a cell becomes mutated or injured, it often stops dividing — to avoid passing that damage to daughter cells. Senescent cells have also been identified in the placenta and embryo, where they seem to guide the formation of temporary structures before being cleared out by other cells.

LISTEN

Hear Judy Campisi and Jan van Deursen discuss why they're excited to be researching senescence.

You may need a more recent browser or to install the latest version of the Adobe Flash Plugin.
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But it wasn't long before researchers discovered what molecular biologist Judith Campisi calls the “dark side” of senescence. In 2008, three research groups, including Campisi's at the Buck Institute for Research on Aging in Novato, California, revealed that senescent cells excrete a glut of molecules

— including cytokines, growth factors and proteases — that affect the function of nearby cells and incite local inflammation[7, 8, 9]. Campisi's group described this activity as the cell's senescence-associated secretory phenotype, or SASP[7]. In recent unpublished work, her team identified hundreds of proteins involved in SASPs.

In young, healthy tissue, says Serrano, these secretions are probably part of a restorative process, by which damaged cells stimulate repair in nearby tissues and emit a distress signal prompting the immune system to eliminate them. Yet at some point, senescent cells begin to accumulate — a process linked to problems such as osteoarthritis, a chronic inflammation of the joints, and atherosclerosis, a hardening of the arteries. No one is quite sure when or why that happens. It has been suggested that, over time, the immune system stops responding to the cells.

Surprisingly, senescent cells turn out to be slightly different in each tissue. They secrete different cytokines, express different extracellular proteins and use different tactics to avoid death. That incredible variety has made it a challenge for labs to detect and visualize senescent cells. “There is nothing definitive about a senescent cell. Nothing. Period,” says Campisi.

In fact, even the defining feature of a senescent cell — that it does not divide — is not written in stone. After chemotherapy, for example, cells take up to two weeks to become senescent, before reverting at some later point to a proliferating, cancerous state, says Hayley McDaid, a pharmacologist at Albert Einstein College of Medicine. In support of that idea, a large collaboration of researchers found this year that removing senescent cells right after chemotherapy, in mouse models for skin and breast cancer, makes the cancer less likely to spread[10].

The lack of universal features makes it hard to take inventory of senescent cells. Researchers have to use a large panel of markers to search for them in tissue, making the work laborious and expensive, says van Deursen. A universal marker for senescence would make the job much easier — but researchers know of no specific protein to label, or process to identify. “My money would be on us never finding a senescent-specific marker,” Campisi adds. “I would bet a good bottle of wine on that.”

Earlier this year, however, one group did develop a way to count these cells in tissue. Valery Krizhanovsky and his colleagues at the Weizmann Institute of Science in Rehovot, Israel, stained tissues for molecular markers of senescence and imaged them to analyse the number of senescent cells in tumours and aged tissues from mice[11]. “There were quite a few more cells than I actually thought that we would find,” says Krizhanovsky. In young mice, no more than 1% of cells in any given organ were senescent. In two-year-old mice, however, up to 20% of cells were senescent in some organs.

But there's a silver lining to these elusive twilight cells: they might be hard to find, but they're easy to kill.

Out with the old

In November 2011, while on a three-hour flight, David read van Deursen and Kirkland's just-published paper about eliminating zombie cells. Then he read it again, and then a third time. The idea “was so simple and beautiful”, recalls David. “It was almost poetic.” When the flight landed, David, a serial biotech entrepreneur, immediately rang van Deursen, and within 72 hours had convinced him to meet to discuss forming an anti-ageing company.

Kirkland, together with collaborators at the Sanford Burnham Medical Research Institute in La Jolla, California, initially attempted a high-throughput screen to quickly identify a compound that would kill senescent cells. But they found it to be “a monumental task” to tell whether a drug was affecting dividing or non-dividing cells, Kirkland recalls. After several failed attempts, he took another tack.

Senescent cells depend on protective mechanisms to survive in their 'undead' state, so Kirkland, in collaboration with Laura Niedernhofer and others from the Scripps Research Institute in Jupiter, Florida, began seeking out those mechanisms. They identified six signalling pathways that prevent cell death, which senescent cells activate to survive[12, 13].

Then it was just a matter of finding compounds that would disrupt those pathways. In early 2015, the team identified the first senolytics: an FDA-

approved chemotherapy drug, dasatinib, which eliminates human fat-cell progenitors that have turned senescent; and a plant-derived health-food supplement, quercetin, which targets senescent human endothelial cells, among other cell types. The combination of the two — which work better together than apart — alleviates a range of age-related disorders in mice[14].

Ten months later, Daohong Zhou at the University of Arkansas for Medical Sciences in Little Rock and his colleagues identified a senolytic compound now known as navitoclax, which inhibits two proteins in the BCL-2 family that usually help the cells to survive[15]. Similar findings were reported within weeks by Kirkland's lab[16] and Krizhanovsky's lab[17].

By now, 14 senolytics have been described in the literature, including small molecules, antibodies and, in March this year, a peptide that activates a cell-death pathway and can restore lustrous hair and physical fitness to ageing mice[3].

So far, each senolytic kills a particular flavour of senescent cell. Targeting the different diseases of ageing, therefore, will require multiple types of senolytics. “That's what's going to make this difficult: each senescent cell might have a different way to protect itself, so we'll have to find combinations of drugs to wipe them all out,” says Niedernhofer. Unity maintains a large atlas documenting which senescent cells are associated with which disease; any weaknesses unique to given kinds of cell, and how to exploit those flaws; and the chemistry required to build the right drug for a particular tissue. There is no doubt that for different indications, different types of drug will need to be developed, says David. “In a perfect world, you wouldn't have to. But sadly, biology did not get that memo.”

For all the challenges, senolytic drugs have several attractive qualities. Senescent cells will probably need to be cleared only periodically — say, once a year — to prevent or delay disease. So the drug is around for only a short time. This type of 'hit and run' delivery could reduce the chance of side effects, and people could take the drugs during periods of good health. Unity plans to inject the compounds directly into diseased tissue, such as a knee joint in the case of osteoarthritis, or the back of the eye for someone with age-related macular degeneration.

And unlike cancer, in which a single remaining cell can spark a new tumour, there's no need to kill every senescent cell in a tissue: mouse studies suggest that dispatching most of them is enough to make a difference. Finally, senolytic drugs will clear only senescent cells that are already present — they won't prevent the formation of such cells in the future, which means that senescence can continue to perform its original tumour-suppressing role in the body.

Those perks haven't convinced everybody of the power of senolytics. Almost 60 years after his initial discovery, Hayflick now believes that ageing is an inexorable biophysical process that cannot be altered by eliminating senescent cells. “Efforts to interfere with the ageing process have been going on since recorded human history,” says Hayflick. “And we know of nothing — nothing — that has demonstrated to interfere with the ageing process.”

Fans of senolytics are much more optimistic, emboldened by recent results. Last year, van Deursen's lab went beyond its tests on super-aged mice and showed that killing off senescent cells in normally ageing mice delayed the deterioration of organs associated with ageing[6], including the kidney and heart. And — to the joy of anti-ageing enthusiasts everywhere — it extended the animals' median lifespan by about 25%.

Successful results from mouse studies have already lured seven or eight companies into the field, Kirkland estimates. At Mayo, one clinical trial has opened, pitting dasatinib and quercetin in combination against chronic kidney disease. Kirkland plans to try other senolytics against different age-related diseases. “We want to use more than one set of agents across the trials and look at more than one condition,” he says.

If eliminating senescent cells in humans does improve age-related illnesses, researchers will aim to create broader anti-ageing therapies, says David. In the meantime, researchers in the field insist that no one should take these drugs until proper safety tests in humans are complete. In rodents, senolytic compounds have been shown to delay wound healing, and there could be additional side effects. “It's just too dangerous,” says Kirkland.

Van Deursen says that continuing to answer basic biological questions is the field's best shot at success. “Only then will we be able to understand what

ageing really is, and how we can, in an intelligent way, interfere with it.”

Journal name:
Nature
Volume:
550,
Pages:
448–450
Date published:
(26 October 2017)
DOI:
doi:10.1038/550448a

Corrections

Corrected:

Reference 4 in this story originally omitted the journal name. This has now been added.

Comments

Commenting is currently unavailable.

Shrew skulls shrink for winter survival

Getting smaller by absorbing bone tissue may help animals to save energy when food is scarce.

23 October 2017

Karol Zub

Skulls of the common shrew (*Sorex araneus*) shrink by about 15% in winter and regrow the next summer.

Common shrews shrink their heads — including their skulls — in winter, researchers have found. They believe that this dramatic example of downsizing may help the animals to survive when food is scarce.

Individual wild common shrews (*Sorex araneus*) captured and tagged in Germany showed large reductions in skull size and body mass over the winter. Their spines also got shorter, and major organs, including the heart, lungs and spleen, shrank. Even their brain mass dropped by 20–30%, according to Javier Lázaro, a biologist at the Max Planck Institute for Ornithology in Radolfzell, Germany. In spring, the animals started to regrow.

“We hypothesize that these seasonal changes could have adaptive value,” says Lázaro, who led the work. Shrews have an extremely fast metabolism, he points out, and reducing their body mass during winter might increase their chances of survival, because they wouldn’t need so much food. In particular, he adds, “reducing brain size might save energy, as the brain is energetically so expensive”.

Up and down

The researchers trapped live shrews, then anaesthetized, X-rayed and weighed them. They also fitted each animal with a microchip, so they could monitor changes in shrews that were recaptured over their roughly 14-month lifespan. Twelve animals were captured during each key life stage: the first summer of their lives, the next winter and the following spring and summer.

The results are published in *Current Biology*[1] on 23 October. The shrews’ skulls shrank by about 15% from summer to winter, an effect that the X-ray images suggest was caused by resorption of tissue at the joints between skull bones. This bone then regenerated in spring, although the skulls didn’t quite return to their original summer size.

“Tracking of individual animals is crucial here — this is really great work,” says zoologist Leszek Rychlik of Adam Mickiewicz University in Poznań, Poland. Rychlik has previously found[2] that common shrews in northeastern Poland show seasonal changes in body mass on a population level. But Lázaro’s team is the first to show that the skulls of individual shrews shrink.

Cold comfort

Lázaro and his colleagues are now investigating which brain structures change most from season to season, and whether the animals experience any cognitive impairments in winter. If they do, it might not matter too much, says Rychlik. “Their winter life is more boring,” he says. “They are less active, less involved in interactions, not busy with reproduction and searching for partners. They are just focused on foraging and saving energy.”

Just how many species might shrink their brains for winter is not known. Even at the population level, seasonal comparisons are often not possible, because biologists tend to collect specimens in summer rather than winter. In work being prepared for publication, Rychlik has found seasonal differences in skull size and body mass in two other members of the red-toothed-shrew sub-family: the pygmy shrew (*Sorex minutus*) and the Eurasian water shrew (*Neomys fodiens*). Some of Lázaro’s co-authors have also found[3] similar differences in two species of weasel.

These differences were observed in dead animals, but “we think they are caused by the same individual shrink–regrow process”, says Lázaro. He adds that a similar ability might exist in other small, high-metabolism animals that live in seasonal environments and don’t hibernate or use other strategies to save energy. Although still exceptional, he says, “the phenomenon might be more common than we think”.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22874

Comments

Comments

There are currently no comments.

Iranian scholar sentenced to death

Ahmadreza Djalali, a researcher in disaster medicine, has 20 days to appeal against his death sentence.

23 October 2017

Courtesy of Vida Mehrannia

Researcher Ahmadreza Djalali was convicted of espionage and sentenced in Iran on 21 October.

A judge in Tehran has ordered the death penalty for Iranian researcher Ahmadreza Djalali, according to his wife and diplomatic sources in Italy.

Djalali is affiliated with the Karolinska Institute in Stockholm, Sweden, and the University of Eastern Piedmont in Novara, Italy. A resident of Sweden

with his family, Djalali was arrested in April 2016 on an academic visit to Tehran and accused of “collaboration with a hostile government”. He works on improving hospitals’ emergency responses to armed terrorism and radiological, chemical and biological threats.

Djalali was convicted of espionage following a trial led by Abolqasem Salavati, a judge in Iran's revolutionary court, and sentenced to death on 21 October, according to Djalali's wife Vida Mehrannia and to Italian diplomatic sources. They say he has 20 days to appeal against the sentence.

Mehrannia says that her husband was accused of obtaining money, academic positions and research projects in exchange for spying on Iran for Israel.

Djalali document

Shortly before the sentence was announced, a close contact of Djalali's (who would prefer to remain anonymous) circulated a document that claims to be a literal transcription of a handwritten text produced by Djalali inside Evin prison, where he is being held. The document states that Djalali believes he was arrested for refusing to spy for the Iranian intelligence service.

According to the document, in 2014 two representatives of the Iranian military and intelligence service asked Djalali to spy on European countries for Iran — in particular, on “critical infrastructures, counter-terrorism and CBRNE [chemical, biological, radiological, nuclear and explosives] capabilities, sensitive operational plans, and also research projects, relevant to terrorism and crisis.” It says he refused.

The document claims that Djalali was forced to make false confessions following “multiple psychological and physical tortures”. “I have never acted against my country, I have never spied for Israel or any other country. My only fault is that I did not accept to use the trust of my colleagues and universities in EU to spy for Iran's intelligence services,” the text states.

Djalali’s colleagues have reacted with dismay. “None of our shared research projects had partners in Israel and I am not aware of any money transfer from Israel to Djalali. We relied on European Commission funds,” says Luca

Ragazzoni, a health researcher at the University of Eastern Piedmont, who worked with Djalali from 2012 to 2015. “We did not have access to secret data,” he says.

Mehrannia says that Djalali is considering a hunger strike in protest at the sentence. Since his imprisonment, Djalali has carried out multiple hunger and thirst strikes. He was also forced to change his lawyer against his will, according to the Committee of Concerned Scientists, a lobby group. Several scholars and human-rights organizations have repeatedly called for a fair trial or release for Djalali.

Djalali’s story echoes those of other Iranian scientists. Omid Kokabee, a physicist released from a Tehran jail in August 2016 after five years' imprisonment, says he believes he was punished for refusing to help a covert nuclear-weapons programme. Hamid Babaei, who was undertaking a PhD in finance in Belgium but is now serving a six-year prison sentence in Iran, has said he was arrested for refusing to spy on his colleagues.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22875

Comments

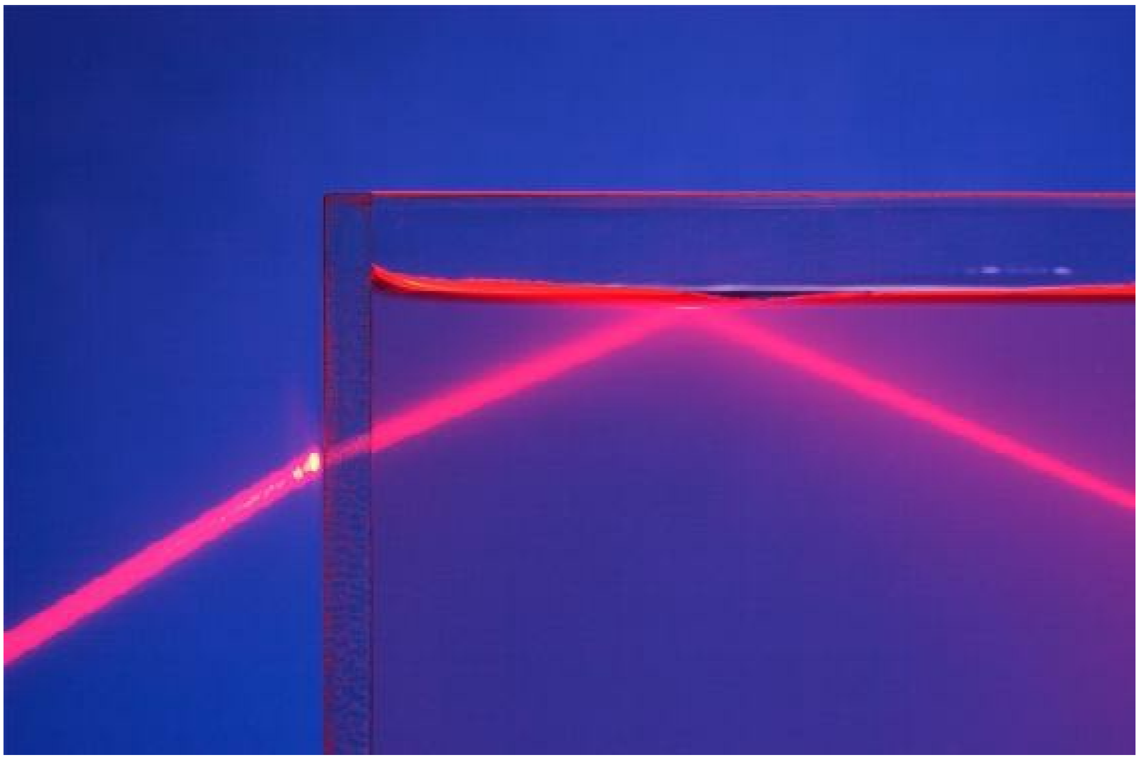
Comments

There are currently no comments.

Photons pair up like superconducting electrons

Discovery raises questions about how a light 'supercurrent' might behave.

20 October 2017



GIPhotoStock/SPL

Photons of light pair up as they travel through water, just like electrons in a superconductor.

Superconductivity — a phenomenon in which electrons can travel through certain materials with zero resistance — has revolutionized parts of medicine, travel and science. Now, an intriguing experiment has seen the same behaviour that underlies superconductivity — but in particles of light. The

finding has left physicists wondering how far the comparison might reach.

“This is really exciting work,” says Nick Vamivakas, a quantum physicist at the University of Rochester, New York, who was not involved with the research. “It’s a beautiful connection between light scattering, condensed-matter physics and quantum optics.”

Conventional superconductivity relies on the formation of ‘Cooper pairs’ of electrons, which stabilize each other’s path and allow electricity to flow without resistance. Its discovery led to the development of powerful superconducting magnets, which are now used in medical scanners, particle accelerators, wind turbines and magnetically levitated trains.

Physicists in Brazil have now seen evidence of photons of light forming similar pairs. The process occurs at room temperature when light passes through a range of transparent liquids, including water, although it is very difficult to observe. “Not only is this formation of pairs possible, but it is everywhere,” says André Saraiva, a theoretical physicist at the Federal University of Rio de Janeiro (UFRJ) and co-author of a paper that has been accepted for publication in *Physical Review Letters.*

The team has yet to explore how far the parallel with superconductivity goes. As photons already interact less with their environment than electrons do, similar pairs in light are unlikely to lead to such dramatic effects as in electric currents. But the work is already triggering speculation about how light ‘supercurrents’ might behave, and how they might be used.

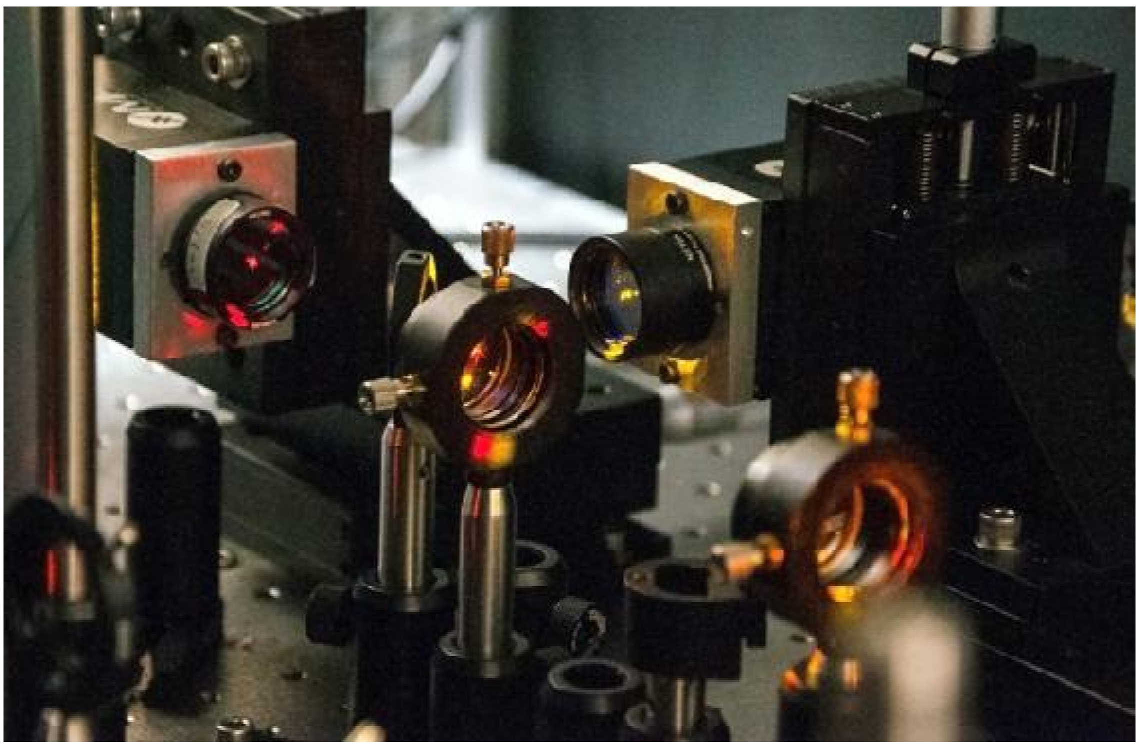
Pairing up

The discovery stems from work led by Ado Jorio at the Federal University of Minas Gerais (UFMG) in Belo Horizonte, Brazil, which investigated how light scatters within materials. When this happens, photons can lose energy to the atoms in the material, which vibrate. If a second photon immediately absorbs this packet of vibrational energy, the two photons become indirectly linked, with one gaining the energy the other lost.

When Jorio described his research to the condensed-matter department at

UFRJ, it sparked an idea in physicist Belita Koiller. She noticed the similarity between this process (in which vibrations caused by one photon affect another) and the formation of Cooper pairs in superconductivity, when distortions in an atomic lattice, caused by a speeding electron, allow the particle to attract a partner in its wake.

In both cases, pairs form as a result of movement in the atoms around them. In superconductors, however, the vibrations are of a fleeting kind allowed by quantum mechanics, known as virtual phonons. Koiller and her team wondered: was this true for light as well?



Cassiano Rabelo

Physicists in Brazil used a filter to capture only photon pairs created by quantum vibrations known as virtual phonons.

First, the UFRJ team showed mathematically that if photons also interact via virtual phonons, their behaviour would be an exact match for Cooper pairs in superconductors. Then the researchers at UFMG looked for evidence of such pairs by shining pulses of laser light at room temperature through water and seven other transparent liquids. They used detectors to examine the emerging photons, searching for pairs that arrived simultaneously, in which one photon had shifted towards red (losing energy) and the other towards blue (gaining energy).

If the arriving pairs were created by virtual phonons, rather than the standard scattering process, the energy shifts of the photons should be too small to come from classically allowed vibrations, so the team applied a filter to let through only this range of energy shifts. They compared the results with the number they saw when both types of energy shifts were allowed.

In both cases, they saw the same rate of photon pairs, suggesting that the pairs had to be created by the virtual process. The signal was tiny: of around 10 quadrillion photons pumped through the material per second, they saw 10 pairs, compared with the 1 pair every 10 seconds that they would have expected to see by chance.

It's an interesting discovery, says Andrea Ferrari, a physicist at the University of Cambridge, UK, although he cautions that the explanation will need to be validated by other groups. “I would say this is not the end, but certainly the beginning.”

Intriguing possibilities

The possibility of Cooper-like pairs in light has both quantum optics and condensed matter physicists taking notice, says Saraiva, largely because they want to see how far the analogy with superconductivity can be stretched. In matter, Cooper pairs are behind a wide range of intriguing effects — but so far the team has no data to hint whether the same would apply with light. “These are very important questions we’re keen to answer,” says Saraiva.

If the team can boost the number of photon pairs, there could also be applications. Harnessing the way the paired photons interact with matter might reveal currently invisible properties of a material. And if the particles can be shown to correlate in ways beyond their timing — to have their quantum properties intrinsically linked — room-temperature water could

prove a remarkably cheap source of 'entangled' photons, which are essential for quantum cryptography and computing.

Physicists are also wondering whether the pairs might form supercurrents, behaving similarly to their electron counterparts: perhaps light would disperse less as it travels through a material, for example, leading to more efficient quantum communication. Might paired photons even make materials more transparent? At this stage, says Saraiva, we just don't know.

For now, all this is pure speculation. But mapping concepts from condensed-matter physics onto light research has a pedigree of generating useful technologies, says Vamivakas. Photonic crystals, for example, which are used to tailor how photons flow through materials, grew out of insights about how a crystal lattice influences electrons in mattter, he points out. Vamivakas says that when he first heard of the latest work, he asked his students: "Hey, why didn’t we think of this?"

The discovery might not have happened at all if it hadn't involved such a simple experimental set-up. Funding for science in Brazil has been cut by 60% since 2013, leaving many laboratories unable to sustain their equipment. “We were fortunate to come across such a profoundly important phenomenon that does not require special equipment to see,” says Saraiva. “We can’t count on this kind of luck every time."

Journal name:
Nature
Volume:
550,
Pages:
438–439
Date published:
(26 October 2017)
DOI:
doi:10.1038/nature.2017.22868

Comments

Commenting is currently unavailable.

| 章节菜单 | 主菜单 |

Nature News

周一, 09 10月 2017

Nature News

[周一, 09 10月 2017]

- **Nature News**

Nature News

Nature is a weekly international journal publishing the finest peer-reviewed research in all fields of science and technology on the basis of its originality, importance, interdisciplinary interest, timeliness, accessibility, elegance and surprising conclusions. Nature also provides rapid, authoritative, insightful and arresting news and interpretation of topical and coming trends affecting science, scientists and the wider public.

- **Navajo Nation reconsiders ban on genetic research** [周五, 06 10月 08:00]
  Tribal leaders are developing a policy for genetic research and data sharing, potentially ending a 15-year moratorium.
- **The scientist who spots fake videos** [周五, 06 10月 08:00]
  Hany Farid discusses how to detect image manipulations — and the increasing sophistication of forgers.
- **Proton-size puzzle deepens** [周四, 05 10月 08:00]
  Measurement in ordinary hydrogen agrees with a surprising 2010 result on the element's exotic cousin — but gives a smaller value than virtually every other experiment.
- **Controversial pesticides found in honey samples from six continents** [周四, 05 10月 08:00]
  Neonicotinoids are at the centre of a long-running debate about whether they harm bees.
- **Antikythera shipwreck yields statue pieces and mystery bronze disc** [周三, 04 10月 08:00]
  Archaeologists think that at least seven life-sized sculptures are hidden nearby.
- **Cryo-electron microscopy wins chemistry Nobel** [周三, 04 10月 08:00]
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- **Crash in sea-turtle births stumps ecologists** [周三, 04 10月 08:00]
  Leading suspect — climate change — doesn’t fully explain what is happening to leatherback turtles in the US Virgin Islands.
- **Scientists plead with Brazilian government to restore funding** [周三, 04 10月 08:00]
  If officials don't act soon, research institutions could start shutting down next year.
- **Supercomputer redesign of aeroplane wing mirrors bird anatomy** [周三, 04 10月 08:00]
  Bird-bone structures emerge from an evolution-like algorithm.
- **Elite Hungarian university may be saved** [周三, 04 10月 08:00]

Hungary-New York agreement could allow Central European University to sidestep law change.

- **[Science without walls is good for all]** [周三, 04 10月 08:00]
  International mobility and collaboration are linked to stronger research.
- **[Nobel prizes, giant telescope and buried treasure]** [周三, 04 10月 08:00]
  The week in science: 29 September–5 October 2017.
- **[Why fake islands might be a real boon for science]** [周三, 04 10月 08:00]
  The seasteading movement is getting close to building its first prototype, an artificial archipelago where people will live, play and do research.
- **[How fracking is upending the chemical industry]** [周三, 04 10月 08:00]
  As shale-gas compounds flood the market, chemists are working out the best ways to convert them into the ingredients of modern life.
- **[Scientists have most impact when they're free to move]** [周三, 04 10月 08:00]
  An analysis of researchers' global mobility reveals that limiting the circulation of scholars will damage the scientific system, say Cassidy R. Sugimoto and colleagues.
- **[Health: The war on germs]** [周三, 04 10月 08:00]
  Tilli Tansey hails a history of Joseph Lister's drive to vanquish post-operative infection and putrefaction.
- **[New in paperback]** [周三, 04 10月 08:00]
  Highlights of this season's releases
- **[Sustainability: China's path to ecotopia]** [周三, 04 10月 08:00]
  Xuemei Bai critiques a critique of the country's eco-city initiative.
- **[Ornithology: All eyes on the 10,000 species]** [周三, 04 10月 08:00]
  Stuart Pimm considers the obsessive, sometimes dark side to the joyous pursuit of watching birds.
- **[Technology: Into cyberia]** [周三, 04 10月 08:00]
  Li Gong weighs up three tomes on Silicon Valley's vast influence, for good or ill.
- **[Fossil fuels: Heed local impact of coal mining]** [周三, 04 10月 08:00]
- **[Hurricanes: rescue natural defences]** [周三, 04 10月 08:00]
- **[Hurricanes: enlist nature's protection]** [周三, 04 10月 08:00]
- **[World Heritage Site: UNESCO honour for Polish mining facility]** [周三, 04 10月 08:00]
- **[Food supply: Blockchain could boost food security]** [周三, 04 10月 08:00]
- **[Collaborative software development made easy]** [周三, 04 10月 08:00]
  Save time and protect critical code with 'continuous integration' services.

- **[A taste of Toolbox]** [周三, 04 10月 08:00]
  Nature 's technology editor, Jeffrey Perkel, started blogging about workplace technology in science in 2016. Here are some highlights.
- **[The daughter you've always wanted]** [周三, 04 10月 08:00]
  Family matters.
- **[South Korea cracks down on dirty air]** [周二, 03 10月 08:00]
  Despite huge clean-up effort, scientists say country’s pollution problem could get worse over next five years.
- **[Xenon view, butterfly wings and a strange squid]** [周二, 03 10月 08:00]
  September’s sharpest science shots, selected by Nature ’s photo team.
- **[Europe’s Joint Research Centre, although improving, must think bigger]** [周二, 03 10月 08:00]
  External report criticizes lack of exploratory research.
- **[Make plans to eliminate cholera outbreaks]** [周二, 03 10月 08:00]
  Governments must stop denying the occurrence of cholera and unite in long-term prevention strategies, says Anita Zaidi.
- **[Ethics of Internet research trigger scrutiny]** [周二, 03 10月 08:00]
  Concern over the use of public data spurs guideline update.
- **[Gravitational wave detection wins physics Nobel]** [周二, 03 10月 08:00]
  Rainer Weiss, Barry Barish and Kip Thorne share the 2017 prize for their work at LIGO to detect ripples in space-time.
- **[Risk of human-triggered earthquakes laid out in biggest-ever database]** [周一, 02 10月 08:00]
  Geologists track hundreds of quakes caused by people and the projects that set them off.
- **[Discoveries have awkward first dates]** [周一, 02 10月 08:00]
  Fuzzy timings over a plate-tectonics anniversary highlight the rolling nature of scientific discovery.
- **[Chinese scientists fix genetic disorder in cloned human embryos]** [周一, 02 10月 08:00]
  A method for precisely editing genes in human embryos hints at a cure for a blood disease.
- **[Medicine Nobel awarded for work on circadian clocks]** [周一, 02 10月 08:00]
  Jeffrey Hall, Michael Rosbash and Michael Young unpicked molecular workings of cells' daily rhythms.

Navajo Nation reconsiders ban on genetic research

Tribal leaders are developing a policy for genetic research and data sharing, potentially ending a 15-year moratorium.

06 October 2017

Ricky Carioti/The Washington Post/Getty

Children play on the Navajo Nation's vast reservation in the southwestern United States.

When the Navajo Nation opens its first oncology centre next year in Tuba City, Arizona, clinicians there may be able to offer a service that has been banned on tribal lands for 15 years: analyzing the DNA of Navajo tribe

members to guide treatments and study the genetic roots of disease.

That's because the Navajo, the second-largest Native American group in the United States, are considering whether to lift their longstanding moratorium on genetic research. The tribal government banned DNA studies in 2002 to prevent the misuse of its members' genetic material. Although there is still some apprehension about the risk of allowing researchers access to Navajo DNA, the tribe's leaders increasingly see genetic research as a tool to improve medical care for the 174,000 residents of their sprawling reservation, which is roughly the size of Scotland.

As it now stands, Navajo people who live on the reservation must drive hundreds of kilometres to access specialized medical care off tribal lands, in large cities such as Phoenix, Arizona. “We spend millions of dollars outsourcing [care] for cancer and diabetes,” says Walter Phelps, a delegate to the Navajo Nation Council. As the tribe — a nation independent of the United States — tries to expand the health services it offers to its members, he says, “the moratorium could become a barrier when blood and tissue have to be collected”.

Phelps is working on the effort to create a policy by which the Navajo Nation would approve genetic-research projects and maintain control of DNA samples. The research-ethics board run by the tribal government’s department of health is working with tribal officials and traditional leaders and holding a series of public hearings to solicit opinions on the matter from tribe members. The group hopes to deliver a draft proposal by the end of October. Whatever the tribe decides could influence the hundreds of other Native American groups, who have tended to be wary of genetic studies because of a history of scientists conducting research without consent or adequate privacy controls.

The Navajo Nation's new oncology centre provides part of the impetus for revisiting the genetic-research ban. It will be the first such facility on Native American lands outside of Alaska. Allowing some genetic testing at the centre could help physicians to identify the most effective therapies for each patient, says Lynette Bonar, chief executive of the Tuba City Regional Health Care Corporation in Arizona, which will run the facility.

That would match the standard of care that many Navajo people with cancer

have received at medical facilities off the reservation. And creating a repository for such genetic material on Navajo land would enable research into the genetic and environmental factors underlying a broad range of diseases, not just cancer.

So far, Phelps says, the idea of allowing some genetic research has not drawn major opposition. Many tribe members consulted about lifting the moratorium have generally supported the idea after learning how physicians could use genetic data to diagnose disease and tailor treatments. And the number of Navajo tribe members who are geneticists and medical experts has grown since 2002, bolstering the tribe's ability to evaluate proposed protocols and represent its own interests.

Fraught history

Still, some Navajo have lingering questions about whether the tribal government can protect the privacy of their genetic material and maintain control over its use. Such concerns helped to shape the current ban back in the early 2000s, when the Navajo Nation's department of health conducted an outreach campaign about genetics and medical research. "In the absence of a research code and lack of expertise at the time, they decided it was not a good time to move forward with genetic research until they were able to develop a research policy," says Nanibaa' Garrison, a member of the Navajo Nation who is a geneticist and bioethicist at Seattle Children's Hospital in Washington.

The tribe had reason to be cautious. "As Native Americans, we have a problem with trust because we have been violated so much," says David Begay, a pharmaceutical scientist at the University of New Mexico in Albuquerque and a member of the Navajo Nation's human-research review board. "In the past, our data have been misused."

Native Americans in the southwestern United States want to avoid repeating the experience of the region's Havasupai tribe. In 2004, the group sued Arizona State University in Tempe over alleged misuse of tribe members' blood samples. The Havasupai said that the samples, which had been

collected for diabetes research, had later been used in studies of schizophrenia, migration and inbreeding without their consent. The university made a settlement with the tribe in 2010, paying US$700,000 and returning the blood samples.

Sara Hull, a bioethicist at the US National Human Genome Research Institute in Bethesda, Maryland, says the case helped to change how researchers engage with the people they study, by raising awareness of the complexities of dealing with vulnerable minority populations. For Native Americans, such thorny issues can include privacy. Science-funding agencies and journals often require researchers to put the genetic data they collect into public repositories, but the relatively small size of many Native American tribes can make it easy to identify individual members in a genetic data base. In recognition of this, the US National Institutes of Health sometimes works with researchers it funds to develop methods for sharing data on a minority group without compromising its privacy.

Garrison, who is helping the Navajo Nation develop its new policy, says that the plan is likely to include rules on what types of research will be allowed, who will have access to tribe members' genetic material and information, and who will provide oversight. It is also likely to require that the tribe maintain ownership of its members' DNA samples and data.

The policy that the Navajo Nation ultimately produces could serve as a template for other Native American groups considering how — or whether — to engage with genetic research, says Ellen Clayton, a bioethicist at Vanderbilt University in Nashville, Tennessee. She expects other tribes to watch the development of the Navajo Nation's new policy. "If they reach an agreement, I think it will be influential."

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22780

Comments

Commenting is currently unavailable.

The scientist who spots fake videos

Hany Farid discusses how to detect image manipulations — and the increasing sophistication of forgers.

06 October 2017

Eli Burakian/Dartmouth College

Hany Farid.

Hany Farid, a computer scientist at Dartmouth College in Hanover, New Hampshire, specialises in detecting manipulated images and videos. Farid, who provides his services to clients as varied as universities, media organizations, and law courts, says that image manipulation is becoming both more frequent and more sophisticated. He spoke to *Nature* about the arms race to stay ahead of the forgers.

Where do you start when trying to spot a fake image?

One simple but powerful technique is reverse image search. You give the image to a site such as Google Image Search or TinEye, and they show you all other instances of it. A project at Columbia University, in New York City, is taking this to the next level, and starting to find parts of images that have been repurposed from other images**.**

Generally, we think about which patterns, geometries, colours or structures are going to be disrupted when someone manipulates a photo. For example, when people add an object into a scene, we know that where they put the shadow is usually wrong. A viral video called Golden Eagle Snatches Kid from 2012 is one of my favourite examples. It took us only 15 minutes of analysis to show shadow inconsistencies: the eagle and baby were computer-generated.

What about if fake images make only slight tweaks?

There are a number of analyses we can do. In a colour picture, every pixel needs three values — corresponding to the amounts of red, green and blue at that point. But in most cameras, every pixel records just one colour, and the camera fills in the gaps by taking the average values of the pixels around it. This means that, for any given colour in an image, each missing pixel has a particular correlation with its neighbours, which will be destroyed if we add or airbrush something, and we can detect that**.**

Another technique is JPEG compression. Almost every image is stored in a JPEG file, which throws away some information to save on storage. There is a huge amount of variation in how each camera does that. If a JPEG is unpacked — opened in Photoshop — and then put back together, it is always repackaged slightly differently, and we can detect that. I wish you could just upload any image and we could tell you if it’s real or not, but it’s still a very

difficult process and requires expertise to understand different components.

Who uses your digital forensic services?

I do analysis for organisations such as the Associated Press, Reuters, and *The New York Times*. There are only a handful of academics worldwide who are specialists in this, so it doesn't scale — and that means you can only do the analysis of really high-stakes images. But there are efforts under way to scale this up. Last year, the US Defense Advanced Research Projects Agency (DARPA) got into this game with a large project of which I'm part. Over the next five years they're trying to create a system that will allow you to analyse hundreds of thousands of images a day. It's a very ambitious programme.

I also do a lot of work in the courts. For example, here in the United States, child pornography is illegal, but computer-generated child pornography counts as 'protected speech' under the First Amendment. If someone's arrested they might say that the offending image isn't real, and I might have to prove that it is. I also get lots of e-mails from people about photo hoaxes — almost daily.

Do you apply your techniques to scientific papers?

I have worked on many cases of scientific misconduct, hired by universities conducting internal investigations. When I visited the US Office of Research Integrity recently, they asked me "how do we get our hands on automated tools?" The reality is we're still not there. But creating something that uses some of the tools, such as clone detection, which looks to see whether parts of an image have been copied and pasted from elsewhere, would be possible as a semi-automated process looking at dozens, not millions, of images a day. It's something my colleagues and I are thinking about, and it's a small but not insignificant part of the DARPA programme.

How about fake videos?

Researchers are now able to splice together footage to create videos of famous people seeming to say things they never said — for instance, this video of President Obama. And they can create fake images or short videos using machine learning techniques: in particular, generative adversarial networks (GANs), which learn to generate fake content. These pit a network that generates fake content against a 'classifer' network that attempts to discriminate between real and fake content, so that the faking network rapidly improves.

I've seen the technology get good enough that I'm now very concerned. In 5 or 10 years, this is going to get really good. At some point we will reach a stage where we can generate realistic video, with audio, of a world leader, and that's going to be very disconcerting. I would say that the field of digital forensics is now behind in video.

How can you detect fake video?

JPEG compression has an analogous construct in video, which is a bit harder to detect because video uses a more sophisticated version. Another approach is to use machine learning for detection. But we're taking an approach similar to what we do with images — which is based on the observation that computer-generated content lacks the imperfections that are present in a recorded video. It's created in almost too perfect a world. So one of the things we look at is, are we not seeing the statistical and geometric patterns we'd expect to see in the physical world?

Another technique is based on some beautiful work by William Freeman and colleagues at the Massachusetts Institute of Technology in Cambridge, who showed how if you magnify really small changes in a video of a person, you can see subtle changes in the colours in their face that correspond to their pulse rate. We showed that you can use this to distinguish real people from computer-generated people.

Couldn’t machine learning algorithms learn to include these features?

Perhaps in principle. But in practice, these algorithms have limited time and training data, and there is little control over which features a neural network will pick up on to discriminate between real and fake videos. A GAN is only trying to fool the classifier it’s trained on. That’s no guarantee that it will learn all aspects of what makes an image or video real or fake, or that it will fool another classifier.

My adversary will have to implement all the forensic techniques that I use, so that the neural network can learn to circumvent these analyses: for example, by adding a pulse in. In that way, I’ve made their job a little harder.

It’s an arms race. As we are developing faster, folks are creating more sophisticated technology to augment audio, images and video. The way this is going to end is that you take the ability to create a perfect fake out of the hands of the amateur. You make it harder, so it takes more time and skill, and there’s a greater risk of getting caught.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22784

Comments

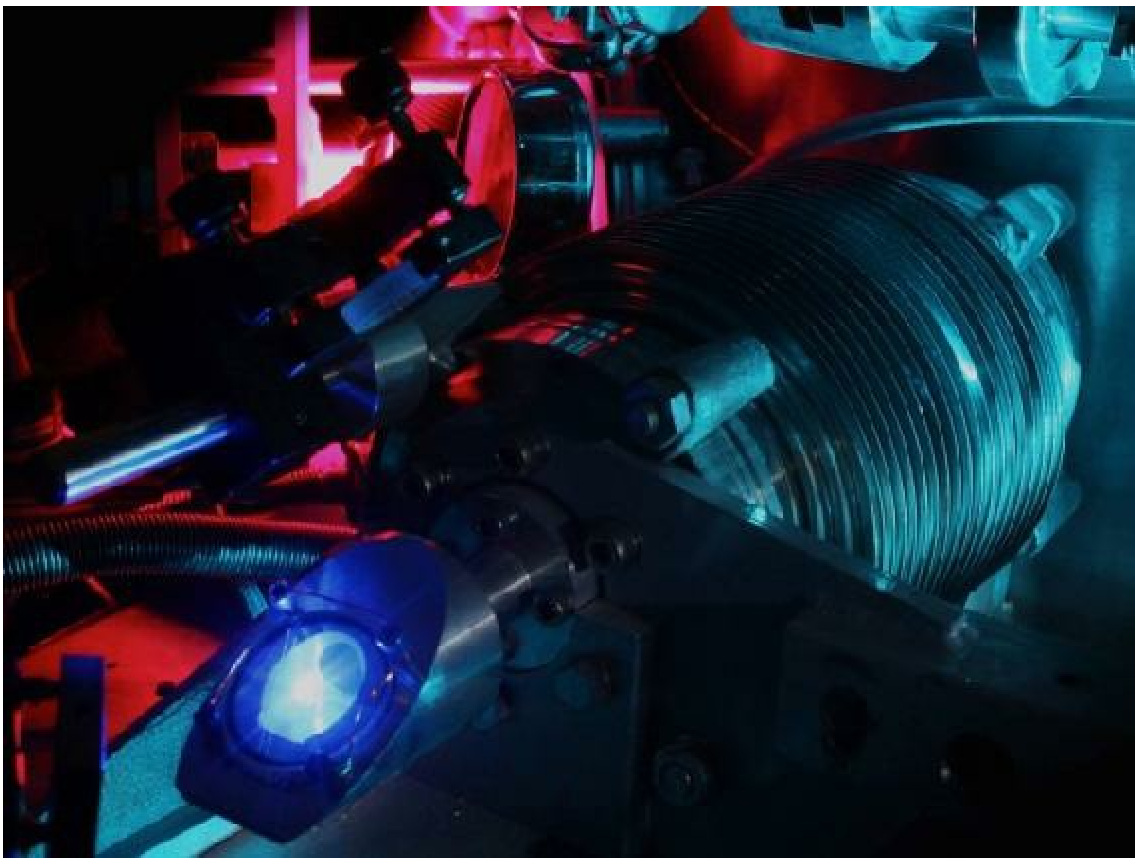
Comments

There are currently no comments.

Proton-size puzzle deepens

Measurement in ordinary hydrogen agrees with a surprising 2010 result on the element's exotic cousin — but gives a smaller value than virtually every other experiment.

05 October 2017



Axel Beyer

Researchers shone lasers at hydrogen atoms in a vacuum chamber to pinpoint the size of the protons inside.

The proton might truly be smaller than was thought. Experiments on an exotic form of hydrogen first found[1] a puzzling discrepancy with the

accepted size in 2010. Now, evidence from a German and Russian team points to a smaller value for the size of the proton with ordinary hydrogen, too.

The results, which appeared on 5 October in *Science*[2], could be the first step towards resolving a puzzle that has made physicists doubt their most precise measurements, and even their most cherished theories.

Still, “before any resolution, this new value has to be confirmed”, says Jan Bernauer, a physicist at the Massachusetts Institute of Technology in Cambridge. If other labs confirm it, he adds, “then we can find why the old experiments were wrong, hopefully”.

Method mix-up

For decades, physicists have estimated the size of the proton using one of two main techniques. Atomic physicists use spectroscopy to measure the energy levels of electrons orbiting an atomic nucleus — consisting of either the single proton in a hydrogen atom, or a bigger nucleus. The size of the nucleus affects those energies because electrons spend some time moving through the nucleus as they orbit it.

Meanwhile, nuclear physicists have used a similar technique to the one that enabled Ernest Rutherford to discover atomic nuclei in the first place. They hit the atoms with beams of fast-moving electrons and measure how the electrons bounce off.

As their precision improved, both methods roughly came to agree on a radius of about 0.8768 femtometres (millionths of a millionth of a millimetre).

But in 2010, a novel kind of experiment completed at the Paul Scherrer Institute in Villigen, Switzerland, disrupted the consensus. After a decade of unsuccessful attempts, a multinational collaboration led by Randolf Pohl, then at the Max Planck Institute of Quantum Optics (MPQ) in Garching, Germany, measured energy transitions not in ordinary hydrogen, but in lab-made ‘muonic’ hydrogen. These are atoms in which the electron has been replaced by a muon — a particle similar to an electron in most of its

properties, but 200 times more massive. The heavier particle spends more time inside the nucleus, which means that the proton's size has a much larger effect on the muon's energies — which, in turn, should lead to a much more precise estimate of the proton's radius.

Pohl's team found the proton to be 4% smaller than the accepted value. Some researchers speculated that perhaps some previously unknown physics could make muons act differently than electrons. This would have required a revision of the standard model of particle physics, which predicts that muons and electrons should be identical in every way except for their masses — and might have pointed to the existence of yet-to-be-discovered elementary particles.

Exciting technique

In the latest paper[2], Pohl, now at the Johannes Gutenberg University in Mainz, Germany, and his collaborators tickled hydrogen atoms — containing ordinary electrons — with two different lasers. The first one sent the atoms' electrons into an excited state, and the second one put them into a higher-energy excitation. The team then detected the photons that the atoms released as their electrons fell back into lower-energy excitation states.

The team combined its data with an earlier, high-precision measurement to calculate the Rydberg constant, which expresses the energy that it takes to rip the electron off the hydrogen atom. Standard theory then enabled the researchers to calculate the radius of the proton from this constant. The value they found was consistent with the muonic-hydrogen measurement, and 5% smaller than the 'official' proton radius.

To ensure that they eliminated any spurious experimental effects, the team spent three years analysing its data, says Lothar Maisenbacher, a co-author of the paper and an atomic physicist at the MPQ.

Bernauer, who works on the electron–proton scattering technique, is impressed. “It's a great experiment,” he says. “I think they really advanced their field with this.”

The care that they took is “very impressive”, and makes their measurement more reliable than many others, says Krzysztof Pachucki, a theoretical physicist at the University of Warsaw who is on the task group of the Committee on Data for Science and Technology (CODATA).

CODATA, the international agency that publishes the best-known values of the fundamental constants, is taking notice of the Mainz experiment. “We will take this result very seriously,” says Pachucki. The committee is due to revise the ‘official’ handbook of universal constants of nature next year. Because of this experiment, CODATA will "most probably” change its values for the proton radius and Rydberg constant, he says.

More evidence needed

But the German–Russian group is not quite ready to claim that the puzzle has been solved, Maisenbacher says. “We have not identified any conclusive reason why the other measurements should not be correct themselves,” he says. “We would like to see more experiments from other people.”

A number of teams around the world are doing just that. Bernauer is interested, for example, in the results of spectroscopy experiments being done at York University in Toronto, Canada. If their measurement is also small, “then I would start to believe that the old data has a problem”, Bernauer says. But that would still leave open the matter of the electron–proton scattering results.

In those experiments, researchers have conventionally used electrons that have a range of different energies. Estimating the size of the proton required extrapolating all the way to an ideal situation, in which electrons had zero energy.

Ashot Gasparian, a particle and nuclear physicist at North Carolina A&T; State University in Greensboro and his team have recently conducted an experiment at the Thomas Jefferson National Accelerator Facility in Newport News, Virginia. They injected cold hydrogen gas directly into their electron accelerator, rather than bombarding liquid hydrogen kept in a plastic box, as

was previously done. This technique enabled them to remove some experimental uncertainties and also to use electrons with lower energies than before. In principle, this could reveal whether and where the previous extrapolations went wrong. They are now analysing their data and hope to have results next year. “The ball is in our court,” says Gasparian.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22760

Comments

Comments

There are currently no comments.

Controversial pesticides found in honey samples from six continents

Neonicotinoids are at the centre of a long-running debate about whether they harm bees.

05 October 2017

Fergus Gill/2020VISION/naturepl.com

Honey is a major source of food for honey bees.

Honey bees on every continent except Antarctica face significant exposure to neonicotinoid pesticides — chemicals that some studies suggest harm bees' health. Researchers who tested honey from nearly 200 sites worldwide found that 75% of their samples contained some level of the pesticides, according to

a report published on 6 October in *Science*[1].

The study is the first attempt to quantify the presence of neonicotinoids in honey on a global scale using standardized methods. Nearly half of the samples tested contained levels of neonicotinoids at least as high as those thought, on the basis of previous research, to impair bees' brain function and slow the growth of their colonies. The study also found that 45% of the samples contained two or more types of neonicotinoid.

"It's not a surprise, in a sense, that we find neonicotinoids in honey. Anybody could have guessed that," says lead author Edward Mitchell, a biologist at the University of Neuchâtel in Switzerland. "What's original is using the same protocol. We now have a worldwide map of the situation."

The research provides additional context for the long-running debate over whether and how neonicotinoids affect bees' health. Some studies have suggested that exposure to neonicotinoids lowers honey bees' nutritional status[2] and impairs their immunity[3]. And in June, a paper published in *Science* reported that neonicotinoids lower honey bees' chances of survival during the winter, and threaten the queen in particular, which can affect reproduction[4].

To assess the scale of honey bees' exposure to neonicotinoids around the world, the authors of the new study collected honey from 198 sites on six continents through a citizen-science project. Then they tested those samples to determine the concentrations of five of the most commonly used neonicotinoids. Honey collected in North America had the highest proportion of samples containing at least one neonicotinoid, at 86%, with Asia (80%) and Europe (79%) close behind.

The extent of the contamination, even in honey from remote places — including islands in the middle of the Pacific Ocean and off the coast of West Africa — is surprising, says Amro Zayed, an insect researcher at York University in Toronto, Canada. The findings suggest that bees the world over are exposed to neonicotinoids constantly over generations, he says, which is worrying because the insects depend so heavily on honey for food. "It's one thing to go out to a restaurant and get a bad meal, but if you have your fridge

at home contaminated with insecticides, that’s an entirely different method of exposure,” Zayed says.

Others say that the widespread presence of neonicotinoids in honey is to be expected, given how commonly the chemicals are used in staple crops such as canola and wheat, as well as in home gardens. “Yes, there is going to be long-term exposure, potentially, to neonics, but that doesn’t say anything about the risk,” says Chris Cutler, an entomologist at Dalhousie University in Halifax, Canada. “Just because it’s there doesn’t necessarily mean there’s a problem.”

Much of the debate about neocotinoids has focused on just this question: how problematic are the pesticides when bees are exposed to them at low levels, but over a long period of time? “One of the issues around assessing the impacts on bees has been the discussion of what a field-relevant level of exposure actually is,” says Nigel Raine, a pollinator-health researcher at the University of Guelph in Canada. “This contributes toward that discussion substantially.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22762

Comments

Comments

There are currently no comments.

Antikythera shipwreck yields statue pieces and mystery bronze disc

Archaeologists think that at least seven life-sized sculptures are hidden nearby.

04 October 2017

Brett Seymour/EUA/ARGO 2017

Archaeologist Brendan Foley discovers a bronze disc, at first thought to be part of the Antikythera mechanism.

Marine archaeologists investigating the ancient shipwreck that yielded the Antikythera mechanism — a complex, bronze, geared device that predicted eclipses and showed the movements of the Sun, Moon and planets in the sky

— have recovered a wealth of treasures, including bronze and marble statue pieces, a sarcophagus lid and a mysterious bronze disc decorated with a bull. The artefacts were trapped under boulders in a previously unexplored part of the site near the island of Antikythera, Greece, and the researchers think that large parts of at least seven statues are still buried nearby.

The discoveries are “extremely exciting”, says Kenneth Lapatin, curator of antiquities at the J. Paul Getty Museum in Los Angeles, California. Only a handful of bronze statues survive from the ancient world, and they have almost invariably been treated and altered by previous conservators, undergoing processes that destroyed much of the information scientists might have gleaned from them. “Technology has improved so much,” says Lapatin. “We can learn from these untreated finds.”

The first-century-BC cargo ship, discovered in 1900 by sponge divers, is famous for yielding a heavily encrusted and corroded geared device that used to predict eclipses and chart the skies. The sponge divers also retrieved many other priceless items, including luxury glassware, jewellery and a two-metre-tall bronze statue, dating from the fourth century BC, nicknamed the ‘Antikythera youth’.

Statue search

Courtesy of ARGO 2017

The bronze arm was one of the most significant recent findings.

The recovery of multiple ‘orphan’ statue pieces — limbs without matching heads or bodies, for example — suggested that several statues still lie buried here. So an international team of archaeologists and divers, co-led by Brendan Foley of the University of Lund in Sweden and Theotokis Theodoulou of the Greek Ephorate of Underwater Antiquities in Athens, is now re-excavating the 50-metre-deep wreck site to look for them.

The team has made a stream of discoveries since work began in 2014, including wine jars, giant anchors, gold jewellery and a human skeleton, which is now being analysed for DNA. But the statues have remained hidden until now.

On 4 October**,** the team announced that during a 16-day dive season the previous month, they found several major statue pieces, including two marble feet attached to a plinth, part of a bronze robe or toga, and a bronze male arm, with two fingers missing but otherwise beautifully preserved. A slim build and “turning hand” gesture suggest that the arm may belong to a philosopher,

says Theodoulou.

In 1900–01, the sponge divers salvaged orphan limbs from a minimum of six bronze statues. The newly discovered arm pushes that total to at least seven, says Theodoulou. The team is particularly excited because the statue pieces were found in an area undisturbed by any previous excavations, buried beneath large boulders dislodged from Antikythera's steep cliffs over the course of 2,000 years by periodic earthquakes. "We think this means that everything is down there still," says Foley.

The discovery of seven bronze statues, if they could be recovered, would significantly boost the world's total from this time period, which stands not much greater than 50, Lapatin estimates. Few of those are complete. And although these ancient figures might look beautiful, they are hard to study because the aggressive treatments by generations of conservators have altered and damaged the bronze.

Technological advances

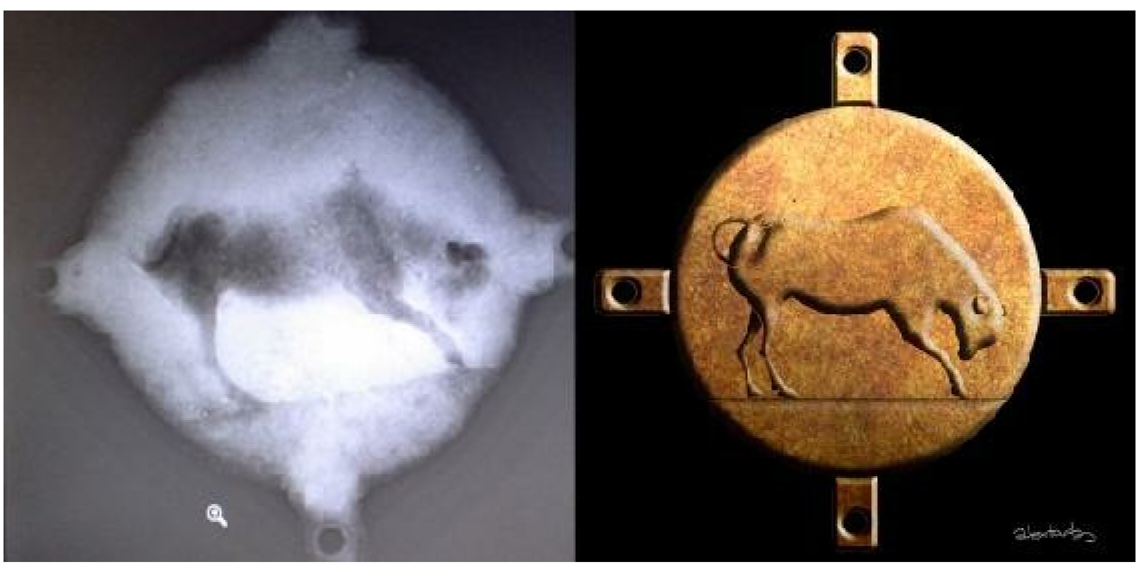
Fresh, untreated finds such as those from Antikythera will give researchers the opportunity to use modern techniques to study a significant aspect of ancient Greek life — for example, by looking at casting methods, which precise alloys were used and whether the statues were made for export or had been previously displayed. Meanwhile, any heads found might enable researchers to identify the people depicted, and to compare their likeness with any existing portraits, for example, marble statues or images etched on coins.

Brett Seymour/EUA/ARGO 2017

The bronze disc, which researchers at first thought might contain some of the lost gears of the Antikythera mechanism.

Foley and Theodoulou’s team also recovered an intriguing bronze disc or wheel, about eight centimetres across, attached to four metal arms with holes for pins. A layer of hardened sediment hides its internal structure, but it superficially resembles the Antikythera mechanism, and researchers had initially hoped that it might be part of that ancient device: perhaps the gearing that calculated the positions of the planets, which is missing from the find.

But preliminary X-ray imaging conducted in an Athens hospital on 25 September revealed a surprise: instead of gear wheels, the image of a bull appeared. The object might have been a decorative element, says Lapatin, perhaps attached to a box or a statue’s shield, or even — because of its sturdy construction — to the doomed ship. More-detailed radiography is planned for the next few weeks.



Left: EUA. Right: Alexander Tourtas.

The X-rays of the bronze disc, and artist's reconstruction of the bull.

Other discoveries this season include a sarcophagus lid made from fine, red marble, more human remains and wooden ship planks and frames that the researchers hope will reveal information about the vessel’s size and shape.

The team plans to return to Antikythera in May 2018, to break up the boulders and excavate beneath. “It’s going to be a major operation,” says Foley. “But we think it will be spectacular.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22735

Comments

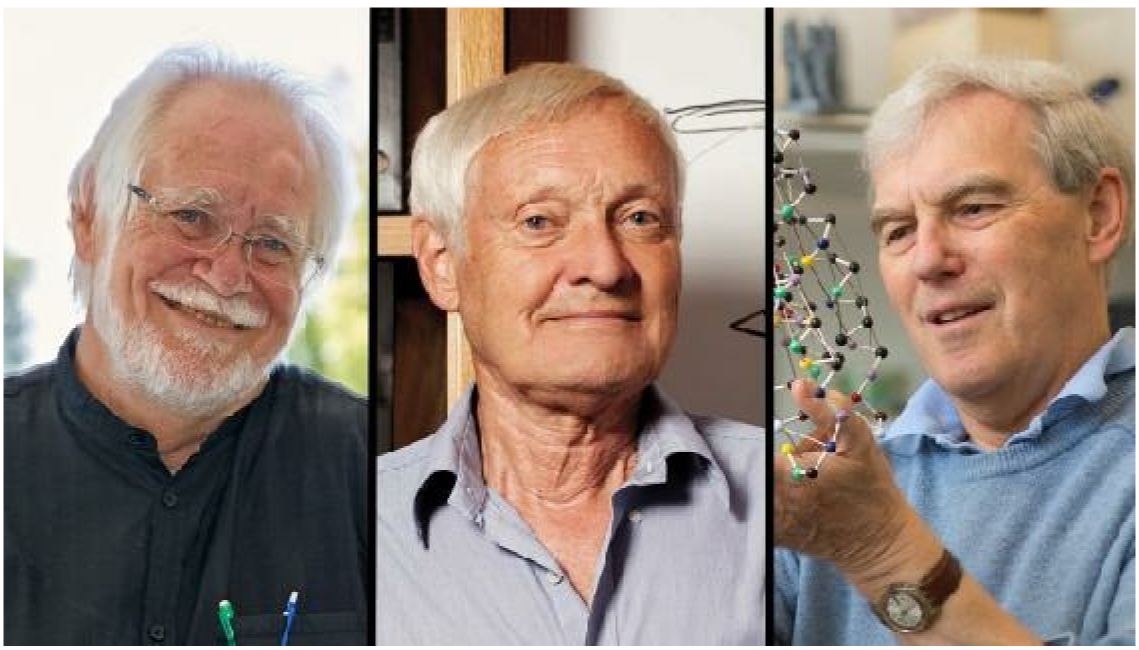
Commenting is currently unavailable.

Cryo-electron microscopy wins chemistry Nobel

Jacques Dubochet, Joachim Frank and Richard Henderson share the prize for developing a technique to image biomolecules.

04 October 2017 Corrected:

1. 05 October 2017



Left: Marietta Schupp/EMBL. Centre: Jorg Meyer. Right: LMB-MRC.

From left: Jacques Dubochet, Joachim Frank and Richard Henderson helped to develop cryo-electron microscopy.

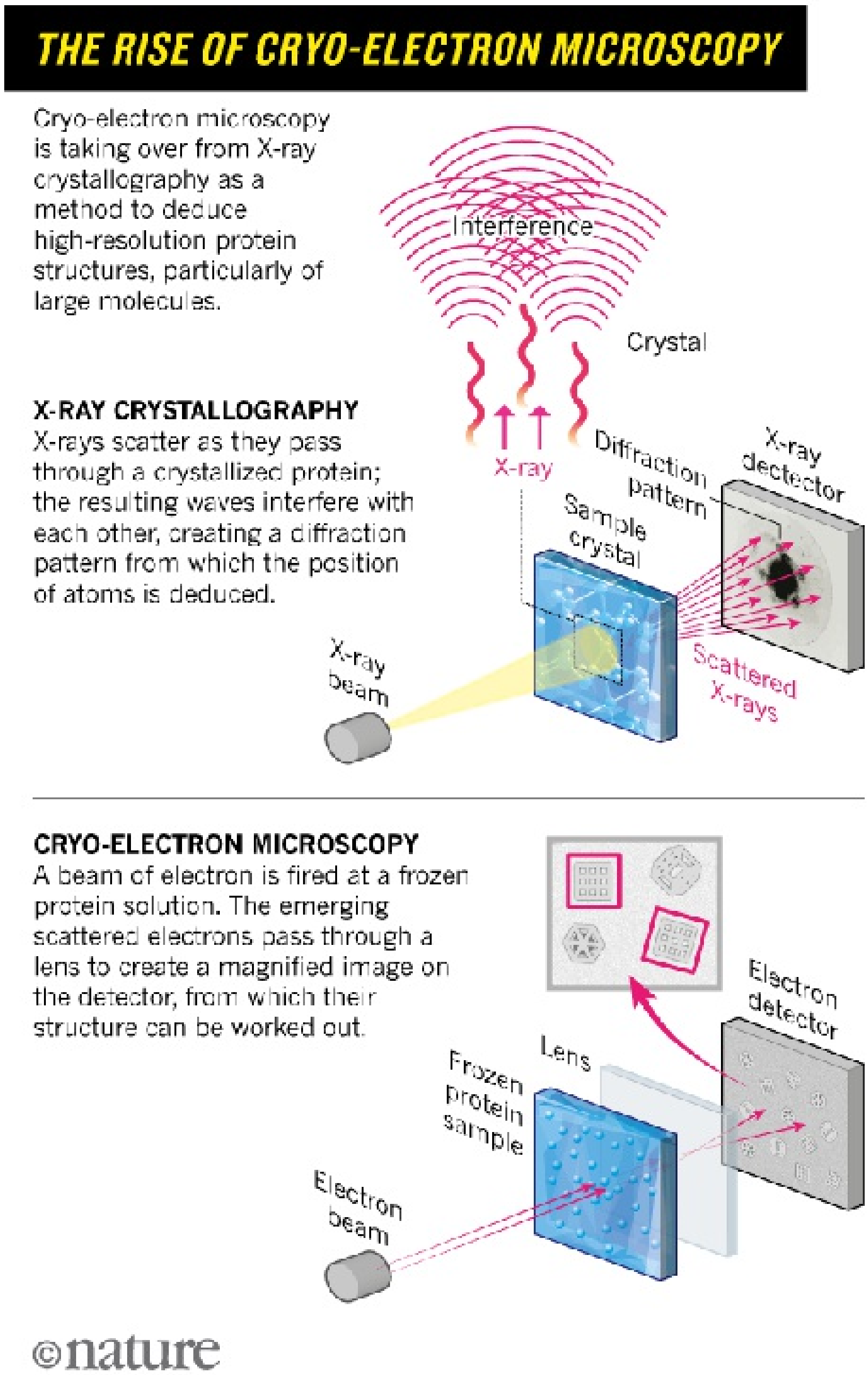
The 2017 Nobel Prize in Chemistry has been awarded for work that helps researchers see what biomolecules look like.

Jacques Dubochet, Joachim Frank and Richard Henderson were awarded the prize on 4 October for their work in developing cryo-electron microscopy (cryo-EM), a technique that fires beams of electrons at proteins that have been frozen in solution, to deduce the biomolecules' structure.

For decades, biologists have used X-ray crystallography — blasting X-rays at crystallized proteins — to image biomolecular structures. But labs are now racing to adopt the cryo-EM method, because it can take pictures of proteins that can't easily be formed into large crystals. The tool has "moved biochemistry into a new era", says the Royal Swedish Academy of Sciences, which awards the prize.

Imaging solutions

In the 1970s, Henderson, a molecular biologist who works at the MRC Laboratory of Molecular Biology in Cambridge, UK, and his colleague Nigel Unwin were trying to determine the shape of a protein called bacteriorhodopsin. The molecule, which uses light energy to move protons across a cell membrane, proved unsuitable for crystallography. So the researchers turned to electron microscopy (see 'The rise of cryo-electron microscopy') and, in 1975, produced their first 3D model of the protein[1].



During the same decade, Frank, a biophysicist who is now based at Columbia University in New York City, and his colleagues developed image-processing software to make sense of the fuzzy pictures that are produced when an

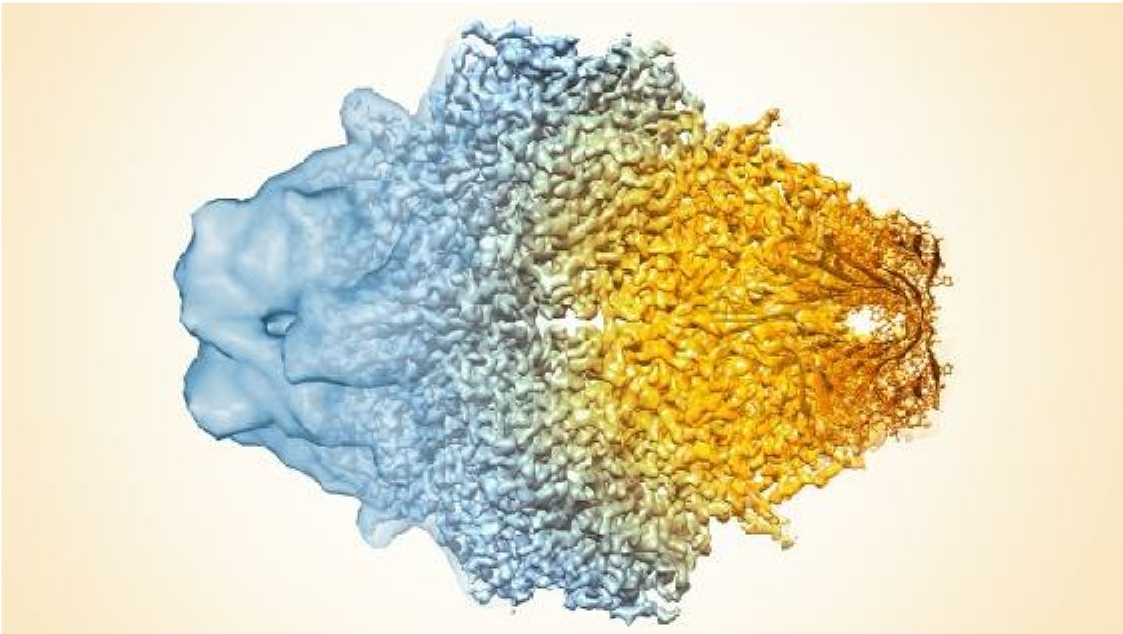
electron microscope is aimed at a protein, and to convert these two-dimensional blurs into 3D molecular structures.

In the early 1980s, a team led by Dubochet, who is now an honorary professor at the University of Lausanne in Switzerland, worked out how to prevent water-soluble biomolecules from drying out in the vacuum of an electron microscope, allowing the molecules to retain their natural shape during imaging. His team found a way to flash-freeze solutions of proteins using liquid ethane, keeping the molecules relatively still when they were pummelled with electrons. This allowed researchers to use electron microscopes to determine the structures of proteins at much higher resolution than before.

These and other improvements enabled Henderson to create the first atomic-resolution images of a protein using cryo-EM in 1990[2].

Resolution revolution

Although the research recognized by the Nobel Committee was conducted in the 1970s and 1980s, it laid the groundwork for what many scientists have dubbed a revolution in recent years. Subsequent improvements in the sensitivity of electron microscopes and in software used to transform their images into 3D structures have caused many labs to favour the technique over X-ray crystallography.



V. Falconieri, S. Subramaniam, NCI-NIH

Cryo-electron microscopy of proteins such as this β-galaxtosidase enzyme has progressed from the low-resolution density map on the left to the atomic coordinates on the right.

Frank told journalists gathered at the Royal Swedish Academy of Sciences in Stockholm that technological innovations can have a larger impact than discoveries. “Cryo-electron microscopy is about to completely transform structural biology,” he said. He added that the ribosome — the machinery that makes proteins inside cells — was the “coolest” molecule he had imaged.

Venki Ramakrishnan, a structural biologist at the Laboratory of Molecular Biology who shared the 2009 Nobel Prize in Chemistry for his work to reveal the structure of the ribosome using X-ray crystallography, is one of many converts to cryo-EM. After learning about the award from a *Nature* journalist, he said: “Oh, fantastic! Those are exactly the people I thought should win the Nobel prize.”

Benoît Zuber, a structural biologist at the University of Bern in Switzerland, who did his PhD with Dubochet, says his mentor was always confident that

cryo-EM would become a vital tool, even as others derided the field as “blobology” for the low-resolution molecular images it captured.“He had a vision and he was convinced about it, even when everybody was telling him that this was just a dream," says Zuber.

“It’s a great recognition for all the developments that have happened in the past. It’s fantastic,” says Sjors Scheres, a cryo-EM specialist who works alongside Henderson. The two were returning from a conference in Leicester, UK, yesterday, when Scheres asked Henderson whether he would keep his phone close in case the Nobel Committee called. “He said, ‘I think they should give it to Jacques Dubochet.’ He would never say that he should get one,” Scheres says. “It’s a well-deserved trio.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22738

Corrections

Corrected:

This story originally indicated that bacteriorhodopsin moves proteins across the cell membrane. In fact, it moves protons.

Comments

Commenting is currently unavailable.

Crash in sea-turtle births stumps ecologists

Leading suspect — climate change — doesn’t fully explain what is happening to leatherback turtles in the US Virgin Islands.

04 October 2017

Jurgen Freund/NPL/Getty

While buried in the sand, sea-turtle eggs are very sensitive to several environmental conditions that affect whether they hatch or not.

The mystery behind a dramatic fall in the number of leatherback sea-turtle (*Dermochelys coriacea*) hatchlings in the US Virgin Islands remains unsolved, despite the latest efforts of researchers. Rising temperatures and

changes in rainfall patterns — the top two suspects — don’t seem to be connected to the decline, according to a study published on 4 October[1]. The finding contradicts previous work, leaving researchers scratching their heads over what could be happening.

The latest study focused on a nesting beach in the Sandy Point National Wildlife Refuge on St Croix island in the Caribbean Sea. The researchers found that about 74% of the leatherback sea-turtle eggs laid there in 1990 hatched, but that rate had plummeted to 55% by 2010.

The study analysed detailed temperature and precipitation data at these nests over the 20 years, and found no corresponding trend in either climate-change factor that could fully account for the decline. The researchers reported their results in *Royal Society Open Science*.

Increases in temperature and more-erratic precipitation patterns do affect the nests, but they aren’t the sole reason for the hatching declines, says Anthony Rafferty, a marine biologist at Monash University in Melbourne, Australia, and a study co-author.

This trend is especially confusing in light of the increase in the adult sea-turtle population. “The number of nesting females and the population size has been trending upwards at this site,” Rafferty says. “But there’s been a decrease in hatching success that we are worried about.” That could have negative effects on leatherback populations within one or two decades, he says, when those hatchlings come of age.

Conundrum continues

“It’s hard to say how much of that is happening because of climate change,” says Vincent Saba, a climate scientist at the US National Oceanic and Atmospheric Administration in Princeton, New Jersey. He co-authored a 2015 study[2] that did find a relationship between air temperature, precipitation patterns and declines in leatherback hatching success. That study examined data from 1982 to 2010 and looked at seasonal rainfall, unlike the latest paper, which analysed rainfall only during the nesting season. The study predicted that, by 2100, Sandy Point would have the most unfavourable climate conditions out of all leatherback nesting sites around the world.

“I like the study. They looked at the effect of climate in finer detail,” says Pilar Santidrián Tomillo, a marine biologist and science director of the Leatherback Trust, based in Playa Grande, Costa Rica. She was a co-author on the 2015 study, and appreciates the fuller picture of what could be happening at Sandy Point that the most recent study has provided.

Sea-turtle eggs are exquisitely sensitive to climate because heat, carbon dioxide, oxygen and water all pass freely through their permeable shells. The surrounding temperatures determine the sex of the hatchlings: warmer conditions produce more females, whereas cooler conditions yield males. And rainfall can influence hatchling development and their ability to escape the nest, says Rafferty. Too little rain might mean that the sand is too dry for the young turtles to climb out of it; too much rain during the early stages of egg development might lead to a reduction in oxygen supplies to the growing embryo.

“I think changes in precipitation levels or patterns could explain the decline in hatching success partially, but there could be other reasons, too, like decline in fertility or increase in pollutants, for example,” Santidrián Tomillo says.

Rafferty, who specializes in embryo research, now plans to look at how the age and health of a female sea turtle might affect her fertility, or where she lays her eggs.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22748

Comments

Comments

There are currently no comments.

| 章节菜单 | 主菜单 |

Scientists plead with Brazilian government to restore funding

If officials don't act soon, research institutions could start shutting down next year.

04 October 2017

Leonardo Benassatto/Reuters

Protests against Brazilian president Michel Temer's policies have consumed the country amid severe budget cuts this year.

Anxiety is growing in Brazil over the country’s collapsing research budgets. President Michel Temer had slashed funding for science by 44% in March and has proposed additional decreases for 2018 — even as some science

institutes run out of money for basic needs, such as paying electricity bills. The 2017 science budget, at 3.2 billion reais (US$1 billion), is the lowest the country has seen in at least 12 years.

On 3 October, the government announced that it will release 440 million reais to science agencies to help keep them afloat until the end of this year. But the money is only about 20% of what's needed, said the Brazilian Society for the Advancement of Science in a statement.

Researchers continue to voice their alarm, with a march scheduled for 8 October in São Paulo — the third such demonstration this year protesting the funding shortfalls. And on 10 October, a public awareness campaign called *Conhecimento Sem Cortes* (Knowledge without cuts) will deliver a petition to Congress with more than 80,000 signatures protesting both the cuts and a 2016 constitutional amendment that put a 20-year cap on federal spending.

Last week, 23 Nobel laureates and nine of the country's scientific societies warned Temer that continued budget reductions will seriously jeopardize Brazil's future. They say that the ongoing uncertainty over science funding risks dismantling research groups and prompting a brain drain.

They all hope to influence a revision of the 2018 budget proposal — first submitted to Congress by the executive branch in August — which included a 16% cut to the Ministry of Science, Technology, Innovations and Communications (MCTIC). The Temer administration has promised to release a revised budget in the coming weeks.

On life support

If the 16% cut remains, it would leave a total of about 2.7 billion reais for 22 federal laboratories and research institutes, 73 National Science and Technology Institutes and Brazil's major science funding agencies, the National Council for Scientific and Technological Development (CNPq) and the Funding Authority for Studies and Projects. "This means institutions will shut down by August next year", says physicist Luiz Davidovich, president of the Brazilian Academy of Sciences.

Davidovich's estimate is based on what has happened this year. MCTIC started 2017 at 5 billion reais, its smallest budget in a decade when adjusted for inflation. In March, after the 44% cut, the ministry was left with 2.8 billion reais, not including money for special projects such as the Sirius synchrotron. The budget rises to 3.2 billion reais with those projects. As a result, institutions began running out of cash in September.

“We don’t have money for electricity bills or for buying radiopharmaceuticals”, says José Augusto Perrotta at the federal Institute of Nuclear and Energy Research. Perrotta is the coordinator of the multi-purpose reactor, a 1.6-billion-reais project that is facing delays because of a lack of funding. This year, the reactor was supposed to receive 106 million reais but got nothing.

The Brazilian Center for Physics Research isn’t doing much better. “We‘ll be able to see it through December without layoffs, but next year I’ll have to cancel all equipment maintenance contracts”, says Ronald Shellard, the centre’s director. The institution’s proposed 2018 budget is 7.8 million reais — well below the 12.7 million reais Shellard says it needs to survive.

Brazil’s 1.6-billion-reais Sirius synchrotron is also in jeopardy. The 2018 budget proposal doesn’t provide funding for the facility’s construction, which is slated for completion in mid-2018.

The build is still on schedule after science minister Gilberto Kassab unfroze 85 million reais this month, says Antonio José Roque da Silva, director of the Brazilian Synchrotron Light Laboratory and head of the project. However, the synchrotron will need an additional 331 million reais to complete construction. “I pay contractors with cash, not with promises,” says Roque.

A skeleton crew

Also at risk is Brazil’s collaboration with CERN, Europe’s particle-physics laboratory near Geneva in Switzerland. The 2017 budget cuts eliminated Brazil’s financial support for CERN, and the proposed 2018 budget doesn’t resume those payments.

The biggest threat, however, is to CNPq, Brazil’s main source of federal research grants. The agency hasn’t paid out the grants it green-lit last year, didn’t launch its annual call for project proposals this year and is 400 million reais short of what it needs to honour its commitments in 2017. If the situation isn’t sorted, Marcelo Morales, a CNPq executive director, fears a repeat of 2016, when scholarships for undergraduates and scientists abroad were suspended.

The continuing funding crisis is already driving away students and young scientists. Sergio Ferreira, a neuroscientist at the Federal University of Rio de Janeiro, runs a lab whose budget has gone downhill since 2014. It's now an average of 85,000 reais — one-tenth of what it used to be. This year, five of Ferreira’s graduate students had to spend six months abroad working with his collaborators because he couldn’t afford the materials the students needed for their research.

“In my group I have several people who have left or are about to leave for good, with no plans to come back”, Ferreira says. “I can’t keep a skeleton colony of students.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22757

Comments

Comments

There are currently no comments.

Supercomputer redesign of aeroplane wing mirrors bird anatomy

Bird-bone structures emerge from an evolution-like algorithm.

04 October 2017

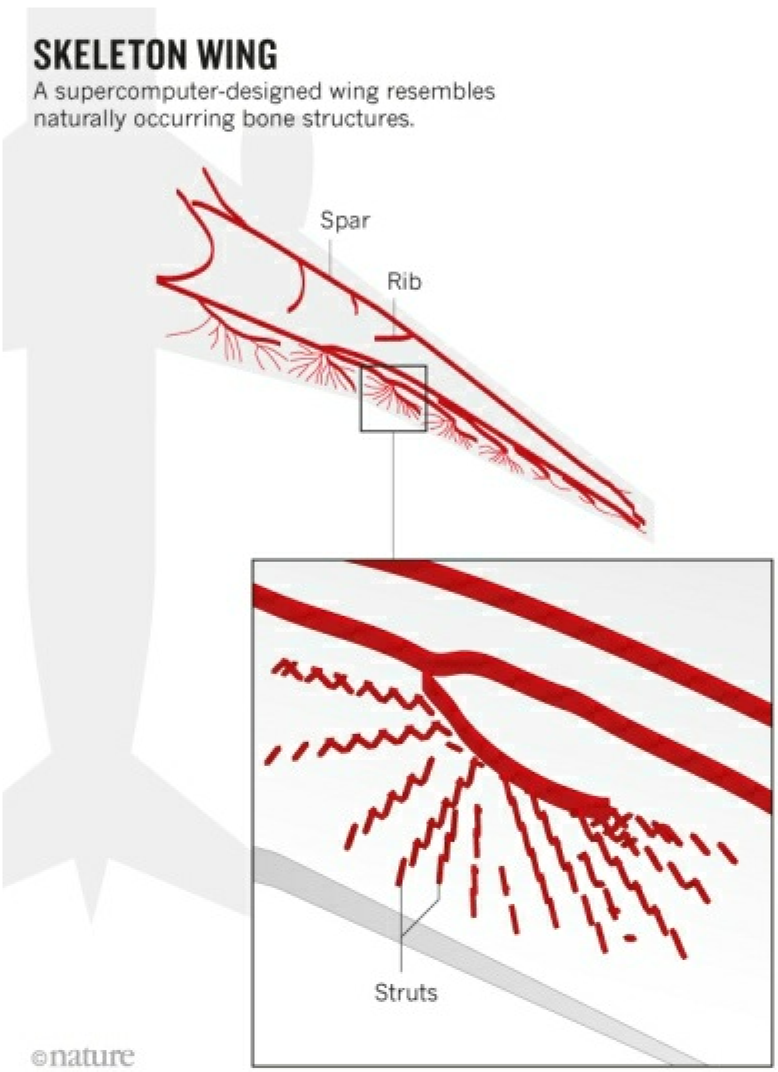
Samuel Taylor/Alamy

Conventional aeroplane wings are supported by straight bars and struts, but a supercomputer has suggested a more organic design.

Engineers have used a supercomputing technique that mimics natural selection to design the internal structure of an aircraft wing from scratch. The

resulting blueprint is not only lighter than existing wings, it also resembles natural formations, such as bird wing bones, that are not present in current aeroplanes. The organic-looking product is as stiff as a conventional aircraft wing but lighter, which could save up to 200 tonnes of fuel per year per plane.

“This is a really nice illustration of how to employ computing-based optimization methods at immensely high resolution,” says Matthew Santer, an aerospace engineer at Imperial College London. The method could feed into the design process, although there are a number of hurdles to using it in aerospace applications in its present form, he adds.



Engineers have been using these kinds of optimization techniques for around

20 years, but only for smaller-scale problems, such as individual wing components, or much simpler structures, says Niels Aage, an engineer at the Technical University of Denmark, near Copenhagen, who led the work[1]. Aage and his colleagues used the Curie supercomputer in Bruyères-le-Châtel near Paris to increase the resolution, enabling them to model the entire 27-metre-long wing of a Boeing 777.

The team started with a wing outline already optimized for maximum lift and minimum drag, known as an aerofoil, and split it into 1.1 billion 3D pixels or ‘voxels’. Each is about the size of the smallest Lego brick — a resolution roughly 200 times greater than previous efforts. The algorithm began by simulating the force exerted on every block and distributing material in response to where the wing experienced a load. Without any human guidance, the program then repeated the analysis several hundred times, adding or removing material depending on the strain felt by each brick, until it reached a final optimum design. “The structure evolves through each design cycle," says Aage. "The process has many similarities to nature’s own evolution."

Organic flight

Unlike conventional wings, the resulting structure did not contain the usual straight beams running the length of the wings, interspersed by crossing supports. Instead, the design looks organic, says Aage. Curved supports fan out at the trailing edge of the wing, resembling the bones in birds’ wings, and intricate support structures in the leading edge look like the internal structure of a beak.

Without compromising stiffness (resistance to deformation), the design weighs 2–5% less than conventional wing structures. That translates into 200–500 kilograms per wing, potentially saving each plane between 40 and 200 tonnes of fuel per year, say the authors. The technique could also be applied to other industries, says Aage, for example, to design high-rise buildings in earthquake-prone zones that maintain their stiffness yet can withstand the dynamics of a quake. It could be used to optimize acoustics, ventilation systems and antennas, as well, he adds.

The technique’s high resolution, which allows the computer to design structures that include features that range in size from millimetres up to tens of metres, could lead to more-innovative designs in these other disciplines, says Liang Xia, a computational engineer at the Huazhong University of Science and Technology in Wuhan, China. But he stresses that running the algorithm requires a heavy computing burden — the equivalent of running a single standard computer for 100 years. This computing cost could be reduced, however, if the team were to employ more-advanced simulation methods, used in artificial intelligence, which in effect model only parts of the wing in such high resolution.

The design is also too intricate to be made by existing manufacturing methods, and would require a giant 3D printer to build. But for now, key aspects of it could be fed into structures produced using conventional methods, says Aage. “We’re speeding up evolution rapidly, meaning we can see how designs should be, and then extract the key features — or those we can afford.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22759

Comments

Commenting is currently unavailable.

Elite Hungarian university may be saved

Hungary-New York agreement could allow Central European University to sidestep law change.

04 October 2017

Bernadett Szabo/REUTERS

Seventy thousand people protested in Budapest last April against a law apparently targeting the Central European University.

The prestigious Central European University (CEU) in Budapest, Hungary, seems to have found a way around a threat to close it down. The university had been affected by a law change that is widely thought to be politically

motivated.

The threat arose in April, when the government rushed through an amendment to its higher-education law, requiring that all international universities operating in Hungary had also to operate as higher-education institutes in their countries of origin.

The law change seriously affected only the CEU, which is legally registered in New York state. The university was founded in 1991 by Hungarian-born philanthropist George Soros, whom Hungarian Prime Minister Viktor Orbán has described as an enemy, because of Soros's statements in support of refugees, which run counter to Orbán's policies. The revised law, which includes other, smaller amendments, comes into effect on 11 October.

New York connection

A CEU spokesperson said on 3 October that the university has now signed a Memorandum of Understanding with Bard College in Annandale-on-Hudson, New York, to provide educational activities. She added that negotiations between the State of New York and the government of Hungary, which opened at the end of June, have now concluded, although the agreement still has to be signed off by Hungary's government and Parliament.

The law change sparked immediate protest last April, when 70,000 protestors took to the streets in Budapest, and the Hungarian Academy of Sciences expressed concern. The European Commission is pursuing an infringement procedure against what it sees as an illegal restriction of academic freedom, and an investigation by legal experts of the Council of Europe, a powerful human-rights organization with 47 member states, published a preliminary opinion in August indicating that the law was inappropriate.

"It's no secret that it has been a hell of a way to treat a university," says CEU rector Michael Ignatieff.

The university has nearly 1,500 mostly postgraduate students from more than a hundred countries, including a large number from Hungary. It operates mainly in the humanities, but recently expanded to include the cognitive and

network sciences.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22761

Comments

Comments

There are currently no comments.

Science without walls is good for all

International mobility and collaboration are linked to stronger research.

04 October 2017

David Williams/Bloomberg/Getty

New studies highlight how closing borders would be bad for science.

Some US biotechnology labs have responded to President Donald Trump's attempts to restrict immigration by releasing contrasting group photographs showing what less-open international borders would do to their workforces. A first image typically shows everyone who works in the lab. A second image includes only those who are permanent US residents, then just US citizens, and then only those who were born in the United States and whose parents also were (see, for example, go.nature.com/2ft02xj). The shrinkage

from the first to the last image is striking — in some cases, about two-thirds of staff are lost. This reflects a widespread reality in research. A 2012 analysis showed that more than 60% of postdocs in the United States grew up overseas (see *Nature* **490,** 326–329; 2012).

When it comes to co-authorship, researchers in Europe are the most international. In 1981, only about one in six papers by a European scientist included co-authors from a different country. By 2011, that had risen to one in two. Papers with authors from more than one country also tend to be more highly cited (J. Adams *Nature* **497,** 557–560; 2013) .

This week, *Nature*'s Comment section publishes two bibliometric analyses that suggest international mobility has similar science-boosting effects.

The first finds that researchers build strong links between nations as they travel around the world. The authors track 16 million individuals who published papers in 2008–15. Only about 4% of these people changed countries, but those who did had 40% higher average citation rates than those publishing solely in one region, a trend that held true across 13 regions. Importantly, mobile scientists retained ties in the countries they left.

The second argues that countries with mobile scientific workforces produce papers that are more highly cited. (These are the same countries that have the greatest fraction of internationally authored papers.) The analysis shows that a nation's willingness to let scientists cross borders was a better predictor of highly cited papers than was the proportion of its gross domestic product that it spent on research.

These are complex issues. Citation rates are not necessarily a sign of quality, influence or long-term importance. And many confounding factors hamper attempts to link policies to impact. Still, such studies are necessary to provide evidence for policies on how to best support the scientific system.

The benefits of international movement are not entirely clear-cut. Leading scientists who change institutional affiliation (but not country) seem to boost both output and impact (G. Halevi *et al. Publ. Res. Q.* **32,** 22–37; 2016). Further work could reveal whether international papers — or more-open countries — prompt more innovative or worthy science. Details of the

relative benefits of collaboration, or how the effects of an international move are mediated by discipline or career stage, must be teased out. So must the effects of particular policies, such as the ease with which potential trainees and working scientists acquire visas or other travel support.

There is a bigger question: does the flow of leading scientists into a country bring tangible benefits for the citizens whose taxes fund their work? What about when one country's funds flow to a scientist's international collaborators? Evidence from patents and technological advances suggests that such investment is rewarded. But attention must be paid to ensure that a nation's connection to elite international scientists also supports work on local interests and needs.

Meanwhile, the scientific powerhouses of the United States and the United Kingdom seem determined to close their doors. US travel restrictions put in place last week tell working scientists from eight countries to stay away. And Britain's departure from the European Union puts scientific collaboration and access to European funds at serious risk.

Many nations with more-welcoming attitudes are poised to benefit. One long-term trend is clear: existing scientific powerhouses are not destined to stand forever. The picture can change — and quickly.

Journal name:
Nature
Volume:
550,
Pages:
7–8
Date published:
(05 October 2017)
DOI:
doi:10.1038/550007b

Comments

Comments

There are currently no comments.

Nobel prizes, giant telescope and buried treasure

The week in science: 29 September–5 October 2017.

04 October 2017

Events | Research | Funding | Facilities | People | Trend watch

EVENTS

Antikythera wreck yields more treasures Marine archaeologists investigating an ancient shipwreck near the island of Antikythera, Greece, announced on 4 October that they have recovered bronze and marble statue pieces, a sarcophagus lid and a mysterious bronze disc decorated with a bull. The cargo ship, which dates to the first century bc and was rediscovered in 1900, is famous for yielding the Antikythera mechanism, a complex bronze geared device that showed the movements of the Sun, Moon and planets in the sky. A team led by archaeologists Brendan Foley of Lund University, Sweden, and Theotokis Theodoulou of the Greek Ephorate of Underwater Antiquities in Athens found the latest artefacts under boulders in a previously unexplored part of the site. They think that at least seven complete statues are still buried nearby.

Brett Seymour/EUA/ARGO 2017

The bronze disc found near the shipwreck.

Volcano threats More than 100,000 residents on the Indonesian island of Bali have reportedly been evacuated to shelters following increased seismic activity from Mount Agung. The government's Center for Volcanology and Geological Hazard Mitigation said on 29 September that, on the basis of the latest information, an eruption was still a probability. Meanwhile, in Vanuatu, the government ordered the evacuation of all residents of Ambae island — about 11,000 people — on 28 September, after Manaro Voui started ejecting lava, poisonous gas and ash. On 1 October, the Vanuatu Meteorology and Geo-hazards Department said the volcano's activity was settling, and a large eruption was less likely. However, as *Nature* went to press, evacuations continued.

Time capsule On an Arctic island, scientists have buried a stainless-steel tube stuffed with artefacts that they say sum up science and technology in 2017. The time capsule, placed in an out-of-use borehole near the Polish

Polar Station in Hornsund, Svalbard, contains samples that include DNA, silicon-based electronics, an ancient meteorite fragment and other items to inform a future discoverer of our present understanding of technology, geology and biology. A team with the Polish Academy of Sciences described the capsule — created to celebrate the sixtieth anniversary of Poland's polar station — in a report in *Gondwana Research* on 28 September.

RESEARCH

Space-time ripples Physicists have announced the first discovery of gravitational waves made together by observatories in Europe and the United States, and the fourth-such discovery overall. At a 27 September press conference, researchers said that on 14 August, both the Virgo observatory near Pisa, Italy, and the twin laboratories of the US Advanced Laser Interferometer Gravitational-Wave Observatory (LIGO) in Livingston, Louisiana, and Hanford, Washington, had picked up gravitational vibrations emanating from a pair of merging black holes 540 million parsecs (1.8 billion light years) away. Observing the event with three detectors, rather than LIGO's two, enabled scientists to pinpoint the location of and distance to the black holes with much greater accuracy. Virgo rejoined the hunt for the waves only on 1 August, after a five-year upgrade.

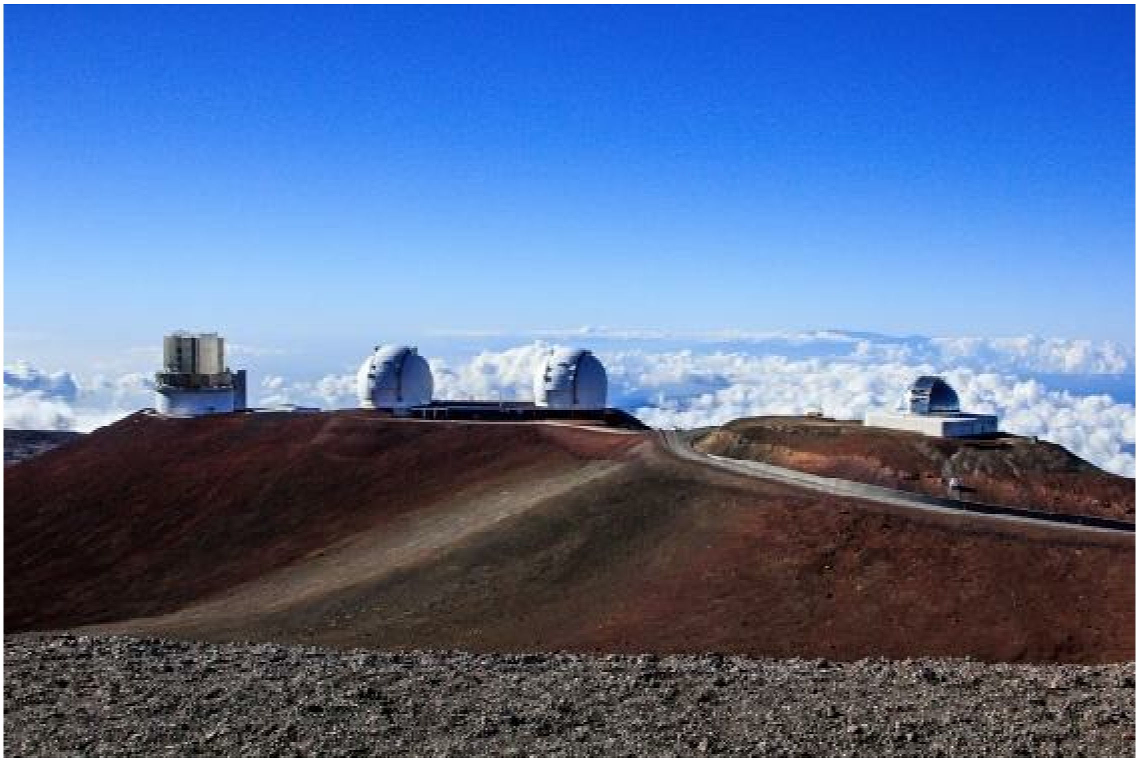
Monkey research The US Food and Drug Administration (FDA) has suspended a study on the effects of nicotine on monkeys after activists, including primatologist Jane Goodall, decried the experiments as cruel. On 25 September, FDA commissioner Scott Gottlieb responded to a 7 September letter from Goodall that called the experiments unnecessary, given that the effects of smoking are well known. The study, which began in 2014 at the FDA's lab in Jefferson, Arkansas, allows monkeys to self-administer nicotine. Gottlieb told Goodall that it would be halted while a team of experts assesses the monkeys' health and determines whether more precautions are needed. The team will also decide whether the study should resume.

FUNDING

French budget French research funding is set for a heartening increase in the country’s first budget under President Emmanuel Macron, if draft 2018 plans released on 27 September are voted into law. The research portfolio of France’s ministry of higher education, research and innovation would rise by more than 6%, to €8.4 billion (US$9.9 billion) in 2018. And a giant economic-recovery plan unveiled on 25 September by Prime Minister Edouard Philippe should divert an extra €2.4 billion to research over the next five years. Separately, in a 26 September speech, Macron backed the idea of a European Union funding agency to accelerate the commercial applications of basic science, an idea also suggested by EU research commissioner Carlos Moedas.

FACILITIES

Hawaii telescope Hawaii’s board of land and natural resources granted a new construction permit to the Thirty Meter Telescope (TMT) on 28 September, reviving the chances that it could be built on the Hawaiian mountain of Mauna Kea. Some Native Hawaiians oppose the TMT, saying that its construction would further violate the sacred mountain, which already hosts multiple telescopes. Hawaii’s supreme court invalidated the TMT’s first construction permit in December 2015, ruling that the board had not followed appropriate procedures. The new permit gives the project the right to proceed on Mauna Kea, but telescope opponents have filed motions that would put the permit on hold until the state supreme court can hear an appeal.



Julie Thurston/Getty

PEOPLE

Nobel prizes Three biologists were awarded this year's Nobel Prize in Physiology or Medicine for their work on circadian clocks. Jeffrey Hall and Michael Rosbash, both at Brandeis University in Waltham, Massachusetts, split the award with Michael Young at Rockefeller University in New York City. The physics prize was awarded to Rainer Weiss, at the Massachusetts Institute of Technology in Cambridge, and Barry Barish and Kip Thorne, both at the California Institute of Technology in Pasadena, for their work on detecting gravitational waves. *Nature* went to press before the chemistry prize was awarded, but full details will be available at go.nature.com/chem2017.

Science adviser On 26 September, Canadian prime minister Justin Trudeau appointed biochemist Mona Nemer as his country's chief government science adviser, fulfilling his campaign promise to establish the position. Nemer was

most recently vice-president of research at the University of Ottawa and director of the Molecular Genetics and Cardiac Regeneration Laboratory there. Her scientific work has focused on the genetics of cardiovascular disease and birth defects. In her new role, Nemer will have a budget of Can$2 million (US$1.6 million) and report to Trudeau and science minister Kirsty Duncan. The country has been without a science adviser for nearly a decade; the last time such a post existed was from 2004 to 2008.

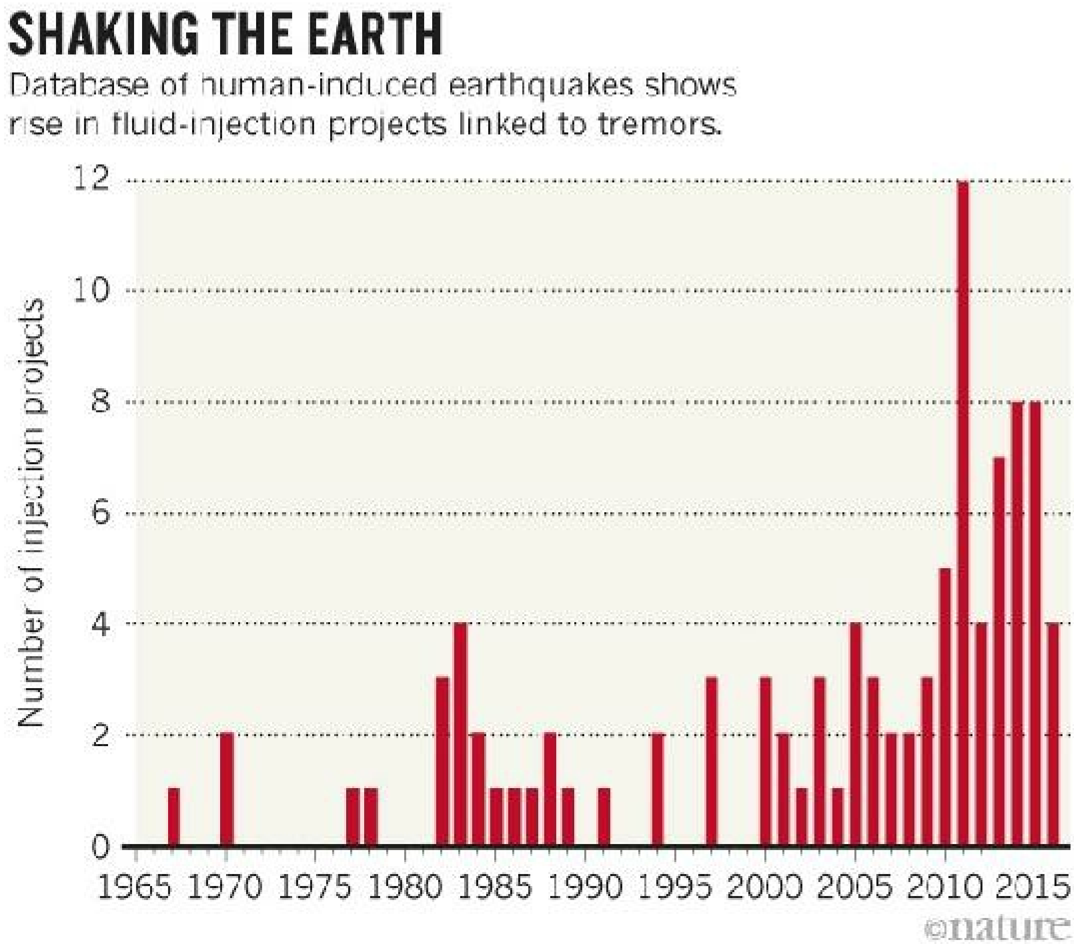
Russian academy After almost six months without a head, the Russian Academy of Sciences (RAS) has a new president: Alexander Sergeyev, a laser physicist and director of the RAS Institute of Applied Physics in Nizhny Novgorod. The academy, which operates a network of hundreds of institutes, is undergoing controversial reforms. In March, its planned presidential elections were unexpectedly cancelled at the last minute, allegedly following a row over voting procedures (see *Nature* **543,** 601; 2017). In the latest elections announced on 26 September, Sergeyev won a majority of votes from the academy's general assembly. A new state law requires that Russia's president Vladimir Putin must also approve the post, which he did the following day.

Defraud alert The FBI has charged bioengineer Yiheng Percival Zhang with defrauding the US government and his employer, the university Virginia Tech in Blacksburg. Zhang was arrested on 20 September and will remain in custody pending a trial, according to court documents. In an affidavit in support of a criminal complaint filed on 18 September, the FBI alleged that Zhang and two of his colleagues at the Tianjin Institute of Industrial Biotechnology in China — Zhiguang Zhu and Chun You — conspired to win US National Science Foundation (NSF) grants for studies that had already been completed in China. The affidavit also claims that Zhang withheld a portion of funds owed to his university from NSF and Department of Energy grants.

TREND WATCH

A database of human-induced earthquakes reveals a rise in tremors linked to wastewater injected into the ground by oil and gas operations. Such projects

spiked in the early 2010s, particularly in the central United States. The HiQuake database is described in *Seismological Research Letters*. Of 728 entries, 37% are linked to mining, 23% to water piling up behind a dam and 15% to conventional oil and gas development. Just 4% are linked to hydraulic fracturing, or fracking, for oil and gas.



Source: M. P. Wilson et al. Seismol. Res. Lett. http://dx.doi.org/10.1785/0220170112 (2017)

Journal name:
Nature
Volume:
550,
Pages:

12–13
Date published:
(05 October 2017)
DOI:
doi:10.1038/550012a

Comments

Comments

There are currently no comments.

Why fake islands might be a real boon for science

The seasteading movement is getting close to building its first prototype, an artificial archipelago where people will live, play and do research.

04 October 2017

Blue Frontiers

Early designs for a floating island in Tahiti aim to mimic a natural landscape.

The view is unbeatable. To the right, steep volcanic mountains, draped in green, rise up from a beachside coconut grove. To the left, the Pacific Ocean glitters turquoise under the midday sun. It is here in this Tahitian lagoon that a group of entrepreneurs plans to build an artificial island — three-quarters of a hectare of floating housing and research space, made up of linked platforms. If the team is successful, the vision could become reality by 2020. But it would be just the first step, says self-described “seavangelist” Joe Quirk. The ultimate goal is to build whole sovereign nations on the open seas, composed of modular floating units.

“French Polynesia has all the stepping stones: lagoons, atolls, shallow waters

right next to deeper waters," Quirk says.

Quirk, one of five managing directors for the company behind the project, and his colleagues propose that artificial islands could serve as laboratories for testing out new technologies and exploring different social structures, or act as life rafts for coastal peoples displaced by sea-level rise.

The non-profit Seasteading Institute was founded by former Google engineer Patri Friedman in 2008, and it has garnered support from influential people in the linked worlds of Silicon Valley, libertarian politics and the anything-goes desert festival, Burning Man. Most media reports have been sceptical, however. The project has been characterized as the dream of "two guys with a blog and a love of Ayn Rand"[1] and "a hacker's approach to government with a *Waterworld*-esque conception of Manifest Destiny"[2].

But the Seasteading Institute and the new for-profit spin-off, Blue Frontiers, have racked up some real-world achievements in the past year. They signed a memorandum of understanding with the government of French Polynesia in January that lays the groundwork for the construction of their prototype. And they gained momentum from a conference of interested parties in Tahiti in May, which hundreds of people attended. The project's focus has shifted from building a libertarian oasis to hosting experiments in governance styles and showcasing a smorgasbord of sustainable technologies for, among other things, desalination, renewable energy and floating food-production. The shift has brought some gravitas to the undertaking, and some ecologists have taken interest in the possibilities of full-time floating laboratories.

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Reporter Geoff Marsh investigates ambitious plans to build artificial floating cities.

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But the project still faces some formidable challenges. The team must convince the people of French Polynesia that the synthetic islands will benefit them; it must raise enough money to actually build the prototype, which it estimates will cost up to US$60 million; and once it is built, the group must convince the world that artificial floating islands are more than just a gimmick. Producing solid science and broadly useful technology would go a long way towards making that case.

“What we are dreaming is that this structure will be a scientific laboratory,” says Winiki Sage, head of the Economic, Social, and Cultural Council of French Polynesia in Tahiti, who has been concerned about brain drain from his country.

Aesthetic appeal

Designs are surfacing for the prototype island, and its look is a key part of Blue Frontiers's public-relations strategy. The company's current plans don't entirely align with the concept art on the Seasteading Institute's website, which swings from tiki bar to Tomorrowland in various iterations. Bart Roeffen, a 'water pioneer' at the Dutch design firm Blue21 in Delft, has been drawing up new plans that fit with the landscape and culture.

“We are working together with Tahitian designers to make something that is not like an alien invasion,” Roeffen says. In particular, he plans to take cues from Polynesian shipbuilding. The elegant outrigger canoes, or *va'a*, used by islanders are stable and light; oceangoing versions are the type of boat rowed by the Tahitian voyagers who discovered Hawaii and New Zealand around AD 1100. Linked platforms would be arranged to ensure that no coral below is completely shaded and killed. The goal is to actually expand the habitat for reef species (see 'Seasteaders in paradise').

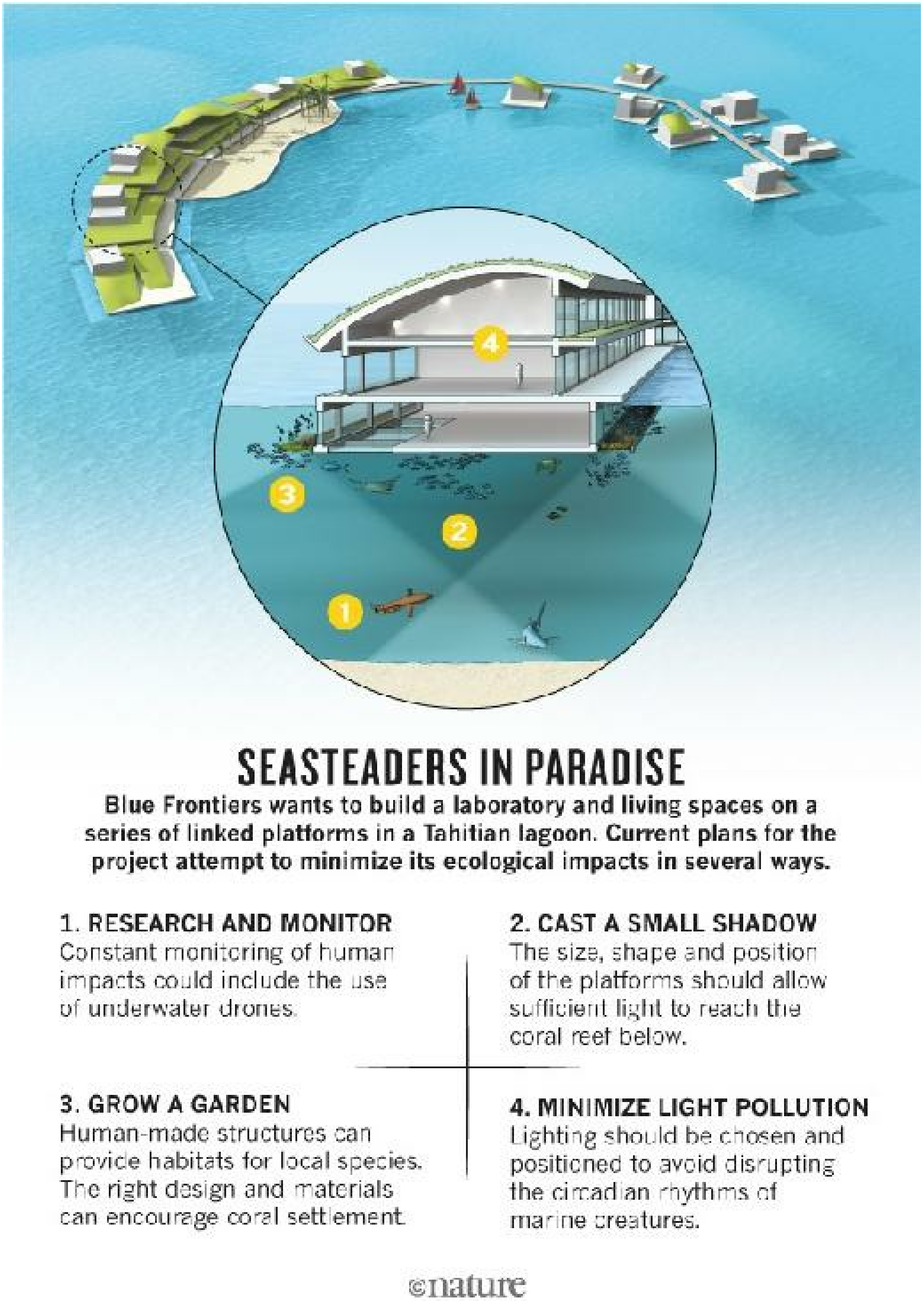


Illustration by Emily Cooper

The team would not provide direct information about funding. Paypal

founder and one-time Donald Trump enthusiast Peter Thiel provided a reported $1.7 million to the Seasteading Institute, but he last contributed to the project in 2014, and any recent investors are keeping a low profile. Quirk says that they have “a nice amount” of seed money and are preparing for what is called an initial coin offering — an investment mechanism that uses digital cryptocurrency. Looking ahead, the company hopes to generate revenue by renting out space on the island and acting as consultants for other would-be island builders. Along with hiring Quirk and the other four managing directors, Blue Frontiers has recruited ten staff members and commissioned environmental, legal and economic studies on the impacts of the project for investors and the government.

The “why?” — everyone's first question about seasteading — is answered differently by everyone involved. Some are captivated by the project because it is an excuse to push sustainable design to the next level. For people on low-lying islands, it looks like a life raft. Félix Tokoragi, mayor of Makemo, an atoll in the Tuamotu archipelago in French Polynesia, told Blue Frontiers that he's interested. The Tuamotus have experienced widespread flooding, and Tokoragi is worried that his people will become climate-change refugees. “We are attached to our atoll; we are attached to our culture,” he says. “We are not against this idea, since the technology can respond to the problems that we face.”

For others, the pull of the project comes down to autonomy and self-reliance, particularly with respect to governance: anyone who decides their island's political style is not for them can detach and depart for another system that they like better.

For at least one scientist advising the project, Neil Davies, executive director of a field station of the University of California, Berkeley, on the neighbouring island of Moorea, the island's appeal is as a base for research that would “fill the gap between oceanographic-research vessels and coastal marine labs”. Ships are on the water, but they are “phenomenally expensive”, he says, and they don't stay put. Coastal labs can gather long time-series of data in one place, but don't provide access to deeper water. Davies dreams about floating “sea stations” that would allow low-cost, long-term access to the ocean for research, especially for students in tropical countries “where

natural systems are among the most sensitive to human activities”, he says. Experiments could include modifying pH or temperature on small sections of a reef to simulate future environmental conditions, and 'planting' different corals to investigate which will thrive best in the future. Data could be gathered using semi-permanent sensors and cameras, along with regular biological-sample collection.

Some scientists not involved in the project see value in the concept, as well. “If you have a floating island and you want long-term study, that is a perfect way to do it,” says Ross Barnes, marine-operations superintendent at the University of Hawaii Marine Center in Honolulu, who oversees two large research vessels and on-shore labs. The university has been conducting research at a spot in the ocean that it calls Station ALOHA, which scientists have visited nearly 300 times by boat since 1988. A floating platform, he says, would mean that scientists could leave behind some instruments — and that some of them could stay as well — allowing for continuous measurement. “It's a good idea,” Barnes says.

Currently, Davies is advising the seasteaders on site selection and environmentally positive design choices. He also plans to help them to document the installation's performance using sensors that measure things such as energy expenditure and waste generation on the platforms, as well as water temperature and quality. And he sees it as a great teaching opportunity for the many students who visit his station. “Seasteading raises many social, legal, ethical, environmental issues, even if it never gets anywhere,” he says.

Whether the seasteaders make progress depends on whether the project is embraced by French Polynesia, a largely autonomous 'overseas collectivity' of France with a population of 287,000 on 67 islands spread out across an area nearly the size of Europe. At one level, a grand floating project could appeal to a nation of voyagers and boat builders. But French Polynesia has been burnt by big-science and technology projects before. From 1966 to 1996, France conducted 193 nuclear tests in its Polynesian possessions, many in the atmosphere. In February 2016, then-president of France François Hollande admitted that the testing had harmed the environment and human health. And the place is littered with defunct projects and closed hotels.

“We have a history of being taken for fools,” says Pauline Sillinger, a

sustainable-development specialist at Te Ora Naho, a federation of environmental groups in French Polynesia, who took a job with Blue Frontiers this year, and also teaches Tahitian dance. “Nuclear testing, big hotels, nice, smiling, white, intelligent people telling us it'll be good for us.”

But their wariness vies against their desperation for new revenue streams, Sage says. After winding down nuclear testing, France began paying French Polynesia more than US$100 million per year in compensation for lost income from military activity. But in 2016, that amount was reduced. Meanwhile, tourism revenues have never recovered from the 2008 recession. Thanks to increased political stability and other factors, things have improved since 2014, when the collectivity was so broke that it risked not being able to pay its civil servants, according to Sage. But it is still dangerously reliant on a small number of income sources — tourism, pearls, coconut oil. Unemployment stands at nearly 18%. “We are looking for new ideas,” Sage says. “We are really open to any ideas, any investors.”

If Sage is sceptical but willing to give it a shot, there are others who have had enough of grandiose project ideas. Among them is a religious leader in Tahiti, Frère Maxime Chan, who heads Association 193, which advocates on behalf of those harmed by nuclear testing. Chan is also vice-president of Te Ora Naho. (Sage, incidentally, is the organization's president.) Chan says that his old friend Sage and the rest of the government are “dazzled” by the flash and money of the Seasteaders. He talks about recent projects — including a tourist resort, an aquaculture scheme and an eco-resort — that were all announced with fanfare and optimistic job projections, only to be cancelled, scaled back or put on indefinite hold. Chan wishes the government would admit that the standard of living for the average Tahitian has been artificially inflated by nuclear-test payments and must come down. This can be done without suffering, Chan contends, by gracefully returning to a version of the pre-1960s subsistence economy. “Small is beautiful,” he says.

Convincing French Polynesia to support the project will fall mainly to Marc Collins, another managing director of Blue Frontiers. Collins is Tahitian and lives there now, but in the early 1990s he lived in Silicon Valley, and fell in love with its fast-paced culture of big ideas and endless possibility. Ever since, he's kept his toe in those waters in part by maintaining a subscription to

Wired magazine. In May 2015, the digital lifestyle glossy ran a story[3] about how the seasteading movement planned to scale back its grand, high-seas concept, reorienting towards safer, shallower waters and looking for “cost-reducing solutions within the territorial waters of a host nation”.

Collins, a serial entrepreneur who has dabbled in every major French Polynesian industry, from hotels to black pearls and telecommunications, saw an opportunity to, as he puts it, “bring some of the DNA of Silicon Valley to Tahiti”. Tahiti joined the world of high-speed Internet in 2010, with the completion of an undersea fibre-optic cable linking it to Hawaii. It has calm lagoons aplenty and daily flights from Los Angeles, California, and, as a minor bonus, is widely regarded as paradise on Earth. Collins fired off a LinkedIn request to the Seasteading Institute's executive director, Randolph Hencken.

The Seasteaders were interested in Collins's pitch, but they wanted a more official gesture of support. So Collins, who served as French Polynesia's minister of tourism in 2007 and 2008, began working his government contacts. By August, the president of French Polynesia, Édouard Fritch, signed a letter formally inviting the Seasteaders to present their ideas. A delegation of nine took him up on the offer the next month, and by January, a memorandum of understanding with pledges of cooperation was signed.

The next step in making the island a reality will be the passage of a law defining the 'special economic zone' that will cover the synthetic island. Blue Frontiers isn't asking French Polynesia for any subsidies to build the island, but it is asking for a 0% tax rate, among other regulatory exceptions. It has hired French firm GB2A, based in Paris, to prepare legal research and a set of requests, which Blue Frontiers presented to the government at the end of September. The team hopes to see a bill emerge before the end of the year.

In the meantime, the Seasteading Institute is building excitement and courting potential investors with a series of gatherings. In May, it held talks, networking events and tours in Tahiti. Speakers included Fritch; Tony Hsieh, chief executive of online retailer Zappos in Las Vegas, Nevada; Tua Pittman, a master canoe navigator from the Cook Islands; and engineers, nanotechnologists and a 'blockchain strategist', a specialist in the distributed information systems behind cryptocurrencies. The seasteaders hope to use

such systems to handle their financials, as well as any scientific data that they generate. But the event wasn't all work. An announcement for a party on outrigger canoes cheerfully suggested: “Do not wear heels. Bring a swimsuit for an optional moonlight swim.”

On 22–29 October, Blue Frontiers will hold an Insiders Access Week for supporters and potential investors, a mix of tours, discussion and morning yoga with Hencken. Always ambitious, the team hopes to have draft legislation from the Polynesian government by then, and some detailed architectural plans. The goal is to break ground — or rather, sea — in 2018.

While all this work goes on behind the scenes, the lagoon remains fairly quiet. On a day in July, locals compete in a stand-up paddle-board race while families play on the shore and young women drink beer with their feet in the waves. By the roadside, freshly caught tuna are for sale. On one level, it is hard to imagine this place being improved upon.

Time will tell whether the Seasteaders' island becomes a refuge for Polynesians facing rising seas and an incubator for Polynesian science and business, or merely a playground for wealthy foreigners who want to dodge bothersome regulations. That is, if it materializes at all.

Journal name:
Nature
Volume:
550,
Pages:
22–24
Date published:
(05 October 2017)
DOI:
doi:10.1038/550022a

Comments

Comments

There are currently no comments.

How fracking is upending the chemical industry

As shale-gas compounds flood the market, chemists are working out the best ways to convert them into the ingredients of modern life.

04 October 2017

Jeff J Mitchell/Getty

A ship carrying US shale gas, the *Ineos Insight*, approaches port in Scotland in September 2016.

As the *Ineos Intrepid* cruised slowly through the sapphire waters of Norway's Frierfjord, chaperone tugboats sprayed jets into the sky to herald her arrival. In giant refrigerated tanks below decks, the ship carried 27,500 cubic metres

of liquid ethane — enough to fill 11 Olympic swimming pools. *Intrepid* also brought a message, painted in giant capital letters along her side: “SHALE GAS FOR PROGRESS”.

The vessel's arrival in March 2016 brought the first ever shipment of shale gas from the United States to Europe — and marked the start of a burgeoning business. More of these 180-metre-long 'Dragon'-class vessels have followed in her wake, forming a 'virtual pipeline' for ethane across the Atlantic Ocean. This gas, which is extracted from the ground through the hydraulic fracturing of shale deposits, isn't destined to fuel power stations or domestic stoves. Instead, it will be transformed into the chemical building blocks needed to make a panoply of products, including plastics, clothes, adhesives and medicines.

Intrepid's voyage is a striking demonstration of how cheap US shale gas is reshaping the chemical industry and changing the origin of countless manufactured objects. For decades, the industry's raw ingredients have mostly come from crude oil. Chemical plants break down long hydrocarbon molecules in crude to produce a smorgasbord of smaller molecules, such as ethene, propene and benzene — all important precursors to polymers.

But shale gas, which is composed mainly of methane, ethane and propane, is turning that pathway on its head. The abundance of the gas has slashed the costs of these molecules. As a result, some are now usurping large hydrocarbons as the preferred starting point for industrial synthesis.

This shift from oil to gas brings enormous opportunities. According to the American Chemistry Council, a trade group based in Washington DC, the shale boom has attracted about US$160 billion in investment from the US chemical industry since 2011, and will help to create half a million jobs in plastics manufacturing over the coming decade[1]. But it also poses huge challenges. Some of the main techniques that are used to turn the components of shale gas into more valuable compounds — processes generally known as upgrading — are decades-old, dirty and energy-intensive. And they rarely produce the same mix of chemicals as conventional oil-based routes, which means that some relatively minor, yet valuable, chemicals such as butadiene, an ingredient of synthetic rubber, are becoming scarcer.

These challenges are driving an intensive research effort, spanning industry and academia, to develop catalysts and reactors that can transmute small hydrocarbons in cleaner, cheaper and more efficient ways.

Translating that research into commercial production will depend on the finely balanced economics of a changeable market. It will also require a reliable supply of gas. The US Energy Information Administration predicts that natural-gas extraction in the United States will continue to grow until at least 2040, but that might be too optimistic (see Nature 516, 28–30; 2014). Meanwhile, concerns that fracking can contaminate groundwater — along with the broader climate implications of extracting fossil fuels — continue to dog the technology. If the glut does persist, however, it could usher in technologies that would form the foundations of a much more sustainable chemical industry. “We could totally redesign our chemical plants,” says Bert Weckhuysen, a chemist at Utrecht University in the Netherlands.

The ethane revolution

Shale gas is extracted from kilometres below ground, and typically contains about 70–95% methane, less than 15% ethane and less than 5% propane. After traces of oil, water and other impurities are cleaned out, the gas is chilled so that ethane and propane can be separated in liquid form, leaving methane behind.

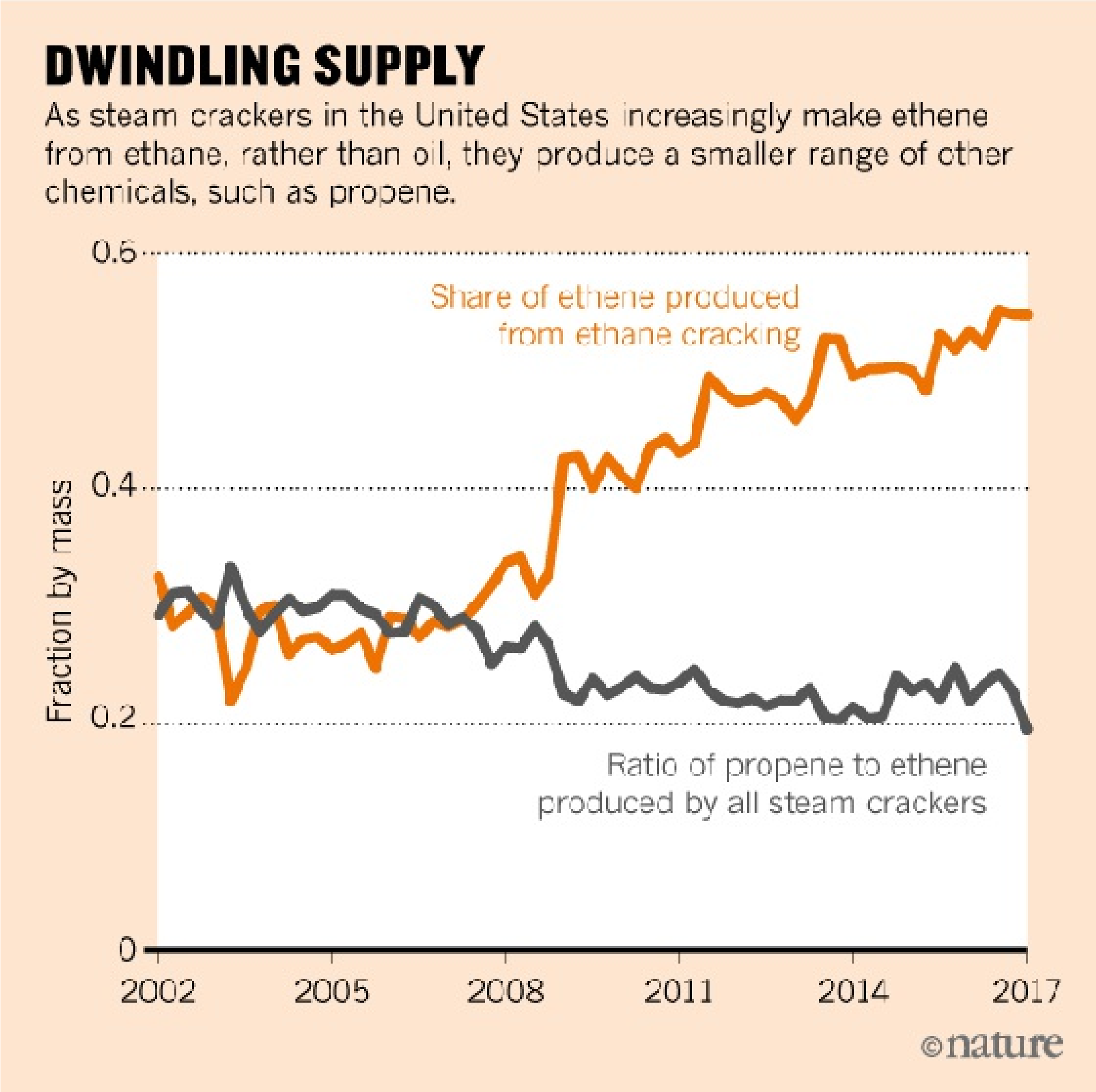
Although ethane makes up a small proportion of shale gas, it has so far had the biggest impact on the chemical industry. That's because chemists can easily use it to make ethene, also known as ethylene. Ethene is used to make various types of polyethylene and the precursors to other plastics, such as polyvinyl chloride (PVC) and polystyrene. So voracious is the world's appetite for these plastics that the chemical industry produces roughly 150 million tonnes of ethene every year, more than any other chemical building block.

Most processes in the chemical industry use catalysts. But ethene can be produced simply by steam cracking ethane or larger hydrocarbons. First developed in the 1920s, steam cracking is a blunt, energy-intensive process

that requires little more than water and 850 °C temperatures. “You basically just heat the snot out of it,” says Jeffrey Plotkin, an industry analyst at IHS Markit in New York City. “The heart and soul of the thing is this gigantic furnace, that's where all the chemistry happens.”

The boom in shale-gas-derived ethane has driven the chemical industry to invest nearly $45 billion in extra steam-cracking capacity[2]. But the transition to this feedstock is also creating a headache. When steam crackers are fed with mixtures of long hydrocarbons from crude oil, they make an array of useful by-products. But when they are supplied with ethane, the output is almost entirely ethene. “So there is a shortage of other building blocks,” says Weckhuysen.

One of those building blocks is propene, arguably the second most important product of the chemical industry after ethene. Propene is turned into polypropylene, a plastic used in packaging and textiles, along with other polymer ingredients such as acrylic acid. But by one estimate, propene production by US steam crackers dropped by almost half between 2005 and 2014, even as global demand rose (see 'Dwindling supply').



Source: S&P; Global Platts

To combat the shortfall, the industry is rolling out alternative ways to make propene. One of the leading routes starts with the shale-gas component propane. A combination of heat and a catalyst to remove two hydrogen atoms can be used to turn it into propene.

The conversion is becoming more profitable: more than 20 of these propane-dehydrogenation units are already operating worldwide, and at least 40 more have been ordered since 2011. But Weckhuysen says that there is much scope to improve the process, which tends to chew up catalysts quickly, requires a

time-consuming and costly catalyst-regeneration step, and can use harsh reagents.

The methane question

Although ethane and propane are already making waves as commercial feedstocks, the big prize for chemists is to upgrade the most abundant component of shale gas: methane.

Most of the world's methane is currently burnt as fuel, its lowest-value application. The gas can also be used as a chemical feedstock, but it contains strong carbon–hydrogen bonds that are difficult to break in a controlled way. When methane is converted into other molecules, it is done mainly through an inefficient sledgehammer of a process called steam reforming. First commercialized in the 1930s, this involves smashing methane and water together at up to 1,100 °C, over a metal catalyst. It produces an extremely useful mixture of carbon monoxide and hydrogen called syngas — and also emits several hundred million tonnes of carbon dioxide per year, accounting for roughly 3% of all industrial emissions[3].

Syngas is the world's principal source of hydrogen, much of which goes to make the ammonia in fertilizer. Syngas can also be used to produce longer hydrocarbons, such as basic components of diesel and waxes.

Such upgrading is typically done through a technique called the Fisher–Tropsch (FT) process, which uses cobalt or iron catalysts and heat to create daisy-chains of carbon atoms. FT was developed in Germany in the 1920s to make petrol and a wide range of other hydrocarbons from syngas derived from coal.

Producing transport fuels in this way is generally more expensive than refining oil. There are just six large-scale FT plants in the world, made economical only thanks to their proximity to huge coal or gas fields and the mind-boggling scale of the plants themselves: the world's largest, in Qatar, cost $19 billion to build and munches through 45 million cubic metres of methane every day, on a par with the natural-gas consumption of Belgium.

Courtesy Velocys

A plant in Oklahoma City owned by ENVIA Energy uses compact reactors developed by Velocys to turn methane-derived gas into products such as diesel.

But the shale boom has prompted chemical engineers to take a fresh look at the FT process. Shale-gas wells typically don't produce enough gas to support a conventional FT plant, so research teams and companies have been developing smaller reactors that can process modest gas flows. One of those is Velocys, based in Houston, Texas, which developed a 5-metre-long reactor that can convert syngas into substances such as naphtha, diesel and wax. Its reactor technology is being used in Oklahoma City in the first commercial mini-FT plant in the United States. The plant, which is owned by ENVIA Energy, started production earlier this year.

Temperature control is a big challenge for the FT process: the reaction kicks in at about 180 °C, then generates huge amounts of heat. If not carefully controlled, it will run away with itself, turning carbon atoms into useless soot. To address this, Velocys's reactor contains corrugated layers of channels that

are alternately stuffed with catalyst or filled with water. This keeps the reaction running at a steady 200 °C, so that the reactor can use an efficient catalyst without risking a runaway reaction. “It allows you to pack a lot of reaction in a very small space,” says Neville Hargreaves, business-development director for Velocys in Oxford, UK.

The reactor in Oklahoma City pulls methane from a landfill site, an activity that comes with renewable-energy credits. But Hargreaves thinks companies could ultimately profit by tapping remote and relatively small natural-gas reserves that are unlikely to get a pipeline. Another potential target is unwanted gas from oil wells, which is often simply burnt off. Such 'flaring' puts about 350 million tonnes of CO_2 into the atmosphere every year. According to the World Bank, it carries enough energy to meet Africa's entire current electricity requirements.

The direct route

The high temperatures involved in producing syngas will always make it a costly way to create complex chemicals — as well as a major source of CO_2 emissions. Researchers have spent decades looking for ways to convert methane directly to methanol or other products, cutting syngas out of the route altogether. The shale boom has given this effort fresh urgency, along with a burst of investment in research and development in both academia and industry.

Turning methane into methanol — itself a key precursor to a wide range of other compounds — involves adding only a single oxygen atom. But first, one of methane's strong carbon–hydrogen bonds must be broken, and the high temperatures or strong oxidants needed to do that can set the molecule on a one-way journey down a thermodynamic roller coaster with a messy end. Methanol sits on a brief crest about halfway down, but it is all too easy to race downhill as the reaction goes too far, producing a mixture of other molecules, including formaldehyde, formic acid or carbon monoxide.

In 2005, however, a team led by Robert Schoonheydt at the University of Leuven in Belgium, found[4] that copper seeded onto a porous material called a

zeolite could unite oxygen and methane to make methanol at less than 200 °C. Crucially, the methanol became trapped in the zeolite's pores, preventing further reactions. But extracting methanol from the pores and reactivating the catalyst would have proved expensive and impracticable in a commercial setting.

Since then, research groups have developed a range of copper–zeolyte catalysts that are more industry-friendly. Others have focused on completely redesigning chemical reactors. The European Union-funded project Adaptable Reactors for Resource- and Energy-Efficient Methane Valorisation, for example, aims to build small reactors that use renewable electricity, rather than heat generated from fossil fuels, to turn methane into compounds such as ethene and methanol. One approach uses microwaves to generate intense hotspots in the catalyst, lowering the heating requirements for the incoming gas.

Another approach to direct methane upgrading aims to couple pairs of the molecule together to make ethene. Since 2015, Siluria Technologies, a start-up in San Francisco, California, has been running a demonstration plant for this process in La Porte, Texas. It relies on a catalyst made of metal-oxide nanowires that collectively offer a surface area of about 200 square metres per gram of catalyst, hundreds of times more than a bulk catalyst could offer.

The company builds its catalysts in a unique way, based on a technique[5] developed by co-founder Angela Belcher, a materials scientist at the Massachusetts Institute of Technology in Cambridge. First, viruses are genetically engineered to express proteins that bind to dissolved metal ions. The ions form orderly arrangements as they stick to the surface of the virus. When the biological template is burned away, it leaves behind a highly stable, crystalline nanowire.

Rahul Iyer, Siluria's vice-president of corporate development, says that the process is cost-competitive with steam cracking ethane, and produces far fewer CO_2 emissions than steam reforming methane. Siluria has already licensed the technology to some chemical companies, and expects the first commercial facilities to be operating in 2019.

Plotkin says that Siluria is currently in the lead in the race to commercialize direct methane upgrading, and is backed by multimillion-dollar investments from big players in the industry. “People are keeping a watchful eye on it,” he says.

Gas that's greener

The shale-gas boom is credited with spurring a major renaissance in the US chemical industry, which has invested heavily in chemical plants and other infrastructure, as well as research and development. Enthusiasm for shale-gas upgrading has fostered major collaborations between academia and industry.

Translating laboratory results into commercial production is an ongoing challenge, although the trend towards small, modular reactors is helping to make it less daunting. The chemical industry is notoriously conservative: if a process succeeds in the lab but fails at commercial scale, tonnes of catalyst can be wasted and a plant shut down for months. “Industry will not take the risk unless they are sure it will work,” says Weckhuysen.

Despite these challenges, he is optimistic that gas upgrading could have a huge impact — not only on the chemical industry's processes, but also on its environmental footprint. Some of the reactor technologies being developed to feed on shale gas could be adapted to use bio-based feedstocks, such as methane from landfills, as Velocys has found. Meanwhile, shortages in some compounds caused by the shift to shale gas could improve the economic case for starting with ethanol from crops, or lignin from wood[6]. There has already been movement along these lines. In 2013, for example, French tyre-maker Michelin and partners launched a €52-million (US$61-million) project to make butadiene from bioethanol.

But for now, US shale ethane continues its relentless march around the world. More chemical companies are commissioning ships to transport the gas to destinations in Europe, Brazil and India. By 2022, according to one estimate, about 8 million tonnes of ethane will flow through these virtual pipelines each year. They will carry this revolution in the US chemical industry to the rest of the globe — both its challenges and its opportunities.

Journal name:
Nature
Volume:
550,
Pages:
26–28
Date published:
(05 October 2017)
DOI:
doi:10.1038/550026a

Comments

Commenting is currently unavailable.

Scientists have most impact when they're free to move

04 October 2017

An analysis of researchers' global mobility reveals that limiting the circulation of scholars will damage the scientific system, say Cassidy R. Sugimoto and colleagues.

Spencer Platt/Getty Images

Measuring the global movements of researchers will help to assess the effects of political actions on science.

Recent political upheavals portend an era of increased isolationism in

science, with a chilling effect on collaboration and mobility. Last month, US President Donald Trump issued his third travel ban in a year, suspending entry of individuals from several countries into the United States, and placing restrictions on many more for visa renewals. These orders have stranded scholars abroad and prevented those who were in the country from engaging in international work. In March, UK Prime Minister Theresa May began the process of formally severing ties with the European Union. As a result, British institutions face a potential exodus of non-resident EU researchers and will have to overcome barriers to participating in and receiving funding for European collaborative projects. The list of countries engaging in these isolationist actions, and the list of actions themselves, grows longer.

To assess the impacts of such political actions, we need better ways to measure researcher mobility. Although the size and composition of the scientific workforce is fairly well established through national surveys and registries[1], less is known about how often researchers move, where they go, what networks they form, and how important their movement is to the scientific impact of their work[2].

We present here a new analysis based on the records of 14 million papers from nearly 16 million unique individuals who published between 2008 and 2015. In our study, some 96% of researchers had only one country of affiliation; we classed these as non-mobile. About 4% (more than 595,000 researchers) were mobile — meaning that they had more than one affiliation during that period. Our analysis revealed surprising trends.

Chain reaction

Over the study period, Europe and Asia saw a dramatic net loss of researchers, whereas North America saw large gains. Many commentators have anguished about 'brain drain' or 'brain gain', assuming that receiving countries get the lion's share of scientific capital at the expense of the nations from which researchers originate. The reality is more complicated (see 'Brain circulation').

We found that the majority of scientists didn't cut ties with their country of

origin but instead built a chain of affiliations that linked nations together. Many researchers returned to their home country. Brain circulation may be a more apt term for the movement of contemporary scholars[3].

Different nations have different roles in the circulation of elite scholars (for which our proxy is highly cited researchers). But wherever they are, wherever they stop off and wherever they come from, mobile scholars have about 40% higher citation rates, on average, than non-mobile ones (see Supplementary Information; Table S7). Closing borders takes these elite scholars out of circulation.

Origin stories

Our study looks at the country stated in a researcher's affiliation when they published their first paper, and uses this as their country of scientific origin (this should not be confused with where they were born). We then track whether they moved or gained new affiliations in other countries over the eight years of this study.

The conventional idea of mobility focuses on migrant researchers — those who begin publishing in one country and then move to another, at some point discontinuing their attachment to the previous country. This group made up less than one-third of the mobile researchers in our study (27.3%, or 162,519 researchers). By far the largest proportion were those we call travellers: scholars who retain a footing in their country (or countries) of scientific origin throughout their career, while gathering up more international affiliations to add to their name (72.7%, or 433,375 researchers). Nearly half of the travellers are 'non-directional': they have more than one affiliation in their first year of publication, and they retain all these affiliations in each publication year.

Circulation networks that map the number and flow of researchers reveal the importance of the United States, United Kingdom, France, Canada and Germany as prominent nodes in the global scientific network (see Supplementary Figure S2). Isolation of these countries would have dramatic consequences. Although the United Kingdom is not particularly central to researcher migration in the European Union, it serves a crucial function in providing a bridge for European scientists to other areas of the world (see Supplementary Figure S2). Isolationist policies in the United Kingdom could deconstruct this network, redirecting scholars through other countries.

More patterns emerge if we look only at migrants and directional travellers who moved between and within continents, who first published in 2008, and who published at least eight papers during the study period. Admittedly, our short time window means that we focus on junior scholars. But it avoids conflating them with senior scholars whose movement and networking are likely to differ.

This group comprised 12,046 researchers. Europe provides the largest share (35%) followed by about one-quarter each from Asia and North America (see 'Making tracks'). The relationship between these latter continents is strong:

the majority of mobile scholars associated with an Asian address in their first publication in 2008 have a North American address by 2015, and more than one-third of mobile North American scientists end up in Asia. Both of these trends can probably be explained by the same underlying phenomenon — the influx of Asian students into the United States (some of whom publish before their arrival, and others of whom do so afterwards), and their subsequent moves back to Asia.

We see a 22% net loss of researchers from Europe, a 20% loss from Asia, and a nearly 50% gain for North America (see Supplementary Table S4). European scholars make up the largest population of mobile scholars in nearly every country, with the exception of Asian countries, where most scholars are drawn from North America (see 'Scientist shuffle').

It is also of interest to know the degree to which certain countries are responsible for the production and cultivation of high-impact scholars. We assess this by looking at citation scores for mobile researchers before and after their moves (see 'Trip adviser').

Countries in North America and Northern Europe act as strong producers: they put into circulation scholars who are well-cited before they move. The same countries are also strong cultivators, identifying talent early and providing fertile ground for scholars to achieve high impact once they arrive. Asian regions are strong recruiters, gaining affiliations with established scholars who were well-cited before their arrival. Oceania is a notable incubator, affiliated with scholars who realize high potential once they move on.

Some migratory routes tend to be associated with highly cited scholars. Those from North America with the highest impact tend to land in Northern and Western Europe and, to a lesser extent, in Southeastern Asia. Mobile, high-impact Northern Europeans are recruited to Southern Europe; mobile, high-impact Western Europeans are recruited to Oceania and Eastern Asia.

Mobile scholars from Oceania produce particularly high-impact work when they arrive in North America and Southern Europe. Central and Western Asian scholars (including those from countries implicated in the US immigration ban) realized their highest citation rates for work done in North

America and Europe. Barring scholars from these countries is likely to displace high-impact ones to other nations.

Regardless of region, mobility pays in terms of citations. Across all regions, mobile scholars are more highly cited than their non-mobile counterparts. The advantage varies by region. Mobile North Americans see only a 10.8% boost in citations over their non-mobile colleagues. For Eastern European scholars, the gulf is 172.8%.

Mobility measures

Of course, our method has limitations. We cannot tell if our 'country of academic origin' represents country of birth, of academic training or of academic employment — it reveals solely where an individual began publishing. If researchers from some countries tend not to publish first in a journal indexed in the Web of Science, then our measures would underestimate mobility from these places. Those we have counted as 'non-mobile' might really be 'pre-mobile' — meaning that they have not yet moved. Furthermore, examining less than a decade of papers, focusing on journal articles and adding restrictions for number of publications may privilege certain disciplines in the analysis. And our study does not look at mobility rates within each country: for large nations such as the United States, these might be significant and interesting.

Internationally comparable mobility indicators for the scientific workforce are particularly necessary in an era in which mobility is growing, complicated and increasingly threatened. We need indicators that provide more nuanced and dynamic assessments of the exchange of human capital and the effect of this exchange on the knowledge economy, particularly given that the 'travellers' in our analysis account for the majority of mobile scholars. This study provides a start.

It might be argued that collaboration can continue, even when mobility is restricted. However, despite advances in computing, collaboration tends to be initiated and sustained through interactions that happen in person[4]. Limiting mobility is likely to have adverse effects on the scientific system, which is

increasingly dependent on international collaboration[5].

Disruption of the existing network would have serious effects on many nations, including large science producers and cultivators such as the United States. The country benefits significantly both from its centrality in the global knowledge network, and from the educational investments of other countries. Its exceptional contributions are disproportionately made by researchers who are both foreign-born and foreign-educated[6]. Disconnection would also seriously affect those nations that benefit from the United States' role as a cultivator — it invests in researchers who come from Asia and elsewhere and later return home.

Some countries may see benefits, however: isolationism among central countries can lead to advantages for other competitive nations. For example, the number of graduate-student applicants to Canada has risen since the change in the US administration (see go.nature.com/2fjc4i). However, if adequate scientific capacity does not exist in these other countries, global talent will not be cultivated to the extent it is today. With good bibliometric standards to measure the impact of mobility, we can test the effects of these political changes in the decades to come.

One thing is already clear. Internationally mobile scholars are in the minority, yet show the highest impact across the globe. Limiting the circulation of scholars will damage the entire scientific system.

Journal name:
Nature
Volume:
550,
Pages:
29–31
Date published:
(05 October 2017)
DOI:
doi:10.1038/550029a

Supplementary information

PDF files

1. Supplementary information (1.6M)

Comments

Comments

There are currently no comments.

Collaborative software development made easy

Save time and protect critical code with 'continuous integration' services.

04 October 2017

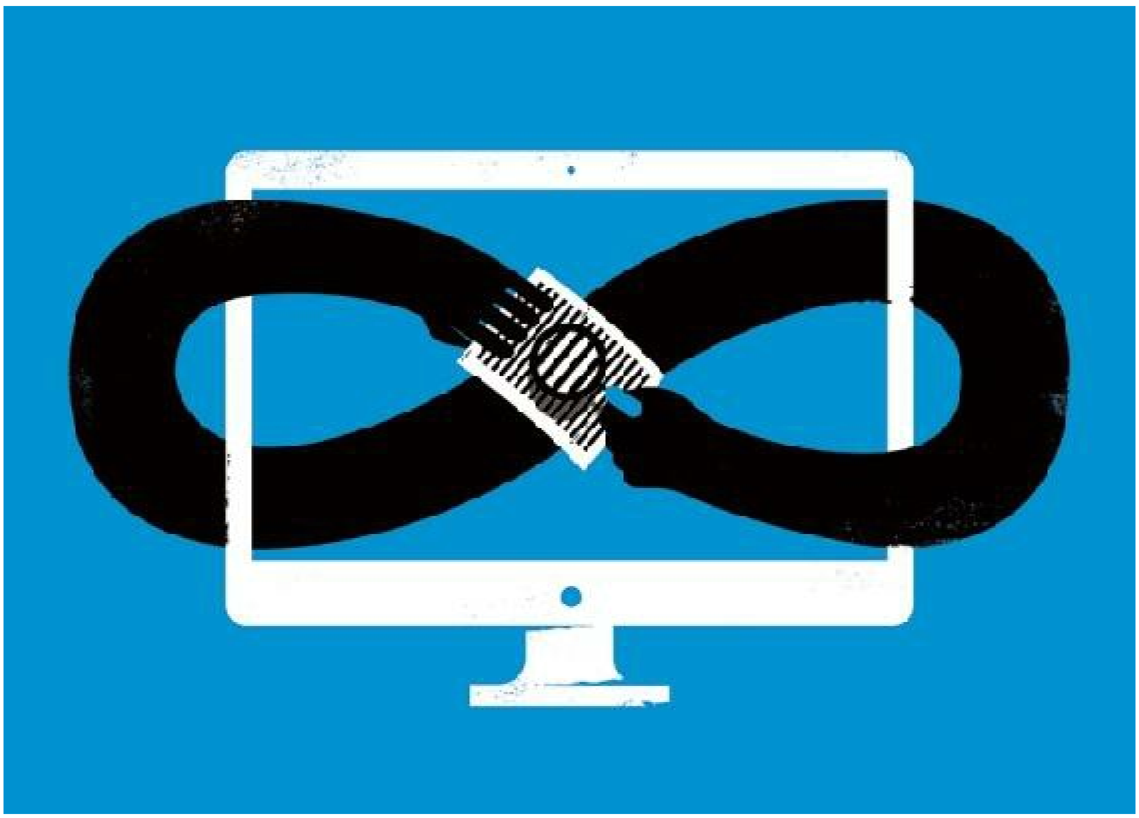


Illustration by the Project Twins

Sebastian Neubert, a particle physicist at Heidelberg University in Germany, leads a group studying subatomic particles called pentaquarks. The six team members all have access to the software code used to run their multi-step analyses, and the programmers update it daily with new features and bug fixes. With each code change, however, they run the risk of introducing

inadvertent errors that foul the underlying algorithms.

To prevent that, the team checks and rechecks the analyses, and uses error-checking algorithms, functions they can call whenever a change is proposed, to ensure that their software works as intended. One test, for example, verifies that a noise-cancelling algorithm gives the correct output when it is run on practice data.

In 2015, in an effort to save time and resources, the team took inspiration from the technology industry, automating their testing using a process called 'continuous integration'.

In continuous integration, changes to software code automatically trigger repetitive tasks, such as error-checking. Fundamentally, the process simplifies a task that diligent coders already perform. Programmers usually write lists of tests that they will run periodically to ensure that their code still works, just as Neubert's team do. But a busy team might forget or lack the time to run them, allowing errors to creep in. Continuous integration automates that process so those checks run whenever a change is proposed, saving team members the time they would spend hunting down an error. A team running genomic analyses could spend more time at the bench, while a group developing climate-prediction software could better refine its models. That said, the resulting peace of mind is only as good as the tests themselves: a poorly designed test can still allow mistakes to pass undetected.

The process is common in the commercial and open-source sectors. A study presented at the 2016 IEEE/ACM International Conference on Automated Software Engineering in Singapore found that about 40% of the 34,544 most-popular open-source projects hosted on the coding collaboration site GitHub used continuous integration in some form.

Only a few of those open-source projects might be considered scientific software, but an increasing number of scientists are looking to continuous integration to automate all sorts of time-consuming tasks, from testing code to updating documents with the latest data.

Researchers at institutions such as CERN, Europe's particle-accelerator laboratory near Geneva, Switzerland; the Pacific Northwest National

Laboratory in Richland, Washington; and the Ontario Institute for Cancer Research in Toronto, Canada, have embraced the practice, but adoption in the scientific sector remains relatively sparse.

For Neubert, continuous integration ensures that the pipeline's behaviour remains correct and consistent as his team refines its code, providing an “incredibly valuable” safeguard. “There is a real danger of just missing something or making a slight mistake,” he says.

Exceptions

A variety of continuous integration services exist. These include the open-source Drone, and commercial options such as CircleCI, Codeship, GitLab, Shippable and Travis CI, all of which offer pricing tiers based on the desired testing behaviour, number of users and whether the project is public or private. Travis CI, for instance, is free for open-source projects; private projects cost from US$69 per month. Shippable offers a free basic service for public projects, but charges $25–150 per month for support for private projects and greater computing power, among other features.

Researchers should consider what is a suitable and worthwhile investment, however. Not every project needs continuous integration and setting up and configuring a service can be challenging. Further difficulties can arise if the services need to interact with software or data with legal restrictions on its use, says Daniel Himmelstein, a data-science postdoc at the University of Pennsylvania in Philadelphia.

Also, code is often used only once, making the cost even less worthwhile. “For day-to-day research coding, the amount of code is not large enough to make continuous integration valuable,” says Andrea Zonca, a specialist in high-performance computing at the University of California, San Diego. He uses Travis CI when publishing code, but most that he writes is for his own one-time use and is not executed again.

Computing costs can also mount if code is being constantly updated and requires repeated testing, which is why Neubert's lab only tests its most

critical data analyses after code changes.

Despite these challenges, continuous integration services tend to improve code quality, says Björn Grüning, a bioinformatician at the University of Freiburg in Germany, especially on large projects such as Galaxy, a bioinformatics toolkit that Grüning, along with about 160 others, contributes to.

According to Grüning, continuous integration has shortened the turnaround time for approving contributions to the Galaxy project and given programmers more confidence when submitting new features and fixes. Before these services were available, it was often impractical for researchers in such projects to test every new feature collaborators proposed because they didn't have the time, he says.

Some researchers use continuous integration to automate non-programming tasks. In April, as part of a project studying how ecosystems change over time, Ethan White, an ecologist at the University of Florida in Gainesville, helped to configure Travis CI to update tables and plots automatically with new field or weather-station data, saving the research team up to 5 hours a month.

Continuous integration helps Himmelstein automate revisions to scientific papers, citations and web pages following text or code updates. Without continuous integration, he says, human maintainers would probably “get lazy and update the manuscript less frequently than every change”.

Initializing

Whether hosted externally by a third party or on a user's own machine, the continuous integration service is controlled with a custom set of instructions. This configuration file defines the tasks to be run and sets up the server with the correct environment — the operating system and software libraries — required to run them. The service then executes those instructions at set times or on receipt of a code or data update.

University of Pennsylvania bioinformatician Casey Greene, who uses

continuous integration to rerun his data analyses, has tested many of today's most popular services. “The good news about all of these services is that they're quite similar,” he says.

Subtle differences do exist, for instance in the number of concurrent jobs users can run, or the amount of computing power available to run them. “I'd encourage people to dig into the limits of each service to make sure they are compatible with their workflows,” advises Greene.

Although continuous integration adoption in science right now is small, it is growing, and more researchers should get on board, Greene says. Getting up to speed takes time, he acknowledges, but often, the effort is worth the reward. “Scientists analysing data should have it in their toolbox.”

Journal name:
Nature
Volume:
550,
Pages:
143–144
Date published:
(05 October 2017)
DOI:
doi:10.1038/550143a

Comments

Comments

There are currently no comments.

A taste of Toolbox

Nature's technology editor, Jeffrey Perkel, started blogging about workplace technology in science in 2016. Here are some highlights.

04 October 2017

From stadiums to genomes

Most bioinformaticians are either biologists skilled in programming or programmers with an interest in biology. Mike Goodstadt, the programmer behind the 3D genome-visualization tool TADkit, took a different approach. In the early-to-mid 1990s, Goodstadt was a student at the University of Bath, UK. His course of study? Architecture, with an emphasis on 3D modelling. After graduation, he helped to design and build a 61,500-seat stadium. But a faltering economy and newly acquired programming skills helped to steer him towards biology.

Lorena Barba, reproducibility champion

Lorena Barba, a mechanical and aerospace engineer at George Washington University in Washington DC, has long championed research reproducibility. “I've always believed that the open-source model is ideal for science, as it exposes the complete sequence of steps that produces a given result,” she says. In January, she travelled to Chile to run a week-long course on reproducible research computing. The month before, she had been awarded a 2016 Leamer-Rosenthal Prize, which celebrates those “working to forward the values of openness and transparency in research”. In this Q&A;, she talks flying snakes, 'repro-packs' and copyright.

The sound of DNA

With an alphabet comprising just four letters, a DNA sequence isn't much to look at. So when sequence-analysis tools want to highlight key elements, they typically do so using colour or font, or by overlaying other types of information. In the not-too-distant future, there may be another option. Molecular biologist and part-time drummer Mark Temple at Western Sydney University, Australia, describes DNA sonification, "an auditory display tool" for DNA: sequence in, audio out. "I'm not saying audio by itself is the bees' knees for interpreting DNA sequence," Temple says, "but surely audio can contribute to your visual interpretation."

Journal name:
Nature
Volume:
550,
Pages:
144
Date published:
(05 October 2017)
DOI:
doi:10.1038/550144a

Comments

Comments

There are currently no comments.

South Korea cracks down on dirty air

Despite huge clean-up effort, scientists say country’s pollution problem could get worse over next five years.

03 October 2017

Ed Jones/AFP/Getty

South Korea's capital, Seoul, ranks among the world's most polluted cities.

In a major attempt to clean its increasingly dirty air, South Korea’s government last week unveiled a five-year, 7.2 trillion won ($6.3 billion) plan to close down old coal plants, get diesel vehicles off the road and curb polluting emissions from industrial plants, construction sites and ships.

Although much of the spending had already been pledged, researchers say that the new strategy, announced on 26 September, is the country's most ambitious attempt yet to scrub its air. But because it omits controls on a class of chemicals called volatile organic compounds (VOCs), the initiative might make air quality worse before it improves.

The plan fulfils a key campaign pledge by President Moon Jae-in, who was elected in May by a Korean public increasingly concerned about their country's worsening air quality. At times this year, Seoul ranked among the world's top three most polluted cities. And the Organisation for Economic Co-operation and Development (OECD), based in Paris, reports that in 2015 South Korea's average exposure to fine-dust particles under 2.5 micrometres in size was the highest of all OECD member nations. This particulate matter, known as PM2.5, is small enough to enter the lungs and can cause respiratory illnesses.

The government hopes to cut domestic emissions of PM2.5 by 30% before 2022. Moon's administration has already focused on shutting down coal plants, temporarily closing eight of them in June and beginning the permanent shutdown of three in July. And the previous administration of Park Gyun-Hye had pledged 5 trillion won by 2020 to speed the adoption of electric cars to replace diesels.

NOx-ious crackdown

But the new strategy also aims to crack down on emissions of nitrogen oxides (NOx), which can react with other atmospheric compounds, including VOCs, sulfides and ammonia, to form ozone and fine-dust particles. Large industrial facilities such as steel plants and petroleum refineries will be fitted with monitoring equipment and held to a cap on their NOx emissions starting in 2019, the environment ministry's deputy director JaeHyun Kim says.

That approach has been informed in part by data released in July from a joint US–South Korean study called KORUS-AQ[1], says Kim. The most comprehensive examination of air quality in the region, it involved more than 580 researchers from the United States and South Korea, as well as several

research aircraft, including a NASA DC-8 jet that flew across the Korean peninsula and the Yellow Sea. Researchers found that South Korea was emitting more NOx and VOCs than its own ministry estimated, and recommended reductions in these chemicals. This highlighted the importance of addressing South Korea's domestic pollution, says Kim, at a time when many in the country were more concerned about pollution blowing over from China.

The focus on NOx means the new plan is "a lot better than before", says Kyung-Eun Min, an atmospheric chemist at the Gwangju Institute of Science and Technology. But she and other scientists point out that it says little about curbing VOCs. These are typically aromatic molecules produced for activities such as painting, printing and dry cleaning. A compound called toluene, used to manufacture solvents, is particularly instrumental in producing fine dust and ozone, the KORUS-AQ study found. The VOCs often leak during production, or while being stored or used by small businesses.

Ozone up?

Paradoxically, Min says, reducing NOx without reducing VOCs is likely to increase ozone across much of South Korea. That is because, according to the KORUS-AQ results and Min's own work, relative levels of NOx are so high in Korea — especially in car-filled Seoul — that they restrict the efficiency of ozone production, much as an over-rich fuel mixture makes an engine sputter. The quickest way to cut ozone is to starve it of both NOx and VOCs, "but the VOC part is not really there," Min says. However, regions downwind of Seoul may benefit more quickly from NOx reductions, says Rokjin Park, an air chemist at Seoul National University.

Tracking VOC emissions is particularly difficult, because there is no clear way to monitor or regulate small businesses such as painters and dry cleaners. A first step would be to collect data to nail down where South Korea's VOCs are coming from, Min says. In the longer term, she suggests developing technology that can capture dirty air from such emissions sites so that it can be purified at treatment facilities — in a process analogous to sewage treatment.

Yong Pyo Kim, an environmental scientist at Ewha Womans University in Seoul and an author of the KORUS-AQ report, says he thinks that both ozone and fine dust could get worse for the next five years. “In my opinion, the environment ministry did not learn from the KORUS-AQ results seriously,” he says. The South Korean environment ministry has not responded to requests for comment from *Nature* about the criticisms.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22448

Comments

Comments

There are currently no comments.

Xenon view, butterfly wings and a strange squid

September's sharpest science shots, selected by *Nature*'s photo team.

03 October 2017

CRISPR catches

Richard Wallbank/Smithsonian Institution and University of Cambridge

The beauty of butterfly wings owes much to just two genes, researchers revealed this month. They used the CRISPR gene-editing system to turn off the genes, called *WntA* and *optix*, to show how their absence dulls the colours

of these fleeting flyers. Left are the wings of an unmodified Sara longwing (*Heliconius sara sara*) from the study; right is a gene-edited version.

Inside Xenon

Image Slideshow

1. 

   Winner of a gold award in the 2017 International Images for Science competition, this picture by Enrico Sacchetti shows the interior of the Xenon1T experiment at Italy's Gran Sasso Laboratory, which hunts for dark matter.

   Enrico Sacchetti/Royal Photographic Society

2. 

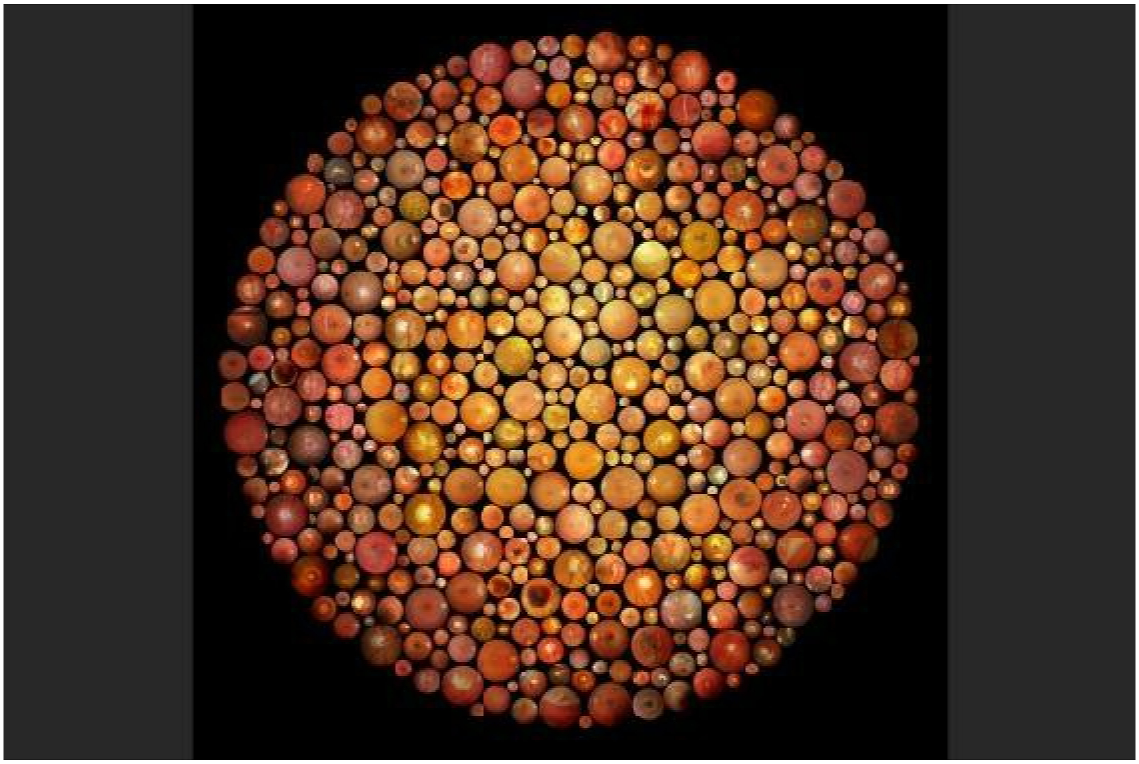
Another gold-award winner, this one taken by Teresa Zgoda. What looks like a frightening visage is actually a close-up of a pork tapeworm (*Taenia solium*), showing in detail the suckers that allow it to stick to the inside of humans and grow — and grow, and grow.

Teresa Zgoda /Royal Photographic Society

3. 

These legs belong to impalas (*Aepyceros melampus*); the black patches are glands used for scent marking. This image from Morgan Trimble won a bronze award in this year’s competition.

Morgan Trimble/Royal Photographic Society

4. 

This shot is a combination of hundreds of images of retinas shot by Jonathan Brett, and assembled to mimic a colour-vision test chart. The eyes took a silver award.

Jonathan Brett/Royal Photographic Society

Coming down…

Bill Ingalls/NASA

At the start of the month, this Soyuz capsule brought back three astronauts to Earth, landing near Zhezkazgan in Kazakhstan. Among them was Peggy Whitson, who spent 288 days in space aboard the International Space Station.

… and going up

Bill Ingalls/NASA

Ten days after Whitson and her colleagues returned to this planet, another three people left it when this Soyuz left for the space station from Baikonur Cosmodrome.

A complex cloud

Artem Mironov

This nebula — called the Rho Ophiuchi cloud complex — is 140 parsecs (460 light years) from Earth. Photographer Artem Mironov took three nights to capture this image of it, which went on to win this year’s Insight Astronomy Photographer of the Year award.

Seamount squid

NOAA Office of Ocean Exploration and Research

On 17 September, the crew of the US National Oceanic and Atmospheric Administration's ship *Okeanos Explorer* were exploring the Musicians Seamounts, a formation of undersea mountains in the Pacific Ocean, with remotely operated submersibles when they spotted this cranchiid squid. You can see more pictures of weird and wonderful deep-sea denizens on their diary site.

Bee bounty

Image Slideshow

1. 

The USGS Bee Inventory and Monitoring Lab in Laurel, Maryland has long been among our favourite purveyors of online insect images. Among the latest additions to its catalogue is this *Hoplitis fulgida*.

Anders Croft/USGS Bee Inventory and Monitoring Lab

2. 

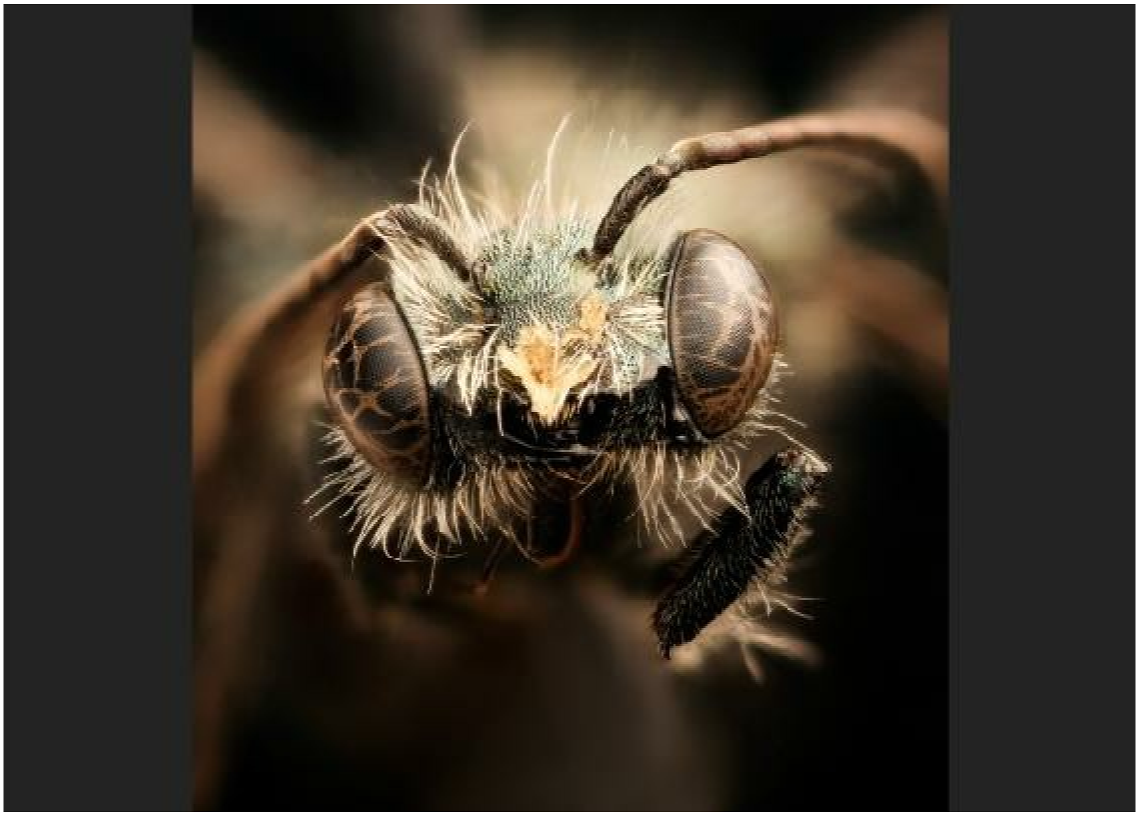
Another shot of *H. fulgida*, collected in Yosemite National Park, California.

USGS Bee Inventory and Monitoring Lab

3. 

Dianthidium singulare glues rocks together to make little houses for its eggs. The lab calls it a “boss looking bee”, and it’s hard to disagree.

USGS Bee Inventory and Monitoring Lab

4. 

The lab says this mason bee *Osmia subarctica* is a terrible specimen, but it has photographed beautifully.

USGS Bee Inventory and Monitoring Lab

Cassini comedown

NASA/Joel Kowsky

It is finally over. The Cassini mission this month dived into Saturn’s atmosphere, destroying itself. In this photo, Cassini programme manager Earl Maize packs up his workspace at mission control in the Jet Propulsion Laboratory in Pasadena, California. on 15 September.

They grow up so fast

Online Tracking of Arabidopsis Root

Arabidopsis thaliana, or thale cress, is widely used as a model organism in labs. Daniel von Wangenheim of the Institute of Science and Technology Austria in Klosterneuburg won first place in the Nikon Small World in Motion Photomicrography Competition for this remarkable time-lapse video of the root tip of one *A. thaliana* plant growing.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22741

Comments

Comments

There are currently no comments.

Europe’s Joint Research Centre, although improving, must think bigger

External report criticizes lack of exploratory research.

03 October 2017

Sean Gallup/Getty

Europe’s Joint Research Centre first raised awkward questions about diesel car emissions.

The European Union’s Joint Research Centre (JRC) uses the label EU Science Hub now. Whether the rebranding will increase its profile is one

question. What science gets done inside this hub is another. In response to that query, there is some positive news. It is doing what it should be, and doing it well: collecting scientific and technical evidence in support of EU policies. That's according to the [report of an external evaluation] released this week. Furthermore, EU research commissioner Carlos Moedas praised the JRC at its annual public meeting on 26 September for contributing to the interminable struggle to counter false information and communicate science effectively to a sceptical public.

The JRC employs more than 2,000 scientists, who generate or collate a constant feed of information for authorities and politicians. In theory, this helps to support evidence-based policies — from the old chestnuts of genetically modified (GM) crops and nuclear safety to the ongoing refugee crisis, for which it holds a repository of relevant information and reliable statistics. Yet most of this work fails to reach public attention. For example, staff in the JRC transport section had worked out and published evidence that car makers were manipulating diesel-emission data years before the public scandal over Volkswagen finally broke in 2015.

The JRC celebrates its 60th anniversary this year. It has become a complex beast, operating at six sites in five EU countries, with a budget this year of €372 million (US$437 million). It was originally set up as a nuclear research organization, but widened its remit over the decades, adding institutes. Twenty years ago, it morphed into a centre with an explicit mission to provide support for a wide range of EU policies. But by that time it had lost its way, and tough reforms were introduced. A 2009 evaluation led by former UK government science adviser David King concluded that it was carrying out its new remit well, but criticized it for doing too little independent research of the type required to attract and keep the best scientists.

The new report, headed by the former Irish government science adviser Patrick Cunningham, echoes this call. It acknowledges how rapidly the centre has broken out of its much-criticized institute-based silos to restructure thematically into cross-site departments, such as energy and health, which more directly mirror policy areas. It also notes that the JRC has significantly increased its presence in the world's top-cited literature. But it says that the centre still does too little exploratory research — such research engages only

3.5% of JRC staff, well below the target of 10% that it set itself in 2015.

Why has it struggled? Although it has established partnerships with European universities and research institutes, and aided the exchange of scientists, many JRC researchers have different motivations from those of colleagues in universities. There is much satisfaction in contributing to policies that influence the lives of people in the EU. But officials and staff must look again at their priorities. As well as keeping the JRC relevant, a wider focus on the cutting edge would allow it to flag up hot topics to policymakers earlier.

But what policymakers do with the information they receive from their science service is another matter entirely. EU policy on GM crops is notoriously weak — scientific evidence for their safety has failed to convince some countries, whose citizens viscerally reject the technology. And sometimes the EU's intrinsic political weakness can block the implementation of its science-based policies. After all, the European Commission and EU member states ignored the findings on diesel emissions, and acted only after regulators in the United States cracked down.

Journal name:
Nature
Volume:
550,
Pages:
8
Date published:
(05 October 2017)
DOI:
doi:10.1038/550008a

Comments

Comments

There are currently no comments.

Bill & Melinda Gates Foundation

Make plans to eliminate cholera outbreaks

Governments must stop denying the occurrence of cholera and unite in long-term prevention strategies, says Anita Zaidi[1].

03 October 2017

As a medical student in Karachi in the 1980s, I saw cholera all the time. We had a dedicated diarrhoea ward in the hospital, and if there was an increase in diarrhoea cases in children aged over 3, we knew we had a cholera outbreak. Over the past decades, the world has become much better equipped to fight cholera, yet the disease continues to spread across sub-Saharan Africa, Asia and the Caribbean.

In Yemen, cholera has killed more than 2,000 people and infected nearly 700,000 in the past 5 months alone, eclipsing the post-earthquake outbreak in Haiti. Haiti still battles with the disease 7 years after its reintroduction. Meanwhile, Somalia is experiencing its worst outbreak in five years. South Sudan continues to fight its worst outbreak since it gained independence in

2011. If nothing changes, cholera will continue to claim some 100,000 lives a year and afflict around 3 million people, many of them children.

This week, the World Health Organization (WHO) launches a campaign to eliminate cholera outbreaks by 2030. The plan could move countries beyond ad hoc reactions, to sustainable prevention.

The disease is caused by the bacterium *Vibrio cholerae* and spreads mainly through contaminated water. Infection usually causes no or mild symptoms, but in approximately one-tenth of cases it swiftly leads to watery diarrhoea, vomiting and cramps. Rapid loss of fluid can result in dehydration and death within hours. An oral rehydration solution that costs cents can reduce fatality from a high of 50% to under 1%. Every year, it still fails to reach tens of thousands of victims in time.

Clean water, improved sanitation and better access to treatment have been game-changing for much of the world, but cholera is still thought to be endemic in 69 countries, including most of sub-Saharan Africa.

In the twenty-first century, no one should die from this disease. We have treatments and prevention strategies that work, including sufficient cholera-vaccine stocks. We know where outbreaks are most likely to start. To spread, cholera needs estuaries, rivers or coastal waters that are contaminated with faeces, and susceptible people living nearby; it has clear patterns of recurrence. What we need to do is get there first.

What's stopping us? One barrier is stigma. Many national and regional governments don't want to admit that their territory harbours cholera. Rather than controlling it, they hide it. The stigma goes back hundreds of years, to when ships with sick passengers were not allowed to dock and people feared being put in quarantine. Now the fears are public anger and loss of economic opportunities. Many countries with known endemic cholera in Asia and Africa report to the WHO that they have no cases, and in the face of an outbreak do not request cholera vaccines. In 2010, during the massive floods in Pakistan, my colleagues and I saw hundreds of cases of acute watery diarrhoea in Sindh that we confirmed to be cholera in our laboratory, but national health officials told us to keep it quiet.

Too many countries act only after a crisis has emerged: then they request vaccine campaigns, set up makeshift cholera clinics and urgently mobilize supplies.

These tactics can quell an outbreak and dampen transmission in the short term, but they don't stop outbreaks from happening again. For that, governments must intervene preemptively to control cholera in places where it recurs frequently. Since the WHO cholera-vaccine stockpile was established in 2013, almost 13 million doses have been delivered. Millions more doses should have been requested.

To truly stop cholera outbreaks, countries must do two things: deploy vaccines where cholera is endemic and strengthen the infrastructure that provides clean water and good sanitation.

Events in Malawi give reason for optimism. In April this year, the country adopted a national plan to control and prevent cholera that directs vaccines to affected communities identified by geo-spatial mapping. More than 2 million citizens have been vaccinated ad hoc since 2015. The new plan, made possible by strong political commitment at the Ministry of Health, collates two decades' worth of information to better estimate cholera burden, identify hotspots and support early intervention. At the same time, Malawi is planning to strengthen water and sanitation infrastructure. Experts are hopeful that this will reduce the country's cholera burden to its lowest level in years.

Similarly, the WHO Global Task Force on Cholera Control is launching a renewed strategy to eliminate cholera outbreaks worldwide. Unlike past efforts, this plan goes beyond responding to cholera flare-ups: it encourages countries to invest in protecting people from cholera over the short and long term.

The success of the WHO's plan ultimately depends on the commitment of governments worldwide. All governments, whether or not they are directly affected by cholera, must unite and increase their political and financial investment in cholera prevention and control.

The first cholera pandemic, in 1817, swept across South Asia, East Africa, the Middle East and Europe, claiming hundreds of thousands of lives. Back

then, we had no vaccine and a limited understanding of transmission. It is unacceptable that, now, in that pandemic’s 200th anniversary year, a disease we know how to fight remains out of control.

Journal name:
Nature
Volume:
550,
Pages:
9
Date published:
(05 October 2017)
DOI:
doi:10.1038/550009a

Comments

Comments

There are currently no comments.

Ethics of Internet research trigger scrutiny

Concern over the use of public data spurs guideline update.

03 October 2017

Matt Cardy/Getty

A Banksy artwork in Cheltenham, UK. Scientists tried to find the artist's true identity using public data.

British graffiti artist Banksy is renowned for his anonymity. But that status was dented last year when researchers published a paper that cross-referenced the locations of Banksy's street art with public information about people's

addresses and likely movements ([M. V. Hauge *et al. J. Spatial Sci.* **61,** 185–190; 2016]). The team, led by academics at Queen Mary University of London, concluded that someone previously suspected to be Banksy probably was the secretive artist.

Because the study used public data, a university ethics committee said that the work was exempt from formal review — and informally advised academics that it would do no harm because a UK national newspaper had already identified the person in question as Banksy. But for some ethicists, the paper highlights growing concerns about the potential hazards of research that uses public data. “I think this study should never have been done,” says Jake Metcalf, a technology ethicist at the think tank Data & Society in New York City.

Metcalf is one of several academics calling for new guidelines to steer scientists through ethical quandaries in Internet research. The unprecedented availability of online data — together with tools to draw patterns from it, such as machine learning — is opening up research possibilities that outpace existing ethics frameworks around privacy, consent and harm, says Charles Ess, a research ethicist at the University of Oslo and a member of the Association of Internet Researchers. The association will discuss how to update its guidelines at its annual meeting on 19 October in Tartu, Estonia.

A flurry of similar initiatives is under way. Earlier this year, the SATORI project, funded by the European Commission, published recommendations on Internet research as part of an effort to standardize and update research-ethics guidelines. In September, the US National Science Foundation funded a US$3-million, 4-year study called PERVADE — of which Metcalf is a part — that aims to chart attitudes to data-research ethics, produce best-practice guidelines and create tools to assess the potential harms of such work. And some British universities are preparing their first guidelines on the ethics of Internet research, after the UK Research Integrity Office, a national advisory body, published non-binding recommendations about it last December.

Common themes among these efforts include rethinking what counts as ‘public’ data, the ethical use of social media and the need to consider a study’s potential harm to wider society, as well as to individuals. Many

countries have long-standing ethical checks for research that intervenes in human lives. But those principles, set up for medical and psychological studies, apply to research on human subjects, the definition of which often excludes Internet research, says Metcalf.

In the United States, for instance, studies using public data (which includes that purchased from a third party) generally do not count as human-subjects research because they don't access private, identifiable information about people. They don't need to be checked by an institutional review board (IRB) or require informed consent. Guidelines issued in 2013 add that researchers should sometimes consider seeking review — if a person incorrectly assumed that access to his or her public information was restricted, for example. But IRBs have no obligation to adopt these proposals, and different committees may come to different verdicts, says Metcalf.

Peter Hedges, head of the research-operations office at the University of Cambridge, UK, argues that even researchers who use information that is undeniably public, such as Twitter data, should review the ethics of their work. The SATORI guidelines advise that regulators and researchers should carefully consider whether publicly available information is actually private, and not fall back on simple classifications.

If someone's data are considered private and identifiable, that would usually mean obtaining their informed consent. But, in practice, such consent is often impossible to acquire for large-scale data studies, says Ess. And anonymizing data is difficult, because search engines can easily identify individuals from even small snippets of anonymized text or by cross-referencing them in multiple data sources. The SATORI guidelines recommend that researchers take precautions to ensure the anonymity of study participants, and Ess suggests that scientists can still, without too much effort, seek consent from anyone they explicitly quote in research papers.

When ethics committees do assess data studies, their viewpoint might be too narrow, says Ansgar Koene, an engineer and ethicist at the University of Nottingham, UK. They tend to consider the direct damage to an individual involved in research, rather than a project's potential to do widespread harm to society. That debate flared up in September when artificial-intelligence researchers at Stanford University in California posted a preprint of research

that predicted whether someone is gay from their photo; it used pictures sourced from an online dating site (see https://osf.io/zn79k). The study was approved by Stanford's IRB, but provoked condemnation from some advocacy groups for lesbian, gay, bisexual, transgender and queer (LGBTQ) people, which branded it dangerous. The study's lead author, Michal Kosinski, said the work aimed to protect people by exposing an existing threat from widely used technology. Kosinski and his colleague, Yilun Wang, discussed their results afterwards with representatives of the LGBTQ community, but Koene says that the discussion should have happened beforehand and the paper should have addressed their comments.

Computer science is a flashpoint for Internet-research ethics. Researchers in this field are not used to working with human study participants and often don't consider the ethical impact of their work, says Koene, who has surveyed approaches to ethics in different disciplines. A major concern, academics agree, is how companies use online data for research — much of which they have proprietary access to. In 2014, for example, Facebook altered users' newsfeeds without telling them, to study how this affected their emotions. A public backlash prompted Facebook to publish some details of its internal review process (M. Jackman and L. Kanerva *Wash. Lee Law Rev. Online* **72,** 442; 2016) — but there is little transparency overall about how this works, says Koene.

Researchers may not want to see their science slowed by formal ethical review, which can be time-consuming and opaque. Better ethics training is one solution, says Koene. But a failure to align data science with public perceptions of what is acceptable could generate a severe reaction, he warns. "The public will see us as no different from corporate or other special-interest groups pursuing a hidden agenda," he says.

Journal name:
Nature
Volume:
550,
Pages:
16–17
Date published:

(05 October 2017)
DOI:
doi:10.1038/550016a

Comments

Commenting is currently unavailable.

Gravitational wave detection wins physics Nobel

Rainer Weiss, Barry Barish and Kip Thorne share the 2017 prize for their work at LIGO to detect ripples in space-time.

03 October 2017

Left: Bryce Vickmark/MIT. Centre: Caltech. Right: Caltech Alumni Assoc.

Rainer Weiss (left), Barry Barish (centre), and Kip Thorne (right), who led work to detect gravitational waves.

Three physicists who had leading roles in the first direct detection of gravitational waves have won the 2017 Nobel Prize in Physics.

Rainer Weiss, at the Massachusetts Institute of Technology (MIT) in Cambridge and Barry Barish and Kip Thorne, both at the California Institute

of Technology in Pasadena, share the 9 million Swedish krona (US$1.1-million) award for their work at the US-based Laser Interferometer Gravitational-Wave Observatory (LIGO). In September 2015, LIGO picked up the deformations in space-time caused by the collision of two distant black holes.

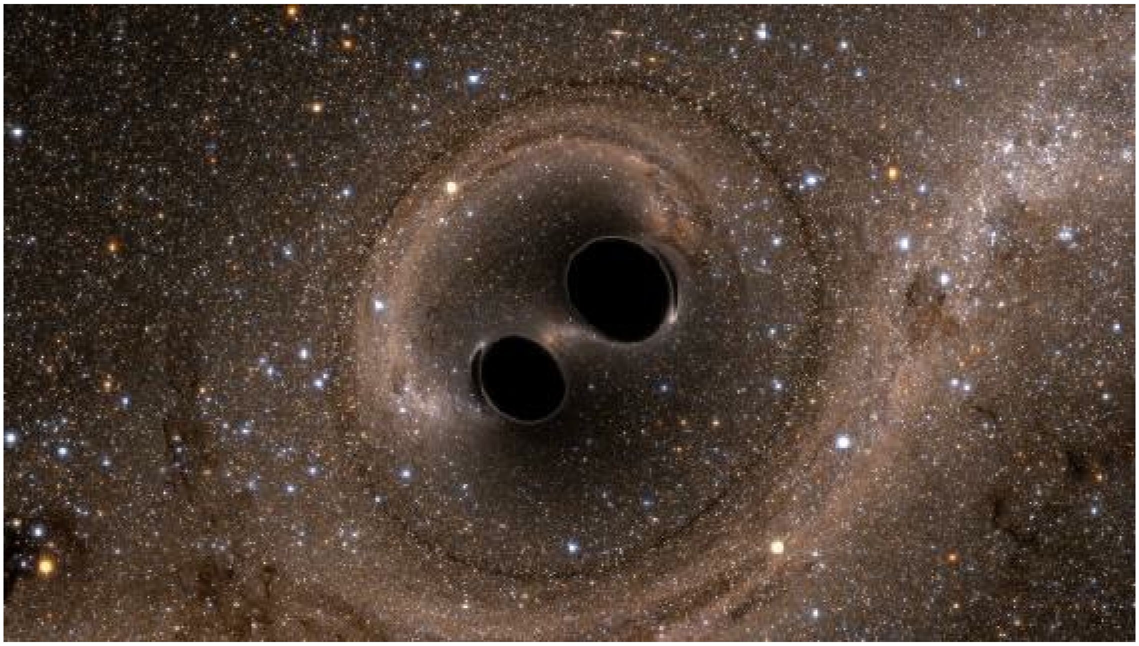
That discovery, which was announced in February 2016, opened up a new field of astronomy, in which scientists listen to the space-time vibrations emitted by some of the Universe’s most cataclysmic events. And it confirmed the existence of gravitational waves, which Albert Einstein had predicted a century before.

Weiss and Thorne are two of three physicists known as the Troika — the founders of LIGO’s giant twin detectors in Livingston, Louisiana, and in Hanford, Washington. The third troika member, Ronald Drever, died on 7 March this year. And Barish, who was LIGO director from 1997 to 2005, is widely credited with having transformed the collaboration from a chaotic endeavour to a well-oiled machine.

"I view this more as a thing that recognizes the work of about 1,000 people, a really dedicated effort that’s been going on for — I hate to tell you — as long as 40 years," said Weiss in an interview with the Nobel Committee just after winning the prize.

"We were all very happy for them to be recognized. They worked on this for decades," says Gabriela Gonzalez, a physicist at Louisiana State University in Baton Rouge, and a LIGO team member and former spokesperson for the collaboration. The Nobel prize can be awarded only to a maximum of three people, but the Nobel Committee noted the huge numbers of people who worked on LIGO in its press release.

Researchers had been widely expecting the committee to reward the team since last year's detection announcement. "I'm very happy that they got the right people," says Charles Misner, a general relativity theorist at the University of Maryland in College Park. Half of the Nobel prize has been awarded to Weiss, with the other half split between Barish and Thorne.



The SXS Project

A computer simulation of two black holes colliding, which generates gravitational waves.

Unimpeded motion

Few physicists doubted the existence of gravitational waves before the LIGO discovery. The distortions in space-time are an inevitable consequence of Einstein’s general theory of relativity, and propagate across the Universe almost unimpeded. In 1974, they were confirmed indirectly when researchers examined the radio flashes emitted by a pair of merging neutron stars; the shifts in the flashes' timing matched predictions of how gravitational waves would carry energy away from the event. That discovery was rewarded with the 1993 Nobel Prize in Physics.

But sensing the waves themselves was a monumental task. Even the most powerful deformations — those produced by collapsing stars or colliding black holes — would typically be tiny by the time they reached Earth. The waves detected in 2015 stretched and squeezed LIGO’s perpendicular 4-kilometre vacuum pipes by a fraction of a proton’s width, but that was

enough to noticeably shift out of sync the laser beams bouncing inside the pipes.

Physicists in the United States and the then-Soviet Union first proposed using laser interferometers to detect gravitational waves in the 1960s. Weiss made the first detailed calculations for how an interferometer would work in 1972. The idea seemed so far-fetched that even he was not sure it would work. “It might come to a junction in a year or so when we will decide it ain’t worth it,” he told science sociologist Harry Collins at the time[1].

Weiss, who was born in Germany in 1932, emigrated with his family to the United States in 1938 to escape from Nazism. He built his first prototype interferometer in the mid-1970s, soon followed by researchers in Europe — among them, Drever and his collaborators at the University of Glasgow, UK, and another group in Munich, Germany.

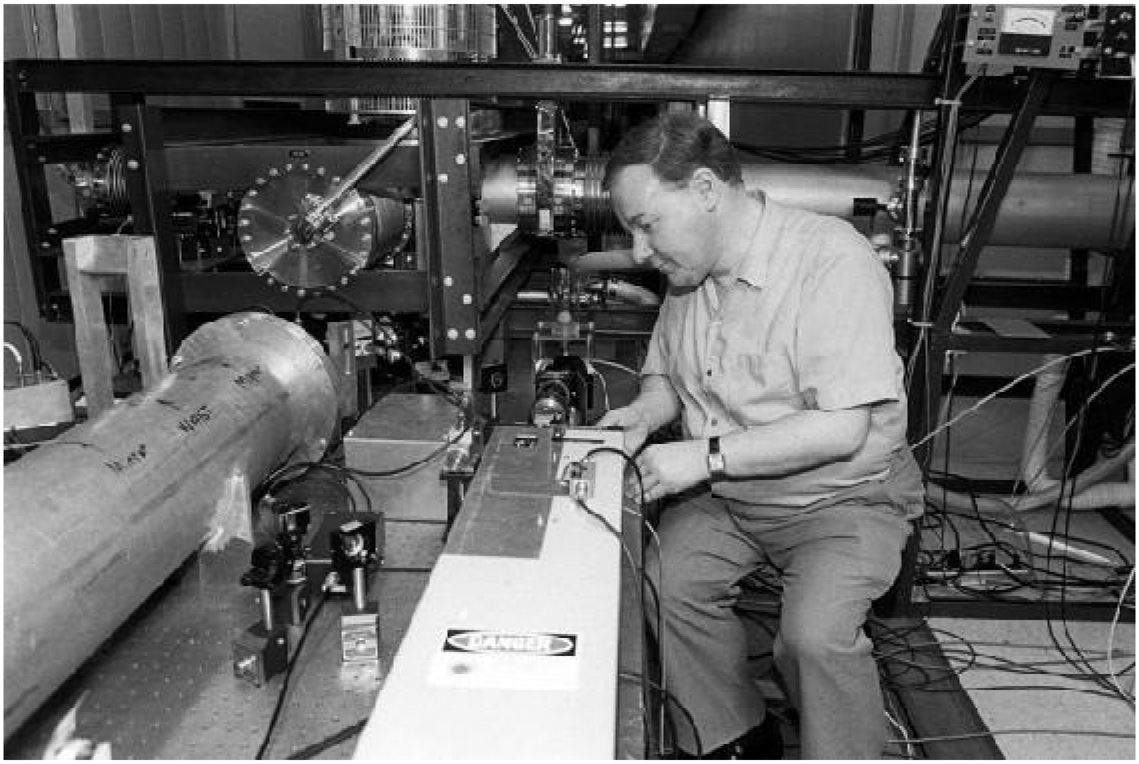
Thorne, born in Utah in 1940 to Mormon parents, specialized in general relativity and had also been developing ideas on the waves. At a conference in Washington DC in 1975, Thorne and Weiss shared a room in an over-booked hotel. During their conversations, Weiss convinced Thorne that interferometers were the right approach. Thorne, Weiss and Drever joined forces in the early 1980s, when it became clear that the US National Science Foundation would not fund two separate efforts, and the LIGO collaboration was born.

Dramatic turn-around

The troika did not always work smoothly and, at their own admission, did not possess the right skills for managing what was quickly becoming a vast operation. Things improved dramatically after Barish, who had been LIGO’s principal investigator since 1994, became director in 1997. Collins, who has closely studied the collaboration for decades, says that Barish turned LIGO into a ‘big science’ organization. “Without Barish turning things around, it would have collapsed,” he says.

LIGO initially struggled to get funded, but ended up being the largest and

most expensive experiment in the history of the US National Science Foundation. Its two nearly identical detectors first opened in 2002, with an admittedly scant chance of detecting anything during their first phase of data collection. The observatory shut down in 2010 for a major overhaul, and restarted in September 2015, three times more sensitive than before.



Bob Paz/Caltech Archives

Ronald Drever was one of the original co-founders of the LIGO project; he died in March 2017.

Researchers were cautiously optimistic of a discovery within a few years. But the Universe was kind to LIGO, providing a dramatic event for it to record on 14 September, while the interferometers were still being calibrated, days before their official science run was due to start. Since then, LIGO has detected at least three other gravitational-wave events — the most recent also spotted by Virgo, a similar interferometer near Pisa, Italy.

The LIGO team benefited from significant research efforts in other countries.

Germany and the United Kingdom have contributed funding and research, and GEO600, a smaller interferometer near Hannover, Germany, is the main test-bed for technologies that are implemented on its larger cousins in the United States.

The three winners have other strings to their bows: as well as working on LIGO, Weiss was a leading scientist in the Cosmic Background Explorer (COBE), a NASA probe that in the 1990s produced the first map of the cosmic microwave background, the 'afterglow' of the Big Bang. (Two other COBE researchers shared the physics Nobel in 2006.)

Thorne, who has spearheaded theoretical studies of gravitational waves, also helped to conceive the original idea for the plot of the 2014 film *Interstellar*, on which he was an executive producer. And before joining LIGO, Barish worked on neutrino experiments at the Fermi National Laboratory in Batavia, Illinois and elsewhere. He has also led the design of a proposed International Linear Collider.

Thorne and Weiss were generally considered shoo-ins for the Nobel. Before Drever's passing last March, the troika raked up almost every prize there was for them to win, including the $3-million Special Breakthrough Prize in Fundamental Physics; the $500,000 Gruber Foundation Cosmology Prize; the $1.2-million Shaw Prize in Astronomy; and the $1-million Kavli Prize in Astrophysics.

Journal name:
Nature
Volume:
550,
Pages:
19
Date published:
(05 October 2017)
DOI:
doi:10.1038/nature.2017.22737

Comments

Commenting is currently unavailable.

Risk of human-triggered earthquakes laid out in biggest-ever database

Geologists track hundreds of quakes caused by people and the projects that set them off.

02 October 2017

Chris McGrath/Getty

A 7.8-magnitude earthquake that hit Nepal on April 30, 2015, has been linked by some to groundwater pumping.

From mining projects to oil and gas operations, human activity has set off

earthquakes around the world and in many geological settings. Research now highlights how big these quakes can get — and how little scientists agree on which ones are caused by people.

The Human-Induced Earthquake Database, or HiQuake, contains 728 examples of earthquakes (or sequences of earthquakes) that may have been set off by humans over the past 149 years. Most of them were small, between magnitudes 3 and 4. But the list also includes several large, destructive earthquakes, such as the magnitude-7.8 quake in Nepal in April 2015, which one paper linked to groundwater pumping[1].

Miles Wilson, a hydrogeologist at Durham University, UK, and his colleagues describe the database in a paper set to be published on October 4 in *Seismological Research Letters*[2]. The scientists say that HiQuake is the biggest, most up-to-date public listing of human-caused quakes ever made. By bringing the data together in this way, they hope to highlight how diverse induced quakes can be — and help society to understand and manage the future risk.

Earth-shaking activity

HiQuake began in 2016, when the Dutch Petroleum Society (NAM), an oil and gas company based in Assen, funded a team of researchers at Durham and at Newcastle University, UK, to collect examples of induced earthquakes. NAM drills in the Groningen gas field in the Netherlands, where it has set off many small earthquakes.

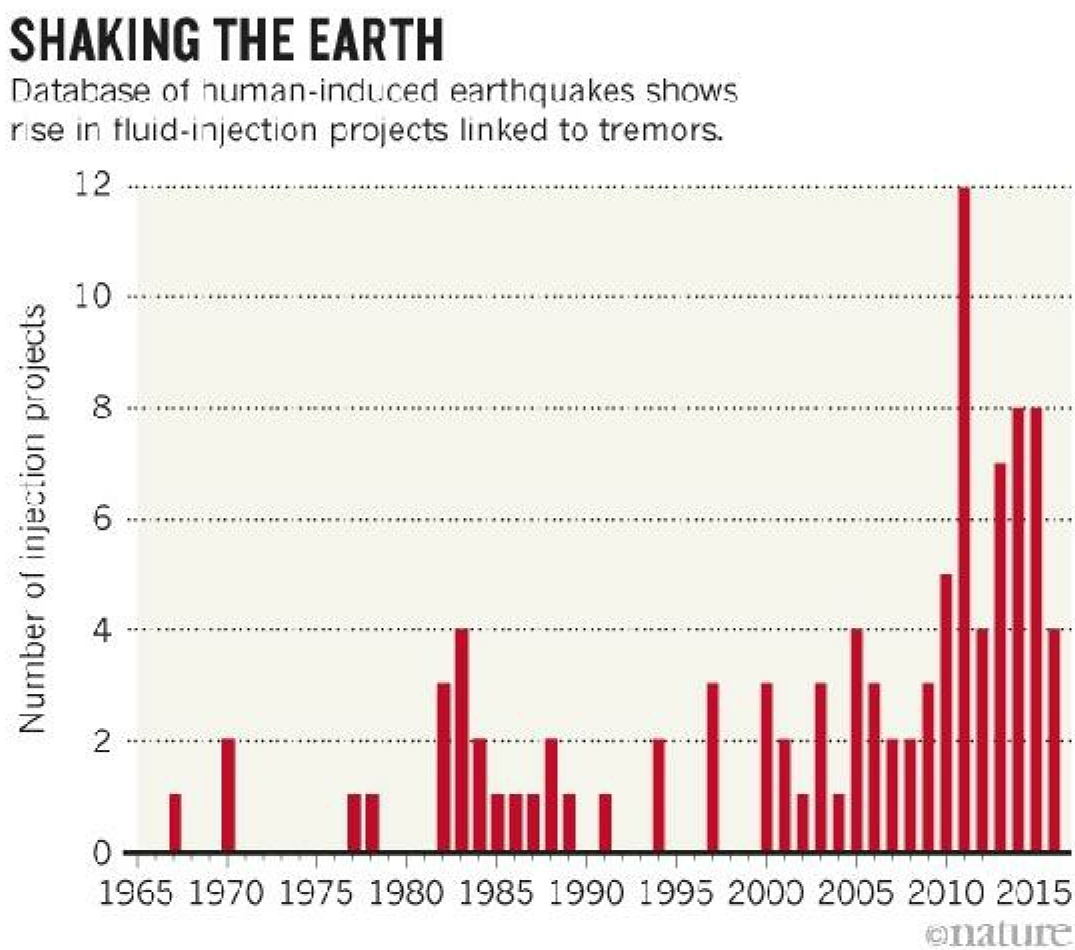
Wilson's team trawled through sources including scientific papers and media accounts to come up with its 728 events. When a single project, such as a wastewater-injection well, set off more than one quake, the researchers counted those as a single event. Further details appear in *Earth-Science Reviews*[3].

The result is a database in which the earliest entry dates to 1868, with a quake triggered by an Australian coal-mining operation. Of the 728 events, 271 (37%) are linked to mining — often from tunnel collapses. About 23% are

linked to water piling up behind a dam and 15% to conventional oil and gas development. Just 4% are linked to hydraulic fracturing, or fracking, for oil and gas. Some of the more unusual cases involve quakes triggered by the building of heavy skyscrapers or by an underground nuclear-bomb test.

Mass movement

In HiQuake, the fastest-growing quake-inducing activity in the database is the injection of wastewater back into the ground by oil and gas operations (see 'Shaking the earth'). The process that can increase stress on buried geological faults and cause them to generate small earthquakes. The number of these projects spiked in the early 2010s, at the height of wastewater-injection in Oklahoma and other parts of the central United States.



The largest event in the database is the magnitude-7.9 earthquake that struck in Sichuan, China, in 2008, which some have linked with the filling of a nearby reservoir[4]. Wilson says his team was initially startled to see quakes that large proposed as human-induced. But in retrospect, he says, “we probably shouldn’t be surprised by any anthropogenic cause”. All the projects linked to earthquakes — whether blasting a mining tunnel, injecting wastewater or pumping groundwater — involve moving mass around on Earth’s surface in ways that can nudge already-stressed faults.

The scientists found a relationship between the volume of material moved — such as the size of the reservoir filled before the Chinese quake — and the magnitude of the largest linked earthquake that followed. No such relationship was seen with factors such as dam height or reservoir area. The researchers suggest that limiting the amount of material moved in a construction project could help to minimize any quakes triggered.

Judgement calls

All possible instances of induced quakes were included “without regard to plausibility”, writes the team, because of the difficulty involved in deciding what constitutes absolute proof that an earthquake was caused by human activity. But that could mislead people about the real hazard from induced quakes, says Raphaël Grandin, a geophysicist at the Institute of Earth Physics in Paris. “When you put a dot in the database, and a scientific reference behind it, then you may lead the non-expert to think that the earthquake was caused by humans,” he says. Such a listing might hide scientific uncertainty, as with the Chinese quake: despite the paper linking it to reservoir filling, many seismologists do not believe it was triggered by human activity[5].

Susan Hough, a seismologist at the US Geological Survey in Pasadena, California, says she understands why the HiQuake team included all possible instances of induced quakes. “I suspect the authors were unwilling to pass judgement on published studies, which I consider a reasonable decision,” she says. “If you start down the road, where do you stop?”

Wilson agrees. “Any judgement calls we leave to users,” he says.

Over time, HiQuake should become more useful as researchers add examples and references to its entries, says Gail Atkinson, a seismologist at the University of Western Ontario in London, Canada, who leads a Canadian collaboration to study induced seismicity.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22693

Comments

Comments

There are currently no comments.

Discoveries have awkward first dates

Fuzzy timings over a plate-tectonics anniversary highlight the rolling nature of scientific discovery.

02 October 2017

Archive of Alfred Wegener Institute

Alfred Wegener first suggested the idea of continental drift which led to the theory of plate tectonics.

This week, the Geological Society in London will mark the 50th anniversary

of plate tectonics — the theory that describes the workings of Earth, how earthquakes strike, and why volcanoes happen. Or will it?

The timing of the anniversary is disputed. After all, this journal published its own 50th anniversary commemoration of plate tectonics 4 years ago (*Nature* **501,** 27–29; 2013). Columbia University's Lamont–Doherty Earth Observatory in New York celebrated last May. Confused? Blame the rolling nature of scientific discovery. Plate tectonics did not spring into existence fully formed, Athena-like, on a particular day in a particular year.

No doubt aware of this, the London conference, although billing itself as "Plate Tectonics at 50", pins next week more cautiously: as a commemoration of the "advent of the paradigm" — the arrival of the model of the theory.

Coming up with the modern theory of Earth involved sparks of insight from many different researchers, working in different laboratories on different continents. Most of the resulting papers were published in the 1960s, many of them in *Nature*.

In September 1963, Frederick Vine and Drummond Matthews described how stripes of changing magnetism on the sea floor represented the spreading of new oceanic crust away from the ridge where it was born (F. J. Vine and D. H. Matthews *Nature* **199,** 947–949; 1963). This was the crucial insight that nailed the concept of sea-floor spreading, which had been hinted at in the 1950s, when oceanic mapping by Marie Tharp and Bruce Heezen revealed a mountainous rift, and so this is the paper that *Nature* editors choose to commemorate in plate-tectonics anniversaries. Fast-forward four years, and Dan McKenzie and Robert Parker publish the first complete description of how crustal plates move around on the surface of the sphere (D. McKenzie and R. L. Parker *Nature* **216,** 1276–1280; 1967), the paper that the Geological Society is now celebrating.

Of course, Vine, Matthews, McKenzie and Parker were far from alone. In the 1960s, plate tectonics was such a fecund, fast-moving field that it involved several instances of simultaneous discovery. In early 1967, as McKenzie was developing his ideas of rigid-plate motions, he looked at a conference abstract by colleague Jason Morgan and decided not to attend the talk. As it

turns out, Morgan veered from the text of his abstract and instead described ideas of plate motions that were eerily like McKenzie's. Later that year, McKenzie sent off his manuscript to *Nature* — and, when he realized that Morgan was about to publish similar ideas, he asked the journal to delay his own paper in order to give Morgan the credit. *Nature*'s editor, John Maddox, sent a telegram back saying that the issue had already been typeset, so there would be no delay. Who has not skipped an event, only to have that affect their careers for years to come?

But back to the question of anniversaries. Popular interpretations of scientific history are biased towards the single great discovery by a single great person — and they are more easily commemorated in an anniversary. But most discoveries are much more nuanced and communal. Charles Darwin would not have published his ideas of evolution by natural selection when he did, had he not been prompted into it by the similar thoughts of Alfred Russel Wallace. Albert Einstein relied on the work of friends and colleagues to develop his general theory of relativity.

Similar broad revolutions are unfolding today. Despite all the bitterness and infighting over who invented the CRISPR–Cas9 gene-editing technique, the fact remains that a large number of very bright scientists made enormous advances quickly by playing off one another. Just as in the heyday of plate tectonics, one gene-editing breakthrough inspired the next, until biologists were brimming with publications. Historians may one day bicker about which CRISPR paper to celebrate on the 50th anniversary of the technique, but science as a whole is much better off than it was before.

And so, we could celebrate a 1963 publication on the magnetism of the sea floor, or a 1967 paper on the geometry of spherical rotations, or even the entirety of the dawning of plate tectonics. But when was that? Was it in 1912, when Alfred Wegener came up with the idea of continental drift? Or was it decades later, when his ideas were finally transformed into the concept we now know as tectonics? Much of that delay might trace to US researchers viciously opposing his ideas, as historian Naomi Oreskes described in *Plate Tectonics* (Westview Press, 2001). But after the slow start, Earth scientists in the 1960s were quick to embrace the data and theories that redrew almost every aspect of their field.

Such is the nature of discovery — incremental at times, fast-paced at others, occasionally derailing into pettiness. But it does nearly always move in the right direction. In these times of political uncertainty and global unrest, that is an accomplishment worth noting.

Journal name:
Nature
Volume:
550,
Pages:
7
Date published:
(05 October 2017)
DOI:
doi:10.1038/550007a

Comments

Commenting is currently unavailable.

Chinese scientists fix genetic disorder in cloned human embryos

A method for precisely editing genes in human embryos hints at a cure for a blood disease.

02 October 2017

Mauro Fermariello/SPL

Fixing the genetic mutation linked to β-thalassaemia would save affected individuals from having to get life-sustaining blood transfusions.

A team in China has taken a new approach to fixing disease genes in human embryos. The researchers created cloned embryos with a genetic mutation for a potentially fatal blood disorder, and then precisely corrected the DNA to

show how the condition might be prevented at the earliest stages of development.

The report, published on 23 September in *Protein & Cell*[1], is the latest in a series of experiments to edit genes in human embryos. And it employs an impressive series of innovations, scientists say. Rather than replacing entire sections of genes, the team, led by Junjiu Huang at Sun Yat-sen University in Guangzhou, China, tweaked individual DNA letters, or bases, using a precision gene-editing technology developed in the United States[2].

Huang's team is also the first to edit out the mutation responsible for a 'recessive' disease: one caused by having two faulty copies of a gene. Because it would be difficult for researchers to find dozens of embryos that all have this rare double mutation, the team worked around this roadblock by developing embryonic clones from their patient's skin cells.

"I thought, 'Why would they do cloning?' Then I read the paper, and thought, 'Wow, that's fascinating,'" says Shoukhrat Mitalipov, a reproductive-biology specialist at the Oregon Health and Science University in Portland who pioneered human cloning and also works on gene editing in embryos. "I would not have thought to do this."

Scientists around the world have now published eight studies reporting gene editing in human embryos, five in the past two months. None have permitted the embryos to grow beyond 14 days, and the research has had different purposes: some to test gene-editing technologies; others to edit various disease-related genes; and some to unravel the mechanisms behind early embryonic development. Huang's team led the first report, published in April 2015, in which they used the CRISPR–Cas9 enzyme complex to snip chromosomes at specific locations, excise DNA and replace it with other genetic material[3].

Precision editing

In the latest study[1], Huang's team used 'base editing', a modification of CRISPR–Cas9. It guides an enzyme to specific gene sequences, but does not

cut the DNA. Instead, the Cas9 enzyme is disabled and tethered to another enzyme that can swap out individual DNA base pairs. So far, this technique can convert guanine (‘G’) to adenine (‘A’), and cytosine (‘C’) to thymine (‘T’). Hundreds of genetic diseases are caused by single-base changes, or ‘point mutations’, and so editing of this sort at the embryonic stage could potentially stave off such conditions.

Huang’s team chose one mutation common in the Chinese population: a switch from an A to a G at a certain spot in the *HBB* gene, which can lead to β-thalassaemia, a recessive blood disorder associated with severe or fatal anaemia. Researchers generally source embryos from *in vitro* fertilization (IVF) clinics, but it’s rare for these facilities to have embryos with two copies of the same rare mutation. So Huang’s team found a person with the blood disorder, extracted their skin cells and used cloning techniques to develop embryos with the same genetic makeup.

The researchers reported that in 8 of 20 cloned embryos, they were able to convert the errant G back into an A in one or both copies of the gene. (Repairing only one copy might be enough to cure a recessive disease.) That rate is too low for the technique to be considered for clinical use, but the efficiency was high relative to that achieved in other gene-editing studies. “The repair rate is pretty good, and certainly promising,” says Gaetan Burgio, a geneticist at the Australian National University in Canberra. “Our study opens new avenues for therapy of β-thalassaemia and other inherited diseases,” says Huang.

But scientists caution that not all cells in the eight embryos were fixed. Such embryos are ‘mosaic’, meaning that they have a patchwork of cells with different genetic make-ups, which is potentially dangerous. “It looks like solid work, but highlights that the problem of mosaicism remains a challenge for any form of gene editing in the human embryo,” says Dieter Egli, a stem-cell biologist at Columbia University in New York City.

Unintended consequences

Some scientists also question whether Huang’s team looked thoroughly

enough for unintended genetic changes, called off-target effects, that might have been caused by the base-editing procedure, although the authors reported that none were found.

Huang says future experiments will be more comprehensive, but that this first study was a successful proof of principle that the base-editing technique can be used to correct a disease mutation in a human embryo. It may be that conventional CRISPR–Cas9 cannot fix embryos when both copies are faulty, although this isn't yet clear. In August, for instance, Mitalipov's team reported using CRISPR–Cas9 to repair a mutation in a gene that can cause a potentially deadly heart disorder, by using the other, healthy copy of the gene as a template[4].

In the future, Huang says, he plans to ask for oocytes and sperm from donors who have one mutated copy of the gene — and so are unaffected by the condition, but are carriers of the disease — and use these to produce embryos. Some of those embryos would have two mutated copies, and some one, but Huang wants to edit both types. That raises the contentious idea that gene editing might be used not only to prevent severe disease, but also to eliminate the chance of people becoming carriers of the disorder. "Base editing can repair the mutant site and block it from being passed on to the next generation," he says.

Journal name:
Nature
Volume:
550,
Pages:
15–16
Date published:
(05 October 2017)
DOI:
doi:10.1038/nature.2017.22694

Comments

Comments

There are currently no comments.

Medicine Nobel awarded for work on circadian clocks

Jeffrey Hall, Michael Rosbash and Michael Young unpicked molecular workings of cells' daily rhythms.

02 October 2017

Nora Tam/SCMP

Michael Rosbash (left), Jeffrey Hall (centre) and Michael Young (right) have been recognized for their work on circadian clocks.

Three scientists who studied the workings of organisms’ inner circadian clocks have won the 2017 Nobel Prize in Physiology or Medicine. Jeffrey Hall and Michael Rosbash, both at Brandeis University in Waltham, Massachusetts, will split the award of 9 million Swedish kronor (US$1.1

million) with Michael Young at Rockefeller University in New York City.

Beginning in the 1980s, the three researchers isolated and characterized a gene in fruit flies, *period*, that encodes a protein that builds up each night, only to be broken down the following day. In subsequent work, the trio, as well as other scientists, unpicked the molecular regulation of the *period* gene (and the protein that it encodes, called PER) and identified additional components of the circadian clock.

All multicellular organisms possess circadian clocks, and human versions of the genes that comprise their clocks have been implicated in sleeping disorders and other medical conditions.

Rosbash, Hall and Young have been collecting awards together for the past five years. In 2013, for example, they shared the Shaw Prize in life science and medicine, then worth US$1 million. That has set the expectation that a Nobel might be around the corner, says Herman Wijnen, who studies circadian clocks at the University of Southampton, UK and was a postdoc in Young's lab. "This has been one that people have been looking out for," he says. "It's been settled in the scientific community that this is the trio."

But Young says he was so stunned by the news that he could barely get his shoes on the morning he found out. "I'd go and I'd pick up the shoes, and then I'd realize I need the socks," he said during a press conference. "And then I realized I needed to put my pants on first." The award took Rosbash by surprise too, says Thomas Perlmann, secretary of the Nobel Assembly, which selects the prizewinners. "I first got hold of Michael Rosbash, and he was silent," says Perlmann. "And then he said, 'you are kidding me'."

The work has its roots in genetic screens performed by physicist and molecular biologist Seymour Benzer and geneticist Ronald Konopka, who together found fruit-fly mutants with abnormal hatching rhythms. (Benzer died in 2007; Konopka in 2015.) At the time, the idea that behaviour could have a genetic basis was controversial, says Wijnen. Years later, two teams — Young leading one, Hall and Rosbash working together to lead another — would clone the genes responsible. "That really changed the situation," says Wijnen. "Since then, it has become clear how conserved this system is and how conceptually it could work."

The competition between the two teams — each with ambitions to be first to identify the gene — was initially intense, says Charalambos Kyriacou, a behavioural geneticist at the University of Leicester, UK, who worked with Hall in the late 1970s. “As they got older they mellowed,” he says. “They’re all good buddies now.”

Subsequent work detailed how abundance of the PER protein peaks at night and then declines during the day. Researchers gradually pieced together a model in which the accumulation of PER serves as a signal that represses expression of the gene that encodes it. This type of negative feedback loop would become a prevailing theme in the study of circadian rhythms, as researchers identified additional loops and clock proteins over the years.

Joseph Takahashi at the University of Texas Southwestern Medical Center in Dallas and others extended the work from fruit flies to mammals, and showed that the system is remarkably conserved across species. Researchers have since tied the circadian clock to many aspects of mental and physical well-being. “We expose ourselves to inappropriate light, we travel across time zones, we do shift work,” says Wijnen. “And all of that is negatively impacting our health.”

The links between the circadian clock and human health are so pervasive that medical schools should increase their focus on chronobiology, says Martha Merrow, chair of medical psychology at Ludwig Maximilian University of Munich in Germany. This could be either as a speciality in its own right, or incorporated into medical training in other specialities such as endocrinology or rheumatology, she adds. A Nobel prize may give Merrow and her colleagues added force to make that case. Merrow learnt of the news before heading into an administrative meeting. “I was so breathless, I could hardly go into my meeting,” she says. “It’s just a fantastic choice. It will be great for our field.”

Journal name:
Nature
Volume:
550,
Pages:
18

Date published:
(05 October 2017)
DOI:
doi:10.1038/nature.2017.22736

Comments

Commenting is currently unavailable.

Nature News

周一, 23 10月 2017

Nature News

[周一, 23 10月 2017]

- **Nature News**

Nature News

Nature is a weekly international journal publishing the finest peer-reviewed research in all fields of science and technology on the basis of its originality, importance, interdisciplinary interest, timeliness, accessibility, elegance and surprising conclusions. Nature also provides rapid, authoritative, insightful and arresting news and interpretation of topical and coming trends affecting science, scientists and the wider public.

- **The Human Cell Atlas: from vision to reality** [周三, 18 10月 08:00]
  As an ambitious project to map all the cells in the human body gets officially under way, Aviv Regev, Sarah Teichmann and colleagues outline some key challenges.
- **Top Chinese university to consider social-media posts in researcher evaluations** [周三, 18 10月 08:00]
  Controversial policy means mainstream media are starting to rival rigorous academic publications in some universities in China.
- **Mysterious particles spotted in Saturn’s atmosphere** [周三, 18 10月 08:00]
  Source may be dust shed by planet’s iconic rings, according to data from NASA's doomed Cassini probe.
- **Efforts to save leading Hungarian university hit hurdle** [周三, 18 10月 08:00]
  US-registered Central European University faces another year of uncertainty over whether it can continue to operate in Hungary.
- **Sleeping sickness can now be cured with pills** [周三, 18 10月 08:00]
  Researchers seek approval from regulators for this quicker, easier treatment.
- **Self-taught AI is best yet at strategy game Go** [周三, 18 10月 08:00]
  Artificial-intelligence program AlphaGo Zero trained in just days, without any human input.
- **Science must examine the future of work** [周三, 18 10月 08:00]
  As automation changes employment, researchers should gather the evidence to help map the implications.
- **Blue is in the eye of the bee-holder** [周三, 18 10月 08:00]
  Flowers have evolved an ingenious way to attract pollinators.
- **Epic star collision, asteroid fly-by and journal resignations** [周三, 18 10月 08:00]
  The week in science: 13–19 October 2017.
- **New definitions of scientific units are on the horizon** [周三, 18 10月 08:00]
  Metrologists are poised to change how scientists measure the Universe.
- **The future of work** [周三, 18 10月 08:00]

Digital technologies are upending the workforce. The right research can tell us how.

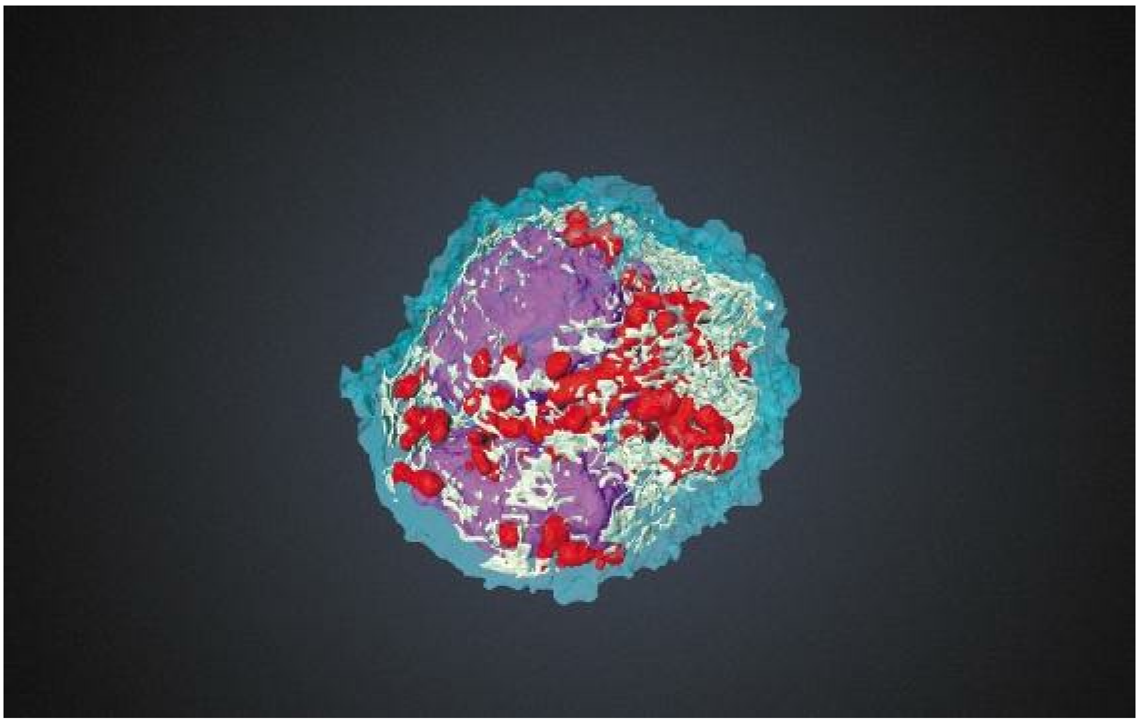
- ## The shape of work to come [周三, 18 10月 08:00]
  Three ways that the digital revolution is reshaping workforces around the world.
- ## Lessons from history for the future of work [周三, 18 10月 08:00]
  Global comparisons of previous social and economic upheavals suggest that what is to come depends on where you are now, argues Robert C. Allen.
- ## The second Renaissance [周三, 18 10月 08:00]
  Ian Goldin calls on scientists to help society to weather the disruptive transformations afoot.
- ## Archaeology: The wonder of the pyramids [周三, 18 10月 08:00]
  Andrew Robinson enjoys a volume rounding up research on the complex at Giza, Egypt.
- ## Books in brief [周三, 18 10月 08:00]
  Barbara Kiser reviews five of the week's best science picks.
- ## History: Five millennia of Indian science [周三, 18 10月 08:00]
  James Poskett applauds a show celebrating discovery on the subcontinent, from zero to the boson.
- ## Federal funding: Stifled by budgets, not irrelevance [周三, 18 10月 08:00]
- ## Ornithology: Danish dairy farmer delivers data coup [周三, 18 10月 08:00]
- ## Open data: Spot data glitches before publication [周三, 18 10月 08:00]
- ## PhD students: living wage key to diversity [周三, 18 10月 08:00]
- ## PhD students: side jobs are no solution [周三, 18 10月 08:00]
- ## Breaking and entering [周三, 18 10月 08:00]
  Escape is not an option.
- ## Brazilian Amazon still plagued by illegal use of natural resources [周二, 17 10月 08:00]
  Practices such as poaching and illegal logging are concentrated near inhabited areas and along rivers, study finds.
- ## Give researchers a lifetime word limit [周二, 17 10月 08:00]
  Brian C. Martinson imagines how rationing the number of publications a scientist could put out might improve the scientific literature.
- ## Japanese research leaders warn about national science decline [周二, 17 10月 08:00]
  Concern mounts over budget cuts and other changes that undermine basic science.
- ## Reboot for the AI revolution [周二, 17 10月 08:00]
  As artificial intelligence puts many out of work, we must forge new economic, social and educational systems, argues Yuval Noah Harari.

- **Eye in the sky offers clearest vision of Earth** [周一, 16 10月 08:00]
  The world’s latest carbon-monitoring satellite has advanced our understanding of how the planet functions. US politicians should take note.
- **Colliding stars spark rush to solve cosmic mysteries** [周一, 16 10月 08:00]
  Stellar collision confirms theoretical predictions about the periodic table.

The Human Cell Atlas: from vision to reality

18 October 2017

As an ambitious project to map all the cells in the human body gets officially under way, Aviv Regev, Sarah Teichmann and colleagues outline some key challenges.



Villani, A.-C. ET AL. SCIENCE 356, EAAH453 (2017); image Kathryn White; reconstruction James Fletcher

A new type of human dendritic cell recently discovered using single-cell RNA sequencing.

Our knowledge of the cells that make up the human body, and how they vary

from person to person, or throughout development and in health or disease, is still very limited. This week, a year after project planning began, more than 130 biologists, computational scientists, technologists and clinicians are reconvening in Rehovot, Israel, to kick the Human Cell Atlas initiative[1] into full gear. This international collaboration between hundreds of scientists from dozens of universities and institutes — including the UK Wellcome Trust Sanger Institute, RIKEN in Japan, the Karolinska Institute in Stockholm and the Broad Institute of MIT and Harvard in Cambridge, Massachusetts — aims to create comprehensive reference maps of all human cells as a basis for research, diagnosis, monitoring and treatment.

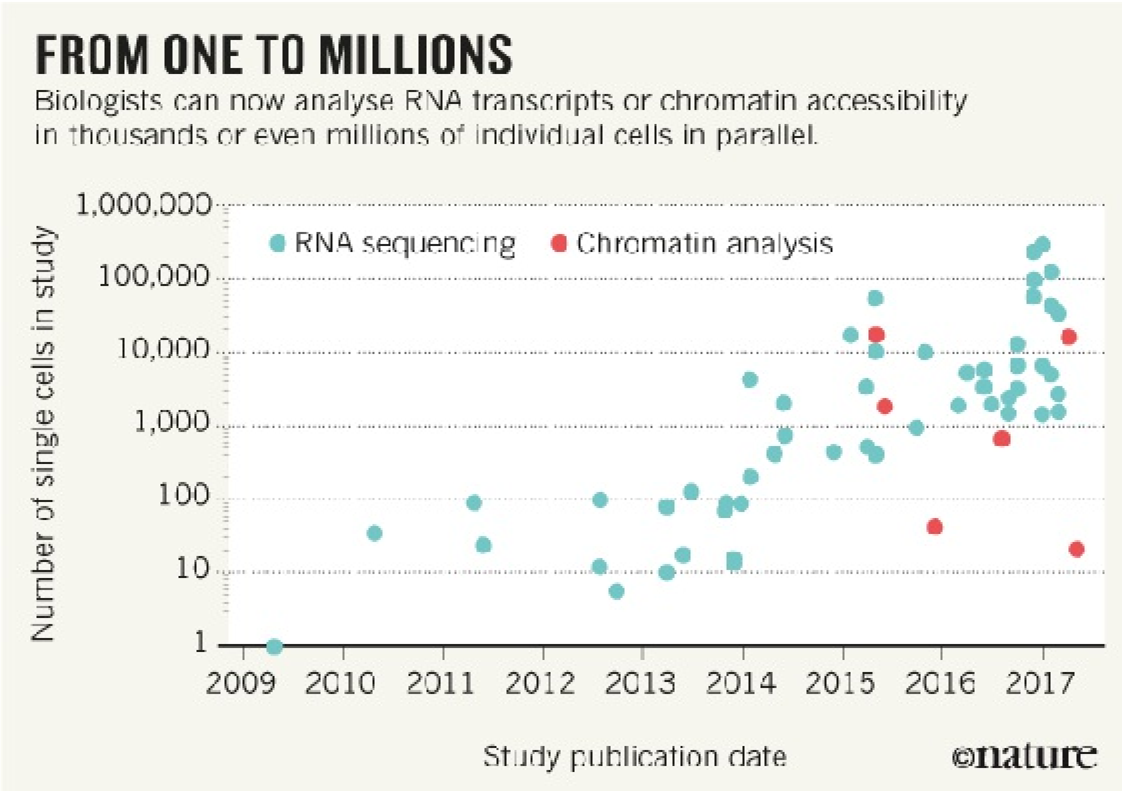
On behalf of the Human Cell Atlas organizing committee, we outline here some of the key challenges faced in building such an atlas — and our proposed strategies. For more details on how the atlas will be built as an open global resource, see the white paper[2] posted on the Human Cell Atlas website.

Cells have been characterized and classified with increasing precision since Robert Hooke first identified them under the microscope in the seventeenth century. But biologists have not yet determined all the molecular constituents of cells, nor have they established how all these constituents are associated with each other in tissues, systems and organs. As a result, there are many cell types we don't know about. We also don't know how all the cells in the body change from one state to another, which other cells they interact with or how they are altered during development.

Technology revolution

New technologies offer an opportunity to build a systematic atlas at unprecedented resolution. These tools range from single-cell RNA sequencing to techniques for assessing a cell's protein molecules and profiling the accessibility of the chromatin. For example, we can now determine the RNA profiles for millions of individual cells in parallel (see 'From one to millions'). Protein composition and chromatin features can be studied in hundreds or thousands of individual cells, and mutations or other markers tracked to reconstruct cell lineages. We can also profile multiple

variants of RNA and proteins *in situ* to map cells and their molecules to their locations in tissues.



Source: Svensson, V., Vento-Tormo, R. & Teichmann, S. A. Preprint at https://arxiv.org/abs/1704.01379 (2017)

We anticipate that the atlas will help researchers to answer key questions in diverse biological fields. In cellular taxonomy, it might enable the discovery and identification of cell types and molecular markers or signatures (a collection of genes, say, that characterize a specific cell type). In histology, it should enable researchers to relate tissue structure to the position of cells and molecules. Developmental biologists will be able to use it to track cell fate and lineage. Physiologists could characterize dynamic states, such as the cell cycle, and transient responses such as a T cell's reaction to a pathogen.

The atlas could also facilitate research on the molecular mechanisms of communication within and between cells. And it should allow biologists to compare cell types across species to better understand human evolution, and

to determine to what extent animal model systems and organoids reflect human biology.

Crucially, the atlas should help researchers to compare healthy reference cells to diseased ones in the relevant tissues — and so facilitate the development of better drugs and more accurate predictions of unintended toxicity. The atlas could also aid regenerative medicine — the process of replacing, engineering or regenerating human cells, tissues or organs to establish normal function. Key diagnostic tests, such as the complete blood count — a routine blood screen that provides crude counts of white blood cells, red blood cells and so on — would become vastly more informative if cell types and states could be identified with much finer granularity. Such information could, for example, help to diagnose blood cancer, autoimmunity or infection before clinical symptoms appear.

Early studies are already showing tremendous potential in all these areas. New cell types have been found in the brain[3–7], gut[8], retina[9] and immune system[10], and these discoveries have yielded new insight — into how the immune system[11] functions, for example, and into the dynamics of tumour ecosystems[12]. Yet, to take the next step — to build a human cell atlas that is truly useful — requires taking the long view and addressing various systemic and organizational challenges, as well as technical and scientific ones.

The challenges

Agree on scope. In light of the enormous complexity of the human body, and the rapid evolution of technologies for probing cells and tissues, and for analysing the data, we plan to build this resource in phases and generate reference maps at increasing resolution as the project progresses.

The first draft of the atlas will profile cells' molecular and spatial characteristics, capturing only those cell types that occur above a pre-specified rarity — ones that make up more than 1% of a sample, say. These cells will be obtained from major tissues from healthy donors, taking into account the genetic diversity, geographical location and person's age. Although disease will not be a focus of the first draft of the atlas, we plan to

look at some disease samples to compare them with healthy cell types.

The first draft will focus on tissues, not whole organs. Extremely rare cells may be missed, and sample sizes may be too small to fully reveal the links between cellular characteristics and human diversity. In later phases, the atlas could take on entire organs, include small cohorts of people (say, 50–60) with diseases of interest, gather bigger sample sizes and provide greater power to associate molecular variation with the underlying genetic diversity. A similar step-wise strategy was deployed in the Human Genome Project; even a partially assembled genome proved immediately useful to researchers, and human genetic variation in health and disease was tackled over several years after the full genome was sequenced.

The atlas will provide an important starting point for functional studies — for instance, those aimed at establishing the mechanistic links between cell states and disease. But such studies are themselves beyond its scope. Again, this parallels what happened with the Human Genome Project: studies of functional elements in the genome, which are ongoing, have relied on the reference sequence obtained through the project.

The atlas will aim to provide a detailed representation of molecules, cells, tissues, organs and systems, allowing researchers to zoom in and out to identify patterns and interactions at various levels of resolution. To this end, those compiling the atlas must establish how many cells to sample, which types of molecular features to analyse, how to assign cells to different categories and how to subdivide those categories. At the spatial level, they must decide how to sample complex anatomies and histologies. Lastly, they need to establish ways of connecting the various layers of cellular and spatial information from different samples to a single anatomical reference by developing what is termed a common coordinate framework.

To ensure the best use of resources, those involved in the initiative must agree on the desired resolution for each phase of the atlas. Researchers could, of course, try to pursue ever-rarer cell types, but potentially at ever-greater expense. In this respect, the Human Cell Atlas will pursue similar approaches to those used in human genetic studies that focus on variants present at a certain frequency. Here, geneticists have begun to tackle increasingly rare variants as technologies have advanced.

Be open and fair. To have maximum impact, the Human Cell Atlas must be an open resource, on many levels.

The project is already open to all interested participants who are committed to its values. Discussions about particular organs, tissues, technologies or computational approaches are running on more than a dozen Slack channels that anyone can join.

Wherever consent agreements allow, atlas data will be made publicly available in an open-source data-coordination platform as soon as possible, after they have been collected and have passed quality-control checks. All standards established to ensure the production of high-quality data, and any updates to those standards, will also be shared. The same goes for new technologies and computational methods resulting from the project.

Atlas data and analysis products will exist in multiple public clouds (currently, those hosted by Google, Amazon and Microsoft) to ensure that people with different preferred cloud environments can access them. Because computation will happen in the cloud, individual researchers will not need to download and store all the data or have access to their own high-performance computing power. Finally, in addition to the continual release of data and periodic formal data releases, publications interpreting the data will help to establish standardized approaches and disseminate the insights and value that can be gained from them.

As much as possible, the atlas must reflect the diversity of humans and human experience. The broad distribution of participating researchers, institutions and countries involved in the initiative will, in itself, help to ensure tissue diversity. The initiative currently includes members from 5 continents and more than 18 countries, including Japan, Israel, South Africa, China, India, Singapore, Canada and Australia.

Getting appropriate consent agreements and fostering public trust from the outset will also help efforts to obtain sufficient geographical, gender, age and genetic diversity in sampling. As part of the global initiative, an ethics working group will establish how best to obtain informed consent from sample donors, how the terms of that consent can be adhered to and how to protect the privacy of participants and donors appropriately. Various existing

projects involving human samples, such as the public-research project ENCODE (the Encyclopedia of DNA Elements), which aims to identify all the functional elements of the human genome, can provide guidance on this.

Procure samples appropriately. Obtaining tissue samples using standardized procedures, with appropriate consent and in a way that enables other researchers to know exactly where the sample came from is a complex endeavour. To access the diversity of human tissues needed, researchers will work with both fresh tissue from live donors and specimens obtained postmortem or from transplant organ donors.

We plan to learn from, and build on, pre-existing reliable procurement processes. Examples include those used in the Genotype-Tissue Expression Project (GTEx, a database and tissue bank designed to help researchers to gain insight into the mechanisms of gene regulation in humans) and the Cambridge Biorepository for Translational Medicine, a resource for multidisciplinary research projects for which fresh tissue is required.

Organize effectively. The Human Cell Atlas consortium is built on four distinct and interconnected pillars. Collaborative biological networks involve experts in biological systems or organs as well as in genomics, computation and engineering, working together to build maps of each tissue, system or organ. Several biological-network pilot projects have been formulated through grass-roots efforts in the Human Cell Atlas community. As well as revealing new biology and helping to build a collaborative international network, these activities are informing the community about how to structure sampling and conduct analyses for a full-scale cell atlas.

A technical forum involving genomics experts, imaging specialists and biotechnologists, is developing new technologies, and testing, comparing and disseminating existing ones. A data-coordination platform is being designed to bring researchers to the data by developing the software to upload, store, process and serve data. The platform also provides an open environment in which computational methods and algorithms developed by any interested group can be shared. Finally, an analysis garden involves computational biologists working together to develop sophisticated techniques for data mining and interpretation.

Activities across all areas are currently governed by a scientific steering group, the Human Cell Atlas organizing committee. Co-chaired by two of us (A. R. and S. A. T.), this includes 27 scientists from 10 countries and diverse areas of expertise. The committee establishes working groups (about 5 so far, consisting of about 5 to 15 members each) that tackle specific key areas. For instance, an analysis working group is crafting best practices for computational analysis through a community-wide process, including workshops and jamborees. The committee governs the data-coordination platform, including making all policy decisions and approving its overall plan.

Join the effort

Having a catalogue of genes at our fingertips has transformed research in human biology and disease. Similarly, we believe that the Human Cell Atlas will catalyse progress in biology and medicine. Descriptors such as 'cell type' and 'cell state' can be difficult to define at the moment. An integrative, systematic effort by many teams of scientists working together and bringing different expertise to the problem could dramatically sharpen our terminology, and revolutionize the way we see our cells, tissues and organs. We invite you to join the effort.

Journal name:
Nature
DOI:
doi:10.1038/550451a

Supplementary information

PDF files

1. HCA organizing committee (61K)

Comments

Comments

There are currently no comments.

Top Chinese university to consider social-media posts in researcher evaluations

Controversial policy means mainstream media are starting to rival rigorous academic publications in some universities in China.

18 October 2017

Wang Zhao/AFP/Getty

News articles written by researchers at some Chinese universities will now be considered in evaluations.

One of China’s most prestigious universities plans to give some articles in

newspapers and posts on major social-media outlets the same weight as peer-reviewed publications when it evaluates researchers.

The policy has sparked a vigorous debate among Chinese academics. Proponents say it will encourage researchers to engage with the public, but many are concerned that it will promote those who toe the party line established by China’s strictly censored media and social media, at the expense of more highly qualified researchers. Critics also say the system could be manipulated to inflate a researcher’s impact, for example by artificially boosting page views.

Zhejiang University in Hangzhou announced the policy on its WeChat page on 15 September, saying that it would mainly apply to the humanities and social sciences. But Chinese researchers say the move could influence science as well, by giving a hiring and promotion advantage to politically minded scientists.

“You do not need to be good scientist, you do not need to publish good science papers,” says one biologist at a prominent Beijing-based university who requested anonymity. He is concerned that the policy could alter evaluations at China’s main grant agency, the National Natural Science Foundation of China (NSFC). “If they open the Pandora’s box, the NSFC might change its policy as well,” he says. The agency's head, Yang Wei, says it will do no such thing. NSFC grants are given solely “according to the judgement of peer reviewers”, he says.

Viewing figures

The Zhejiang policy sets specific criteria: articles have to be original, written by the researcher and at least 1,000 words long; they need to be picked up by major news outlets and widely disseminated through social media; and they need to have been seen by a large number of people. The policy requires an article to be viewed more than 100,000 times on WeChat, China’s most popular instant-messaging service, or 400,000 times on news aggregators such as Toutiao. Articles that meet the criteria will be considered publications, alongside papers in peer-reviewed journals.

The university has also established a publication hierarchy, with official media outlets such as the *People's Daily* considered most important, regional newspapers and magazines occupying a second tier, and online news sites such as Sina, NetEase or Sohu ranking third.

Ping Fu, who researches library science at Central Washington University in Ellensburg, is concerned that the policy will blur the distinction between peer-reviewed academic publications and popular writing. This could affect the top levels of scholarship in China, he says. Liu Jin-ping, a biologist at Hainan University in Haikou, also worries that the policy will give prominence to stories that "flatter the government". Some academics will aim to "become Internet stars" so they can be promoted, he wrote on his blog.

Full credit

Lin Boqiang, an energy-policy and climate-change researcher at Xiamen University who has published some 800 media commentaries, thinks researchers should get credit for this work. He "criticizes government policy all the time" and would never write something incorrect to please political powers, he says: "Our reputation is on the line."

But both Liu and Lin are concerned the system could be gamed, either for self-interest or with political motivation. Lin says these articles should not be considered equal to academic publications. "Other universities will do this," he says. "I hope they do it in a more sophisticated way."

Zhejiang University refused to answer *Nature*'s questions about the policy, but it posted a statement on its homepage in response to the controversy, saying that the commentaries in the mainstream media will supplement and not replace peer-reviewed journals: "This policy is to explore more forms of exposure of research, especially for humanities and social sciences, and the assessment will be made by a strict panel review, which will not lower the academic standard."

Grant committees in other countries encourage researchers to do public outreach, but the Zhejiang policy is rare in how it ranks such efforts for

researcher evaluation. Jilin University in Changchun announced a similar policy in August.

Balancing act

Glen Peters, a climate-policy researcher at the Center for International Climate Research in Oslo, agrees that researchers should be acknowledged for important contributions to public understanding, but he says the challenge in giving scientists credit for public outreach is how to measure its quality and impact against those of conventional journal publications. “If you don’t get the weighting right, then incentives could be perverted and lead to bad outcomes, such as poor quality and political bias,” he says. “The potential is high, but so are the risks.”

One journalist at China’s *Legal Daily* has questioned whether such a policy is legal. It was drafted by the university’s propaganda department, part of the Communist Party of China. According to the laws that govern universities, evaluation decisions are supposed to be made by university administrative departments or faculty committees, writes the journalist.

Some scientists contacted by *Nature* are confident that this initiative will not affect science. But others see it as part of the government’s attempts to control information. There is already concern about Chinese President Xi Jinping’s efforts to align education with communist values and to control what is written by journalists or on social media. Scientists say that bans on Google, Google Scholar and other Internet-based technologies hamper their ability to stay in touch with international peers. “There are certainly many layers of concern,” says one environmental scientist who did not want to be named for fear of damaging relationships with Chinese colleagues.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22822

Comments

Commenting is currently unavailable.

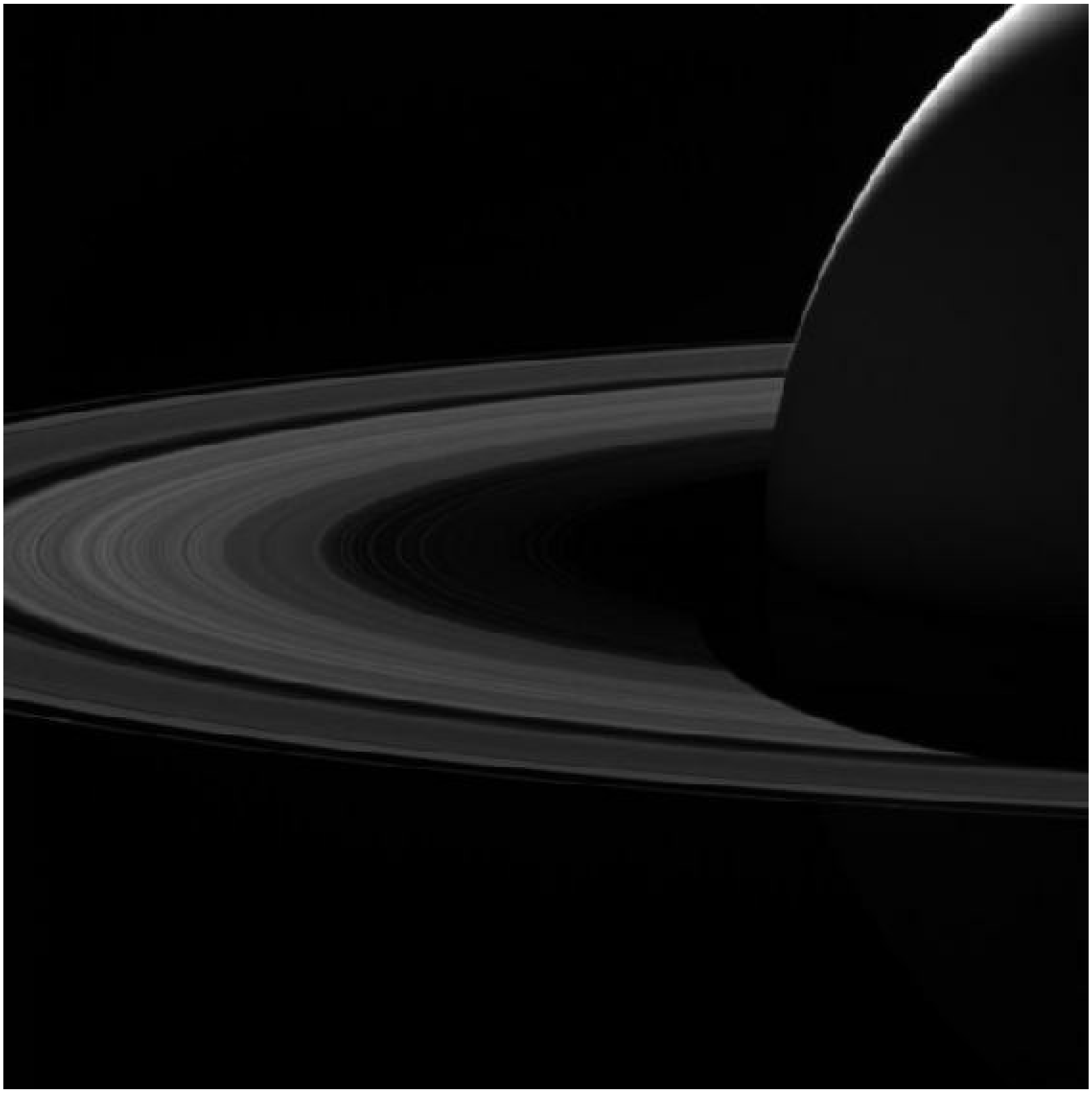
| 章节菜单 | 主菜单 |

Mysterious particles spotted in Saturn’s atmosphere

Source may be dust shed by planet’s iconic rings, according to data from NASA's doomed Cassini probe.

18 October 2017

Provo, Utah



NASA/JPL-Caltech/SSI

Saturn's rings are made of whirling bands of ice and dust.

NASA's Cassini spacecraft continues to yield surprising discoveries, more than a month after [it burned up on its mission-ending dive into Saturn](). New data from the probe suggest that Saturn's majestic rings are showering tiny dust particles into the planet's upper atmosphere, where they form a complicated and unexpected chemical mix.

A mass spectrometer aboard Cassini detected the strange chemistry as the

probe spent its final five months looping between Saturn and its rings.

“We really hit the jackpot,” said Mark Perry, a planetary scientist at the Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland. He reported the findings on 17 October at a meeting of the American Astronomical Society’s Division for Planetary Sciences in Provo, Utah.

Mission scientists had expected Cassini's mass spectrometer to spot the signature of water molecules as the spacecraft slipped between the planet and its rings. In the 1970s and 1980s, NASA's Pioneer and Voyager missions found fewer charged particles than expected in Saturn’s uppermost atmosphere. On the basis of those data, researchers proposed in 1984 that water molecules coming off the rings — mostly in the form of ice — act as catalysts to strip charged particles from the atmosphere[1]. Cassini's final months gave scientists their first opportunity to test this idea directly.

Chemical surprise

But it wasn't evidence of water that jumped out at Cassini's science team. Data from the mass spectrometer revealed a witch’s brew of chemicals, including methane, a molecule that could be carbon monoxide and more-complex molecules. The concentrations of these chemicals are greatest around Saturn’s equator and at high altitudes, which suggests that the material is shedding off the planet’s rings.

The deeper the probe went into the atmosphere, the stranger the measurements became. Cassini’s closest swings past Saturn's surface revealed a panopoly of heavy molecules, Perry told conference attendees. The scientists have not yet pinpointed each type of molecule, but clearly, there is much more than just water around.

By analysing the types of material that could be coming off the rings, Perry’s team concluded that the debris must be fragments of tiny dust particles, which measure just 1 to 10 nanometres across but are relatively heavy. When these particles spiralled off the rings and slammed into Cassini’s mass spectrometer, they shattered into smaller pieces.

Exactly how those particles make the journey from the rings to the atmosphere remains to be seen. “We have a lot of work to do to understand how they are getting in there,” Perry said. “None of the models predict this.”

On these final plunges, pulled along by Saturn’s gravity, Cassini was zooming along at more than 30 kilometres per second — a speed more than four times greater than the mass spectrometer was designed to withstand. “These are higher speeds than anything it has ever seen,” noted Linda Spilker, a planetary scientist at the Jet Propulsion Laboratory in Pasadena, California, and Cassini’s project scientist.

At such enormous speeds, anything that Cassini rammed into would have splintered into bits.

Journal name:
    Nature
DOI:
    doi:10.1038/nature.2017.22838

Comments

Comments

There are currently no comments.

Efforts to save leading Hungarian university hit hurdle

US-registered Central European University faces another year of uncertainty over whether it can continue to operate in Hungary.

18 October 2017

Ferenc Isza/AFP/Getty Images

A sudden change to Hungarian higher-education law in April led to widespread protests.

The threatened Central European University (CEU) in Budapest has been dealt a blow in its efforts to avert possible closure in Hungary.

The country’s parliament voted on 17 October to postpone for a year a

decision that would allow the university to keep operating there. At a press conference held by the university shortly after the vote, CEU rector Michael Ignatieff called the delay “unacceptable” and “unnecessary”.

In April, the Hungarian government unexpectedly amended its higher-education law to require that all foreign-accredited universities there had to operate as higher-education institutes in their countries of origin by 1 January 2018.

The change drew protests and was widely believed to be politically motivated. Critics saw it as an attack on billionaire philanthropist George Soros, who founded the university in 1991 and has openly criticized Hungary’s strict refugee policies.

The CEU took steps to comply with the new requirements and on 3 October sealed an agreement with Bard College in Annandale-on-Hudson, New York, to provide educational activities there. Accredited courses run jointly by the universities would be launched next year, the CEU said. The agreement still needs to be signed by the Hungarian government and ratified by the country’s parliament.

But on 16 October the government proposed delaying the implementation of the amendment until 1 January 2019, and the parliament approved the delay the next day.

A government spokesperson told *Nature* that the purpose of the delay was to give other foreign higher-education institutions time to comply with the new requirements, adding that three institutions, including the CEU, are still in negotiation.

Zoltan Balogh, Hungary’s minister for human capacity, suggested on 16 October that government sign-off of the CEU’s agreement might have to wait for the new deadline.

“We are being deliberately kept in legal limbo,” said Ignatieff, who fears the uncertainty will make it hard to retain faculty and recruit students. “We are being slowly strangled in this battle for academic freedom.”

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22855

Comments

Comments

There are currently no comments.

Sleeping sickness can now be cured with pills

Researchers seek approval from regulators for this quicker, easier treatment.

18 October 2017

Neil Brandvold

Health workers screen people in a remote village in the Democratic Repulic of the Congo for sleeping sickness.

For the first time, researchers have cured the deadly neurological disease sleeping sickness using pills instead of a combination of intravenous infusions and pills. The investigators presented the results from final clinical trials on 17 October at the European Congress on Tropical Medicine and

International Health in Antwerp, Belgium, providing hope that the treatment will help to eliminate the malady within a decade.

The oral therapy — called fexinidazole — cured 91% of people with severe sleeping sickness, compared with 98% who were treated with the combination therapy. It also cured 99% of people in an early stage of the disease who would typically undergo a spinal tap to determine whether they needed infusions. The relative ease of the treatment with fexinidazole means that if approved, it might save more lives than the current option, say the investigators leading the phase 3 trial, the final phase of testing before the drug goes to regulators for approval.

Sleeping sickness is endemic to Africa and generally infects extremely poor people who live in remote regions. The sick often suffer from the disease for years before seeking treatment, causing them and those caring for them to miss work and spend their savings on traditional medicines. Trekking to a hospital and remaining there for intravenous infusions is costly as well.

“It’s not just the person with sleeping sickness, it’s the family that takes care of them during years of this neurological, very serious disease,” says Philippe Büscher, a sleeping-sickness specialist at the Institute of Tropical Medicine in Antwerp, Belgium, who was not involved in the study. “Whatever money they have, they’ll spend on this instead of anything else.”

Büscher commends the team for conducting a quality clinical trial under extraordinary circumstances in countries hit hardest by the disease, the Democratic Republic of the Congo and the Central African Republic. Investigators had to carry equipment to remote clinics over rugged terrain; one study site was repeatedly robbed; and early on in the trial, some participants fled armed conflict. “I need to congratulate them for beautiful work,” Büscher says.

Neil Brandvold

The hospital where Pablo Loela was being treated for sleeping sickness canno afford to provide food for their patients: families must provide meals for their loved ones.

A better way

Sleeping sickness — also known as human African trypanosomiasis — is spread through the bite of tsetse flies carrying parasites, most commonly *Trypanosoma brucei gambiense*. The organism infects the central nervous system, and patients can experience confusion, daytime sleepiness, night-time insomnia and various psychiatric symptoms, including manic episodes and aggression. If left untreated, they enter a coma and die. For decades, the only treatment was a toxic arsenic-based drug that killed one in 20 patients.

In 2009, researchers introduced a safer option: nifurtimox–eflornithine combination therapy, or NECT, which consists of pills and 14 intravenous

infusions. For the first time in 50 years, the incidence of sleeping sickness slipped below 10,000 new cases per year; it's currently around 2,200, according to the World Health Organization. But the need for infusions, along with the spinal tap required to qualify a patient for the treatment, still present obstacles in regions where sterile equipment, electricity and doctors are in short supply.

The group that developed NECT — a non-profit research organization based in Geneva, Switzerland, called the Drugs for Neglected Diseases initiative (DNDi) — continued searching for a better therapy. In 2007, it discovered fexinidazole, a compound that had been shelved by Paris-based pharmaceutical company Sanofi. With the firm's agreement, the DNDi took the drug through clinical trials. It estimates that developing the therapy through to approval will cost a total of around US$50 million — a fraction of what pharmaceutical companies often spend on new drugs.

Just the beginning

Sanofi will soon submit an application for drug approval through the European Medicines Agency, whose sign-off could pave the way for regulators in the Democratic Republic of the Congo. The drug might get a green light by the end of next year, says Nathalie Strub Wourgraft, the DNDi's medical director. Because it is a simple oral treatment, she suggests that patients might even be treated at home, which would save them and their families the expense of hospital stays.

However, Büscher argues that home treatments could be dangerous because people who don't respond to fexinidazole could die of the disease if not seen immediately by medical staff. It's imperative that patients follow up with health workers, he says, and he suggests offering people incentives to return to the clinic, such as money or staples including salt or sorghum. "This is a success," he says, "but it is not the end."

DNDi researchers and their colleagues are currently working on what they hope will be an even better oral treatment to cure the disease in a single dose, and more reliably than fexinidazole.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22856

Comments

Commenting is currently unavailable.

Self-taught AI is best yet at strategy game Go

Artificial-intelligence program AlphaGo Zero trained in just days, without any human input.

18 October 2017

Xavierarnau/Getty

AlphaGo Zero came up with Go strategies that human players haven't invented in thousands of years.

An artificial intelligence (AI) program from Google-owned company DeepMind has reached superhuman level at the strategy game Go — without learning from any human moves.

This ability to self-train without human input is a crucial step towards the dream of creating a general AI that can tackle any task. In the nearer-term, though, it could enable programs to take on scientific challenges such as protein folding or materials research, said DeepMind chief executive Demis Hassabis at a press briefing. “We’re quite excited because we think this is now good enough to make some real progress on some real problems.”

Previous Go-playing computers developed by DeepMind, which is based in London, began by training on more than 100,000 human games played by experts. The latest program, known as AlphaGo Zero, instead starts from scratch using random moves, and learns by playing against itself. After 40 days of training and 30 million games, the AI was able to beat the world's previous best 'player' — another DeepMind AI known as AlphaGo Master. The results are published today in *Nature*[1], with an accompanying commentary[2].

Getting this technique, known as reinforcement learning, to work well is difficult and resource-intensive, says Oren Etzioni, chief executive of the Allen Institute for Artificial Intelligence in Seattle, Washington. That the team could build such an algorithm that surpassed previous versions using less training time and computer power “is nothing short of amazing”, he adds.

Strategy supremo

The ancient Chinese game of Go involves placing black and white stones on a board to control territory. Like its predecessors, AlphaGo Zero uses a deep neural network — a type of AI inspired by the structure of the brain — to learn abstract concepts from the boards. Told only the rules of the game, it learns by trial and error, feeding back information on what worked to improve itself after each game.

At first, AlphaGo Zero’s learning mirrored that of human players. It started off trying greedily to capture stones, as beginners often do, but after three days it had mastered complex tactics used by human experts. “You see it rediscovering the thousands of years of human knowledge,” said Hassabis.

After 40 days, the program had found plays unknown to humans (see 'Discovering new knowledge').

Discovering New Knowledge

Deepmind

Approaches using purely reinforcement learning have struggled in AI because ability does not always progress consistently, said David Silver, a scientist at DeepMind who has been leading the development of AlphaGo, at the briefing. Bots often beat their predecessor, but forget how to beat earlier versions of themselves. This is the project's first "really stable, solid version of reinforcement learning, that’s able to learn completely from scratch," he said.

AlphaGo Zero’s predecessors used two separate neural networks: one to predict the probable best moves, and one to evaluate, out of those moves, which was most likely to win. To do the latter, they used ‘roll outs’ — playing multiple fast and randomized games to test possible outcomes. AlphaGo Zero, however, uses a single neural network. Instead of exploring possible outcomes from each position, it simply asks the network to predict a winner. This is like asking an expert to make a prediction, rather than relying on the games of 100 weak players, said Silver. “We’d much rather trust the predictions of that one strong expert.”

Merging these functions into a single neural network made the algorithm both stronger and much more efficient, said Silver. It still required a huge amount of computing power — four of the specialized chips called tensor processing units, which Hassabis estimated to be US$25 million of hardware. But its predecessors used ten times that number. It also trained itself in days, rather than months. The implication is that “algorithms matter much more than either computing or data available”, said Silver.

Think outside the board

Several DeepMind researchers have already moved from working on AlphaGo to applying similar techniques to practical applications, said Hassabis. One promising area, he suggested, is understanding how proteins fold, an essential tool for drug discovery.

Generating examples of protein folding can involve years of painstaking crystallography, so there are few data to learn from, and there are too many possible solutions to predict structures from amino-acid sequences using a brute-force search. The puzzle shares some key features with Go, however. Both involve well-known rules and have a well-described goal. In the longer term, such algorithms might be applied to similar tasks in quantum chemistry, materials design and robotics.

Silver acknowledged that to apply its approach to real-world tasks more generally, the AI will need the ability to learn from smaller amounts of data and experience. Another essential step will be learning the rules of a game for itself, as another DeepMind bot did in 2015 for arcade games. Hassabis reckons this is something AlphaGo Zero could eventually do: “We’re pretty sure it would work, it would just extend the learning time a lot,” he said.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22858

Comments

Comments

There are currently no comments.

Science must examine the future of work

As automation changes employment, researchers should gather the evidence to help map the implications.

18 October 2017

VCG/Getty

Automation will take away jobs, but a bigger question is how many it will generate.

In 2014, the *Los Angeles Times* began beating its rivals to report earthquakes, using an algorithm to convert announcements from the US Geological Survey

(USGS) to breaking news within a few minutes. This June, it announced that a magnitude-6.8 quake had shaken Santa Barbara, California. That was certainly news to the distinctly unshaken residents of Santa Barbara; the earthquake the newspaper was reporting on had actually happened in 1925. The paper's Quakebot had misinterpreted an update to the USGS seismic database and published its story online without anyone checking. The story was deleted and Santa Barbarans (and human journalists everywhere) could breathe a sigh of relief.

The tale encapsulates many of the issues that surround the intensifying debate about the roles of computers and humans in the workplace of the future — both the very near and the very far. Much of that debate places people and algorithms in direct competition. From lorry drivers threatened by self-driving vehicles to doctors who could be replaced by know-it-all diagnostic devices, many jobs as we know them could be done by artificial intelligence (AI) systems.

In an Editorial last year on the likely role and risks of AI in future society, *Nature* noted that even academic debate on the topic is polarized between sceptics and fanciful futurists (see *Nature* **532,** 413; 2016). In a special issue this week, we try to find and explore some middle ground, by bringing together and assessing the evidence on how automation will affect the future of work.

In a sense, this debate is nothing new. Technology and automation have been putting people out of jobs for hundreds of years, as historian Robert Allen discusses in a Comment. So have other factors — chiefly economic trends and globalization. But the spread of technology has also created new roles. In broad terms, as manufacturing jobs in the West have been transferred to low-wage economies elsewhere, politicians and economists have looked to tech to help fill the gap. These new industries, they argue, both need direct labour to develop them and create employment indirectly through the need for service and support. But will this trend continue? The true debate over the future of work is not whether computers will replace people in many jobs — they surely will — but whether they are team players. For how long will Quakebot and its descendants need a human supervisor?

Both sceptics and fanciful futurists will find something to agree and disagree

with in the articles that follow. In a Comment, Yuval Noah Harari, historian and best-selling author of *Sapiens* (Harper, 2014) and *Homo Deus* (Harvill Secker, 2015), argues: “The challenges posed in the twenty-first century by the merger of infotech and biotech are arguably bigger than those thrown up by steam engines, railways, electricity and fossil fuels.” He also offers reassurance about job prospects for some people, from a perhaps unlikely source. Each US military drone flying over Syria keeps 110 people in a job, he writes — 30 operators and 80 analysts to process the information it sends back. This is not an argument for more drones, the use of which is controversial. But, as Harari writes: “A careful study of the military job market might tell us a lot about potential future developments in the civilian economy.”

Careful study, *Nature* naturally argues, is something that (human) scientists and other academics excel at. As the 2016 editorial put it, “it is crucial that progress in technology is matched by solid, well-funded research to anticipate the scenarios it could bring about”, such as impacts on mental health and management, and how humans interact with robots. It’s important, too, to study possible political and economic reforms that will allow those usurped by machinery to contribute to society.

The Oxford Martin Programme on Technology and Employment at the University of Oxford, UK, is doing just this (see go.nature.com/2xxauvm). Oxford economist Ian Goldin offers his own thoughts.

Among the topics worthy of examination is the future fate of science and scientists. So far, the application of technology and automation to research has fuelled, and not felled, the need for human support. Indeed, fields such as bioinformatics exist only because of the work that computers generate for scientists. But as explored in a Careers Feature, science is not immune from the gig economy — short-term employment on specialist tasks such as writing a literature review or managing a database. The trend towards parcelling off and even publishing science as a series of steps rather than full papers could see demand for freelance services rise. (The breakdown of complex tasks into a series of simpler steps is, of course, also a proven path to automation.)

Still, browse ‘help needed’ adverts for scientific gigs and the future looks less

rosy. As little as US$80 to perform a detailed meta-analysis of published studies? It’s hardly worth even plugging in for that.

Journal name:
Nature
Volume:
550,
Pages:
301–302
Date published:
(19 October 2017)
DOI:
doi:10.1038/550301b

Comments

Comments

There are currently no comments.

Blue is in the eye of the bee-holder

Flowers have evolved an ingenious way to attract pollinators.

18 October 2017

Ron Reznick/VW Pics/UIG via Getty Images

Nanostructures on flowers generate a blue halo that attracts bees.

The car maker Lexus announced a new paint job for its LC coupé this month, which it says will appeal to drivers who value the interaction of science and craftsmanship. The car is blue and the science it leans on is the optics of iridescence. Lexus says that it uses several layers of pigment to increase the amount of incoming light that reflects as blue. The finish, it claims, is “more blue” than anything seen before — and more time-consuming to apply. People who buy the model are unlikely to suffer that common psychological

bias experienced by owners of a new car who suddenly notice other vehicles everywhere the same colour as theirs: at present, the company can make just two a day.

Lexus says that its new blue is based on the famous wings of the morpho butterfly. These contain no pigment, but look blue because of how the wing structure physically separates the various components of white light and reflects only certain wavelengths. The company could also have borrowed the idea from the (less PR friendly) tarantula spider, many species of which use the hairs on their legs and body to show off the same blue effect. In fact, such iridescence is fairly common in plants and animals — sometimes deliberate (the shimmer of the peacock tail) and sometimes less so (the same effect from a fresh cut of meat). It's why a blue-cooked steak really does look blue. blue pigments are rare), and this week a paper online in *Nature* explores its role in flowering plants (E. Moyroud *et al. Nature* http://dx.doi.org/10.1038/nature24285; 2017).

Fewer than 10% of the 280,000 species of flowering plant naturally produce blue petals. This presents a problem, because the bees on which many flowers rely for pollination struggle to see any colour other than blue. So how do these flowers attract the insects they need?

The new study shows that they use structural-colour techniques to generate an iridescent blue halo. From the tulip to the golden perennial sweet pea, a dozen different flowering plants of varying colours were found to have surface nanostructures that produced the optical effect. It's visible to the human eye, too, and best seen against dark-coloured petals.

In a series of tests with bumblebees (*Bombus terrestris*), the researchers demonstrate that the insects avoid artificial flowers made to have smooth surfaces that don't produce the blue ring. And they show how the insects see the halo more easily than we do, because bee vision can better distinguish the ultraviolet frequencies into which the structural-colour effect spreads. The findings are discussed in an accompanying News & Views article (D. D. Deheyn *Nature* http://dx.doi.org/10.1038/nature24155; 2017).

Lexus boasts that it took more than a decade to develop its new blue paint. It took the flowers a lot longer: their ability to generate the halo effect has

evolved over millions of years, and perhaps emerged in each species independently. In both cases, the colour is best appreciated at first hand. Photographs do not do it justice. Take a stroll in the garden. And keep one eye on the road.

Journal name:
Nature
Volume:
550,
Pages:
302
Date published:
(19 October 2017)
DOI:
doi:10.1038/550302a

Comments

Comments

There are currently no comments.

Epic star collision, asteroid fly-by and journal resignations

The week in science: 13–19 October 2017.

18 October 2017

Events | People | Research | Facilities | Policy | Awards | Funding | Trend watch

EVENTS

Flames devastate northern California Wildfires have scorched about 890 square kilometres in Northern California, leaving at least 41 people dead as of 17 October, making them the deadliest fires in the state's history. Nearly 100,000 residents of Napa and Sonoma Counties had been evacuated from their homes, although this week officials have started to let people return. At least 88 of the many hundreds of people who were reported missing are still unaccounted for. The exact cause of the flames is unknown, but the area was primed for a conflagration. Vegetation flourished in the region after record rainfall last winter, and heatwaves this summer dried everything out, turning it into kindling. Winds gusting at more than 100 kilometres per hour hindered the efforts of firefighters to bring the blazes under control.

Justin Sullivan/Getty

Journal editors quit Five German scientists said on 12 October that they have resigned their editorial positions at journals published by Elsevier, after negotiations over a national licensing agreement for German institutes ground to a halt. For more than a year, a consortium of German science organizations called Projekt DEAL has been pushing for a new type of nationwide licence with Elsevier that would include open-access options and replace the need for individual institutional subscriptions. About 200 German universities and research institutes have cancelled their individual contracts with the Dutch publisher.

Asteroid buzz A house-sized asteroid whizzed by Earth on 12 October, passing within 44,000 kilometres of the planet — just above the orbits of geostationary satellites — and providing a test of international planetary defences. Telescopes around the globe swivelled to track the body, which is estimated to be 15–30 metres wide and is known as 2012 TC4. NASA, the European Space Agency and other asteroid-hunting groups gathered data to fine-tune orbital calculations and establish its future path. The asteroid's next

close pass will be in 2050, when it will safely fly by Earth. Future Earth impacts after that date have not been ruled out.

PEOPLE

Trump nominations Barry Myers, the chief executive of weather-forecasting firm AccuWeather, is US President Donald Trump's pick to lead the National Oceanic and Atmospheric Administration (NOAA), the White House said on 11 October. Myers, an attorney by training, has led AccuWeather — based in State College, Pennsylvania — since 2007. Some scientists worry that his ties to the company could lead to conflicts of interest, and note that he has no direct experience with NOAA's broader research portfolio, which includes the climate, oceans and fisheries. Two days later, the White House announced that Trump had nominated Kathleen Hartnett White, a former Texas environmental regulator and prominent climate sceptic, for its top environmental post. If confirmed as chair of the Council on Environmental Quality, White would advise the president and coordinate federal policies on energy and the environment. White is a fellow at the Texas Public Policy Foundation, a conservative think tank based in Austin. She has called efforts to shift away from fossil fuels "environmental lunacy".

New Pasteur chief Stewart Cole was appointed on 13 October as the next president of the Pasteur Institute in Paris, replacing Christian Bréchot, who had reached the institute's mandated retirement age. Many of the Pasteur's researchers had wanted Bréchot to stay on, but a campaign to change the age-limit rule was unsuccessful. Cole, a microbial-pathogenesis specialist, has held several posts at the biomedical research institute and will begin his four-year term in January. Last month, Bréchot was appointed president of the Global Virus Network, an international coalition of virologists based in Baltimore, Maryland.

RESEARCH

Epic stellar clash Researchers announced on 16 October that they had for the first time witnessed the collision of two neutron stars — and perhaps the

subsequent formation of a black hole. The event was first spotted on 17 August by gravitational-wave detectors in the United States and Italy and by a NASA γ-ray probe. More than 70 observatories rushed to observe the collision's aftermath; their discoveries are detailed in dozens of papers and solve several cosmic mysteries.

FACILITIES

FAST's first pulsars The world's largest single-dish telescope has observed its first two pulsars. The Five-hundred-meter Aperture Spherical Telescope (FAST) in southern China's Guizhou province detected the neutron stars in August. Researchers at the National Astronomical Observatories of China reported the results on 10 October after they were confirmed by an Australian telescope. The observations suggest FAST is working well, despite its radical design: the dish consists of thousands of panels that move to track radio signals, requiring elaborate coordination. Signals from the two pulsars were captured a year into an estimated three-year debugging phase. FAST, which is expected to find hundreds, possibly thousands, of pulsars, is looking for clues to how the Universe formed, as well as for signs of extraterrestrial life.

China Daily/Reuters

POLICY

Climate-rule repeal On 10 October, the US Environmental Protection Agency moved to repeal former president Barack Obama's landmark regulations to reduce greenhouse-gas emissions from power plants. Agency administrator Scott Pruitt signed a measure to begin the process of rescinding the Obama policy, a move that is expected to spark lawsuits by environmental groups and some states. The power-plant rule would reduce greenhouse-gas emissions to 32% below 2005 levels by 2030. In 2016, the Supreme Court blocked the policy from taking effect; legal challenges from 27 state governments are still pending, although a federal appeals court has put the case on hold while the administration of President Donald Trump reviews the rule.

Measuring impact UK science minister Jo Johnson has announced plans to

assess universities on their economic impact and engagement with wider society. Higher-education bodies will consult on creating a Knowledge Exchange Framework, an evaluation system designed to incentivize activities such as transferring technology into industry, spinning off companies and conducting contract research, training and consultancy, Johnson said on 12 October. If implemented, the framework would become a third strand of UK university assessment, alongside the Teaching Excellence Framework and Research Excellence Framework.

AWARDS

MacArthur grants The philanthropic MacArthur Foundation in Chicago, Illinois, announced its 2017 award recipients on 11 October. Six of the 24 winners — often referred to as MacArthur geniuses — are scientists. They include anthropologist Jason De León of the University of Michigan in Ann Arbor, who uses methods including archaeology and forensic science to study undocumented migrants on the US–Mexican border; computational linguist Regina Barzilay of the Massachusetts Institute of Technology in Cambridge, who deciphers ancient languages using machine learning; and immunologist Gabriel Victora of the Rockefeller University in New York City, who observes how antibodies evolve in the immune system in real time. Each winner gets US$625,000 over 5 years, with no restrictions on how they can spend the money.

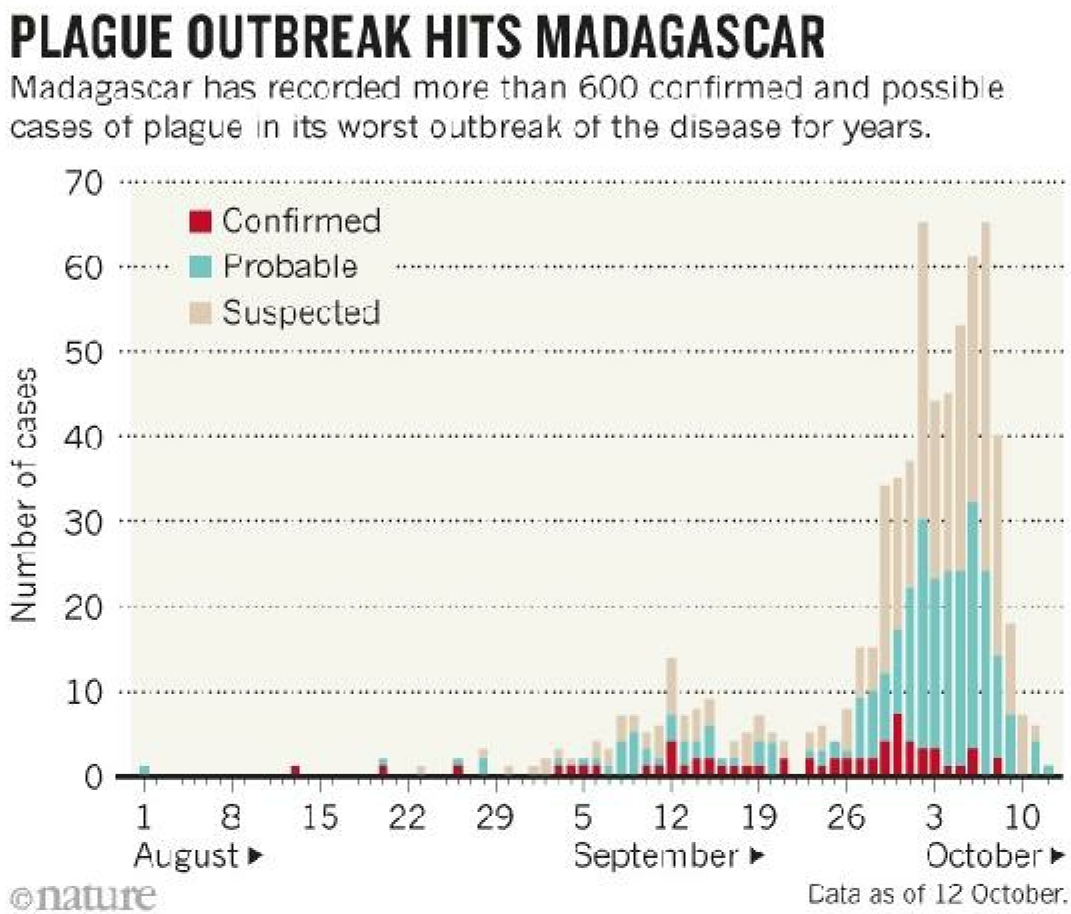
FUNDING

Research boost Online shopping giant Alibaba will set up seven international research laboratories as part of its plan to spend US$15 billion on research and development over the next three years. The company, based in Hangzhou, China, announced the Alibaba DAMO Academy on 11 October. The seven labs will be established in China, the United States, Russia, Israel and Singapore. Research topics will include data intelligence, the ‘Internet of things’, quantum computing and human–machine interfaces. Recruitment of the first 100 researchers is under way. The advisory board of the academy includes prominent scientists from outside China, including

geneticist George Church of Harvard University in Cambridge, Massachusetts.

TREND WATCH

Madagascar is battling an outbreak of plague, with more than 600 cases and at least 57 deaths since 1 August. Plague is endemic to the island and surfaces almost annually. But the current outbreak is unusually large, and cases are mostly of pneumonic plague, which is deadlier and more transmissible than the more usual bubonic form. Untreated, pneumonic plague can kill within 24 hours. On 10 October, the World Health Organization reported a linked case of plague in the Seychelles.



Source: WHO

Journal name:
Nature
Volume:
550,
Pages:
306–307
Date published:
(19 October 2017)
DOI:
doi:10.1038/550306a

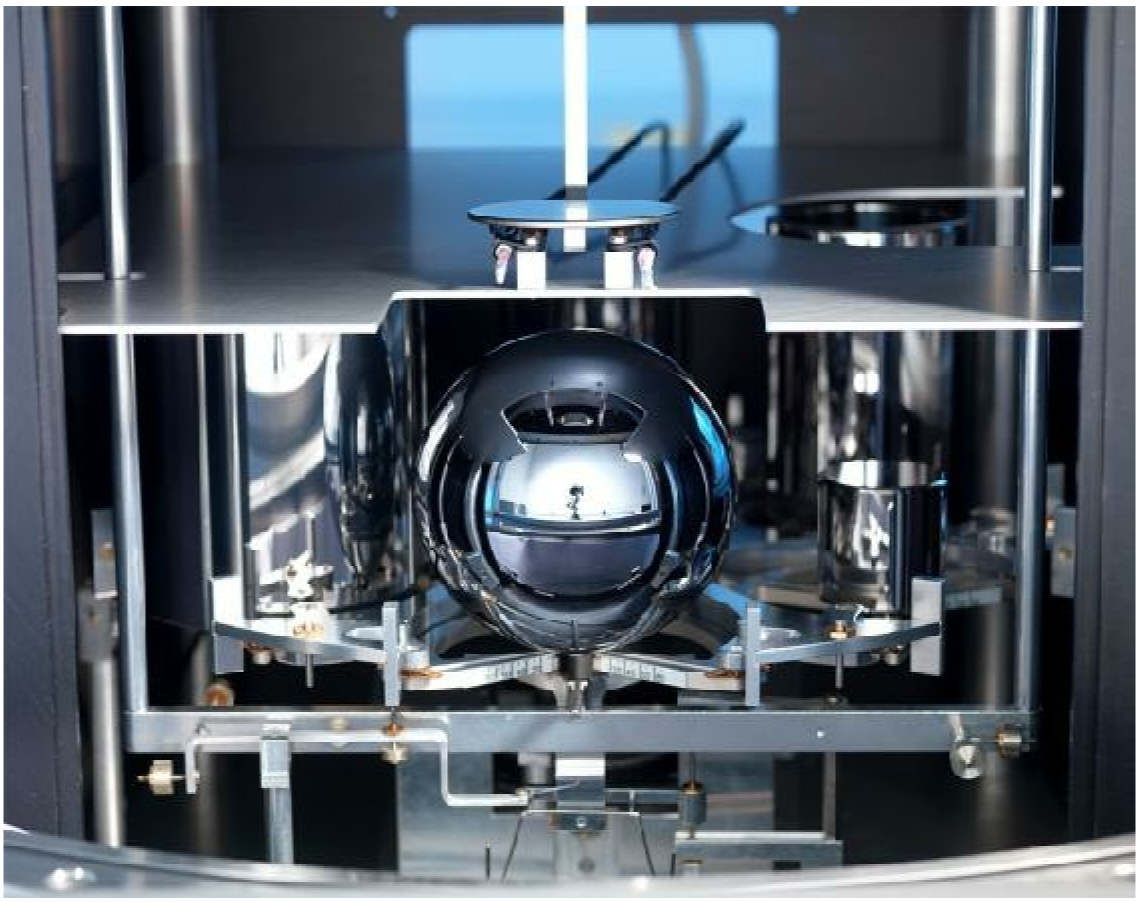
Comments

Commenting is currently unavailable.

New definitions of scientific units are on the horizon

Metrologists are poised to change how scientists measure the Universe.

18 October 2017



Natl. Phys. Lab., UK

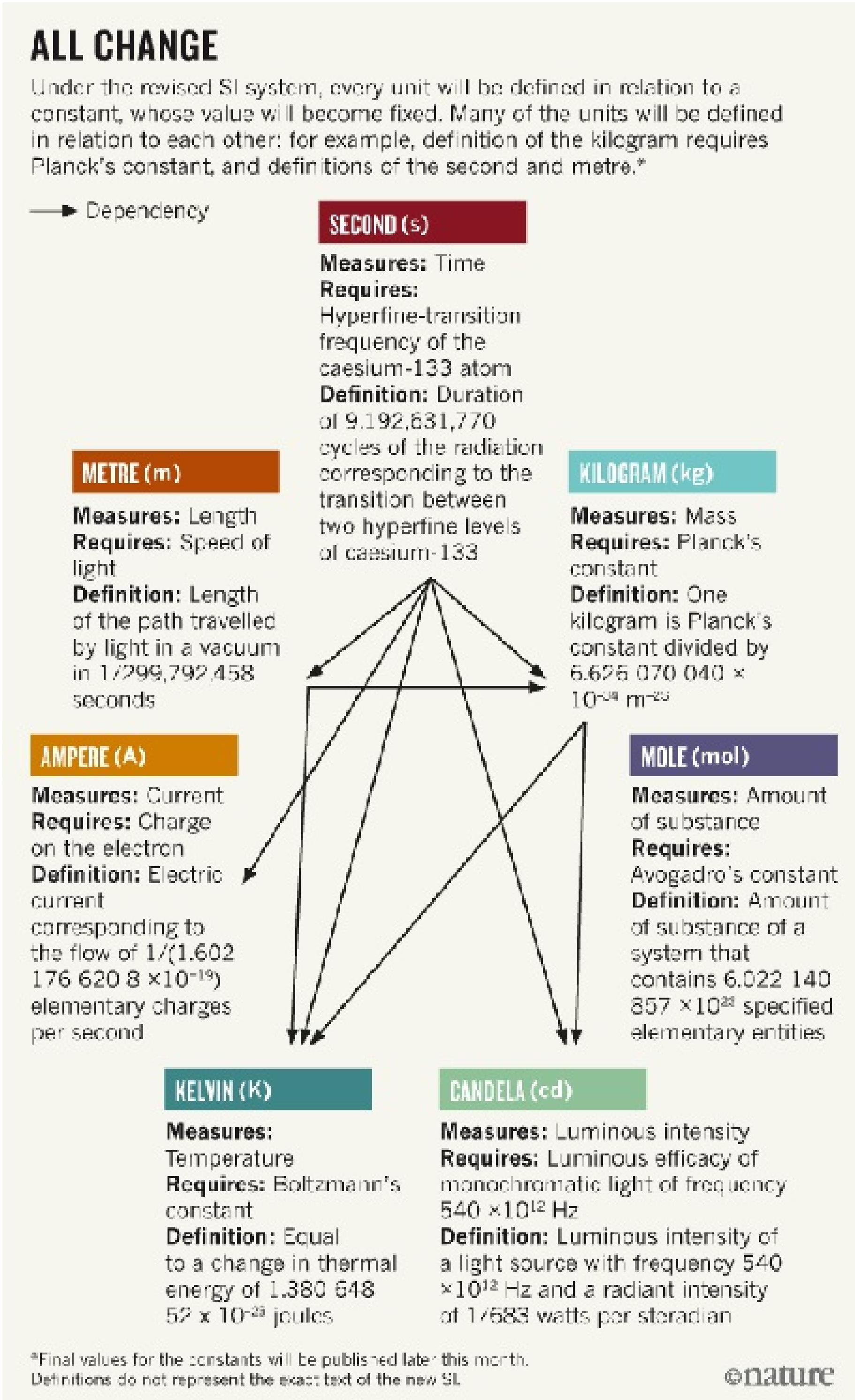
A sphere of pure silicon can be used to define a unit of measurement known as a mole.

Revamped definitions of scientific units are on their way. In the biggest

overhaul of the international system of units (SI) since its inception in 1960, a committee is set to redefine four basic units — the ampere, the kilogram, the kelvin and the mole — using relationships to fundamental constants, rather than abstract or arbitrary definitions. The International Bureau of Weights and Measures is reviewing the plans at a meeting near Paris from 16 to 20 October. Its recommendations will then go before the General Conference on Weights and Measures, which oversees the SI system, in November 2018. The changes would take effect in May 2019.

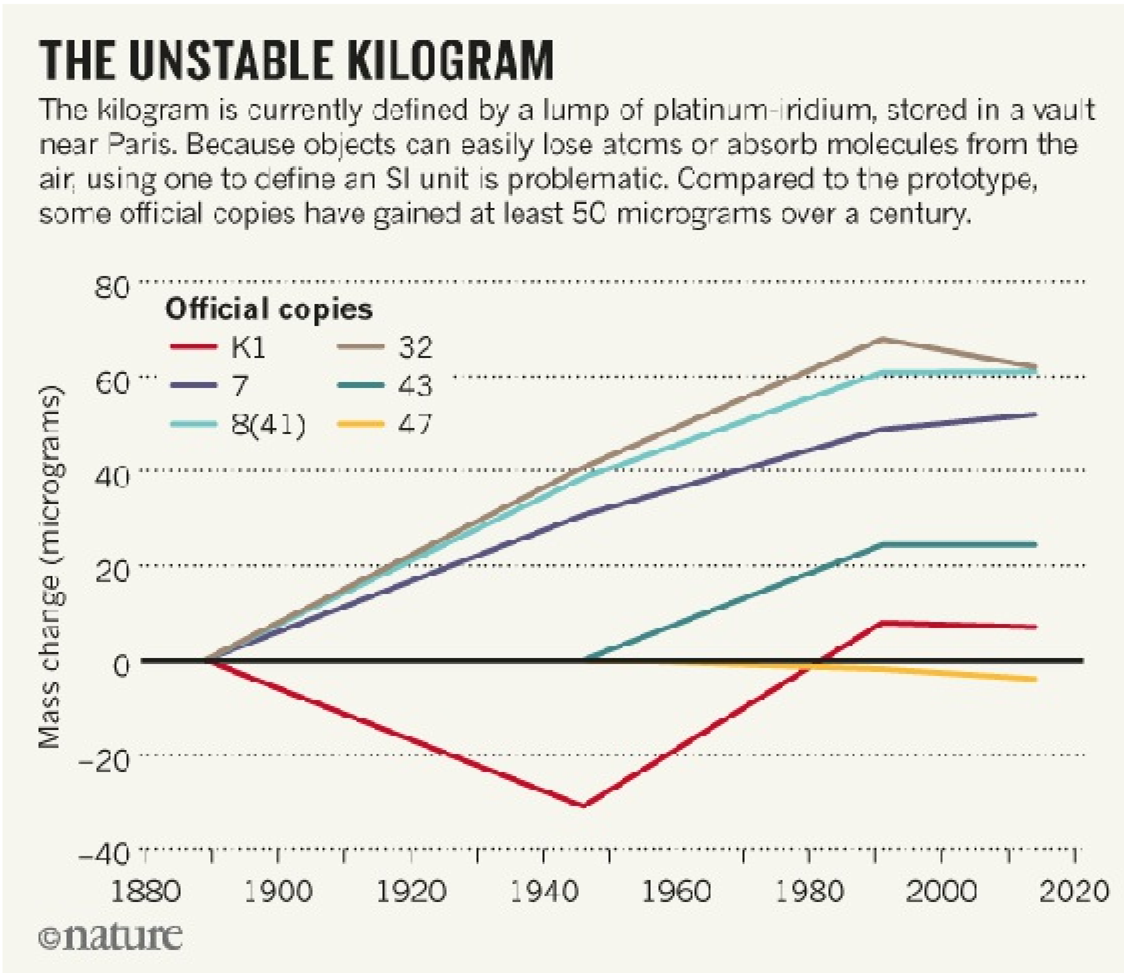
The kilogram is currently defined as the mass of a chunk of metal in a vault in Paris. And an imaginary experiment involving the force between two infinite wires defines the ampere, the unit of electrical current. The mole, meanwhile, is the amount of substance in a system with as many elementary entities as there are atoms in 0.012 kilograms of carbon-12, while the kelvin relates to the temperature and pressure at which water, ice and water vapour co-exist in equilibrium, known as the triple point of water. In the future, these units will be calculated in relation to constants — for example, the ampere will be based on the charge of an electron.

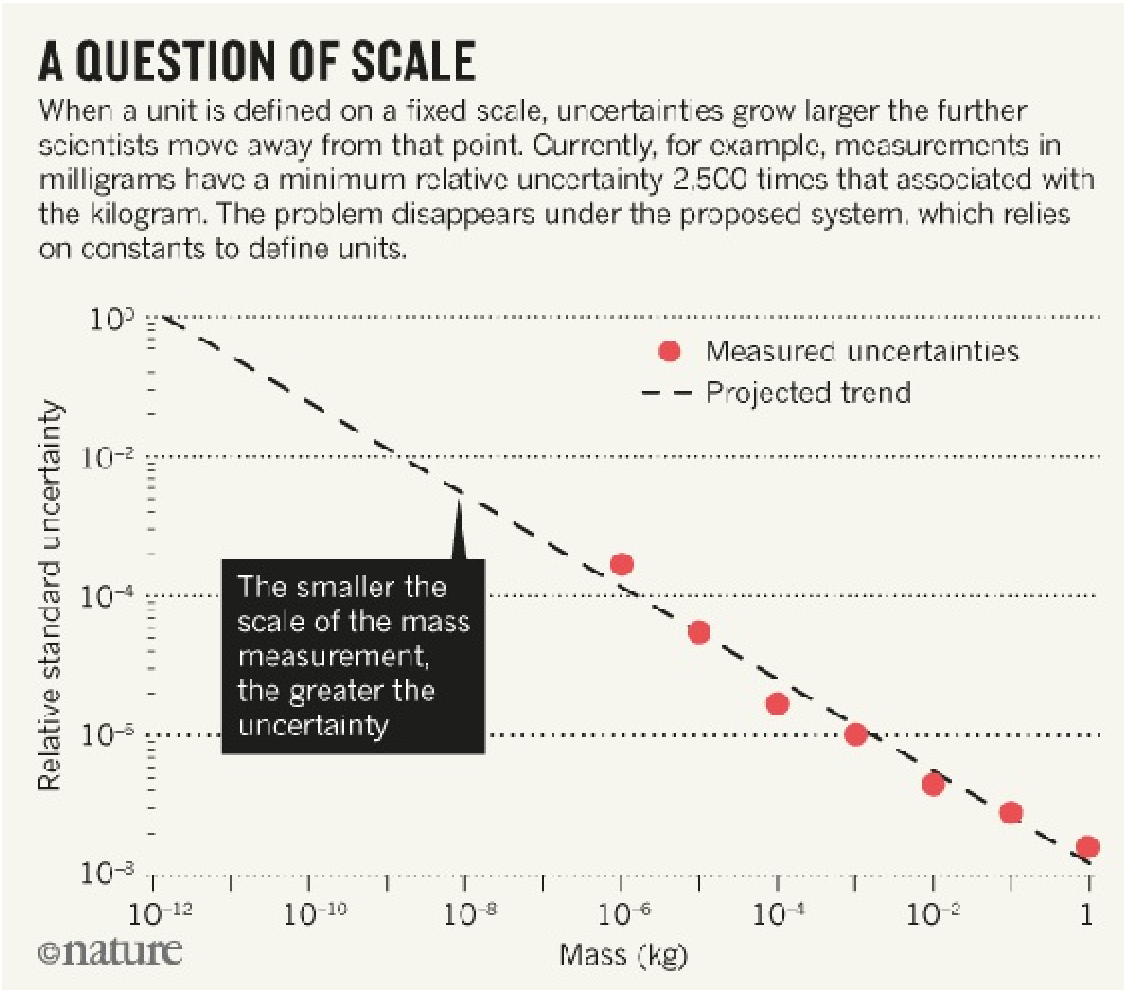
Redefinition might not affect everyday measurements, but it will enable scientists working at the highest level of precision to do so in multiple ways, at any place or time and on any scale, without losing accuracy.


ALL CHANGE
Under the revised SI system, every unit will be defined in relation to a constant, whose value will become fixed. Many of the units will be defined in relation to each other: for example, definition of the kilogram requires Planck's constant, and definitions of the second and metre.*
Dependency
SECOND (s)
Measures: Time
Requires: Hyperfine-transition frequency of the caesium-133 atom
Definition: Duration of 9,192,631,770 cycles of the radiation corresponding to the transition between two hyperfine levels of caesium-133
METRE (m)
Measures: Length
Requires: Speed of light
Definition: Length of the path travelled by light in a vacuum in 1/299,792,458 seconds
KILOGRAM (kg)
Measures: Mass
Requires: Planck's constant
Definition: One kilogram is Planck's constant divided by 6.626 070 040 × 10⁻³⁴ m⁻²s
AMPERE (A)
Measures: Current
Requires: Charge on the electron
Definition: Electric current corresponding to the flow of 1/(1.602 176 620 8 ×10⁻¹⁹) elementary charges per second
MOLE (mol)
Measures: Amount of substance
Requires: Avogadro's constant
Definition: Amount of substance of a system that contains 6.022 140 857 ×10²³ specified elementary entities
KELVIN (K)
Measures: Temperature
Requires: Boltzmann's constant
Definition: Equal to a change in thermal energy of 1.380 648 52 x 10⁻²³ joules
CANDELA (cd)
Measures: Luminous intensity
Requires: Luminous efficacy of monochromatic light of frequency 540 ×10¹² Hz
Definition: Luminous intensity of a light source with frequency 540 ×10¹² Hz and a radiant intensity of 1/683 watts per steradian
*Final values for the constants will be published later this month.
Definitions do not represent the exact text of the new SI.
©nature

The problem

For measurements on conventional scales, existing definitions of SI units suffice. But they are poor tools for modern science at the extremes. And basing units on specific points or materials can be troublesome and inelegant, say metrologists.





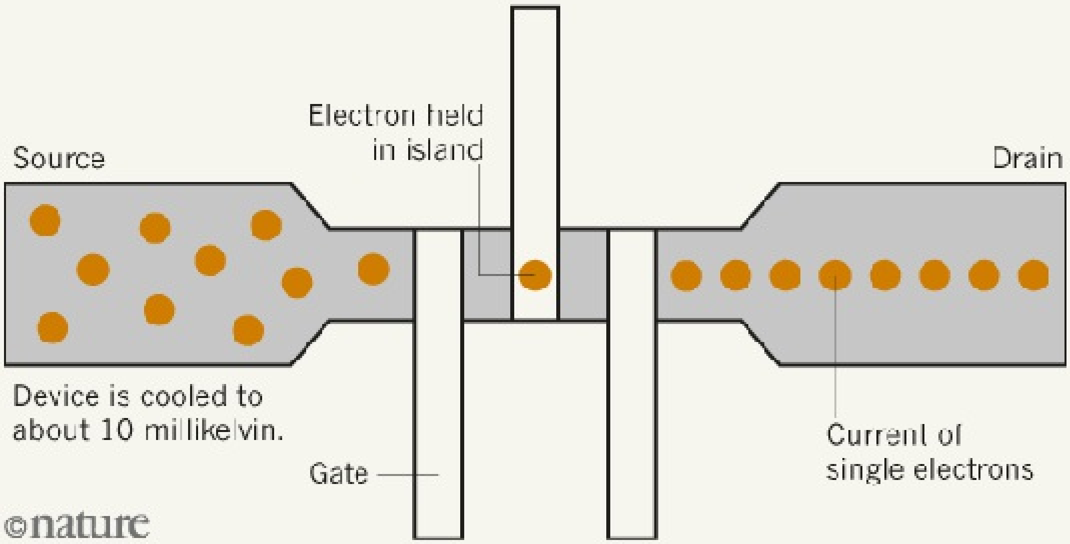
Source: Shaw, G. et al. Metrologia 53, A86–A94 (2016).

The techniques

Under the revamped SI system, researchers will be able to use various experiments to relate constants to each of the units measured.

AMPERE: THE SINGLE-ELECTRON PUMP

Used to measure the charge of an electron, an electron pump could become one tool for determining the ampere. By trapping individual electrons as they travel rapidly across a conductor, the pump can generate a measureable current by counting single electrons.



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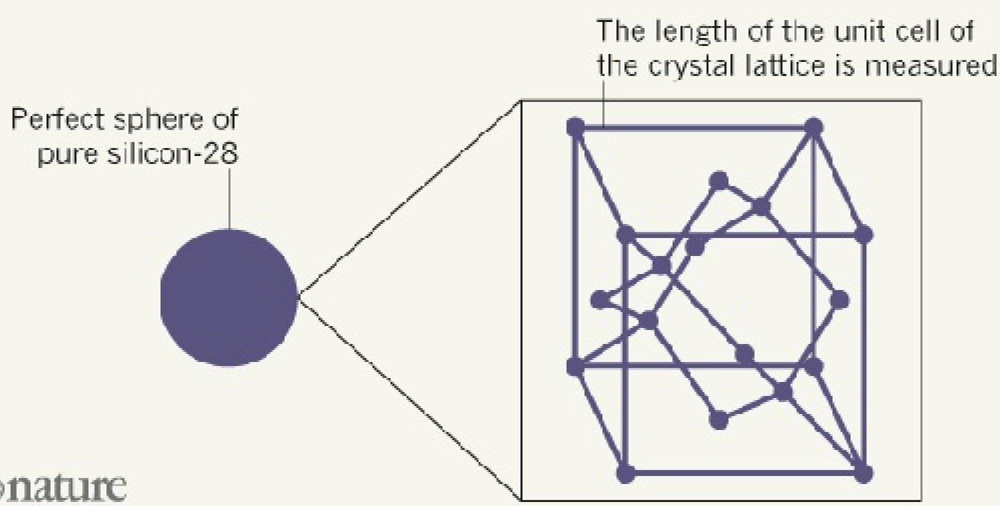
MOLE: THE SILICON SPHERE

As the device that gives scientists Avogadro's constant, this silicon sphere offers a state-of-the-art way to measure a mole. It would determine the precise number of atoms in a perfect sphere of pure silicon-28. Researchers do this by using lasers to measure the length of a unit of the sphere's crystal lattice, and its mean diameter.



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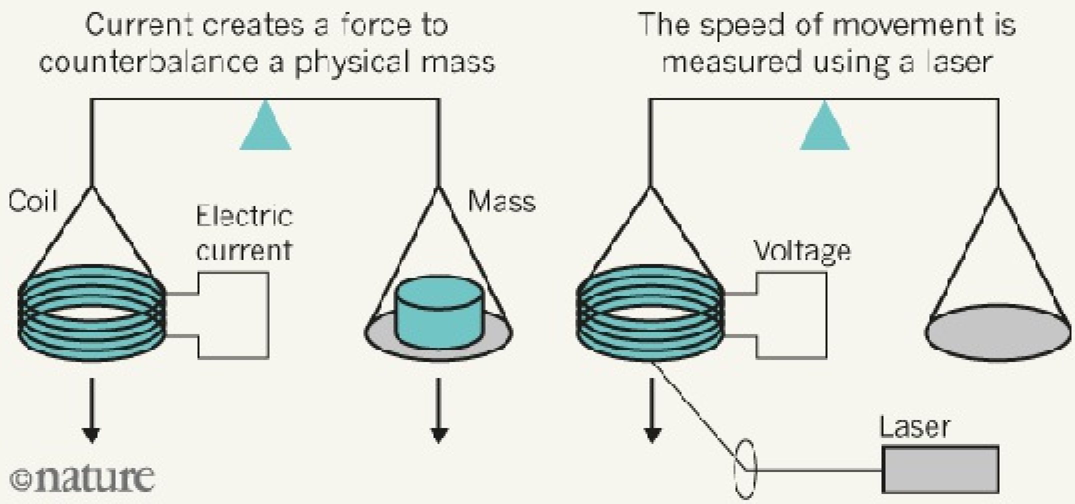
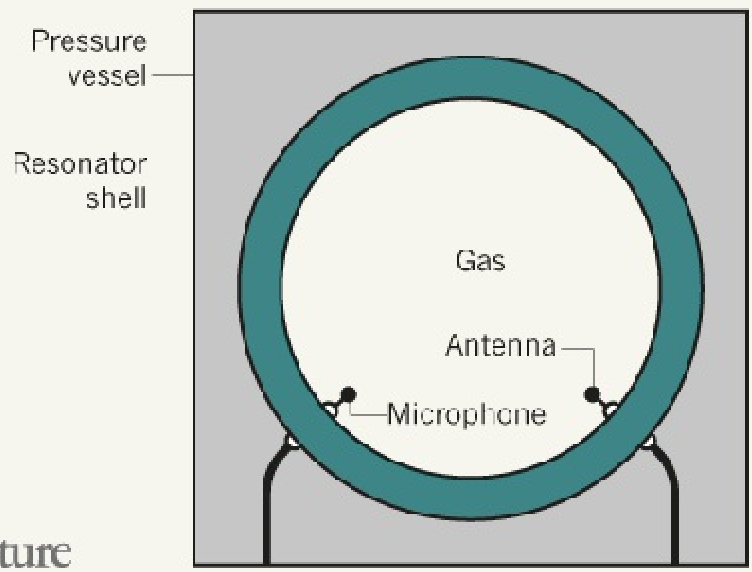
KILOGRAM: THE WATT BALANCE

The Watt balance compares mechanical power with electromagnetic power using two separate experiments. First, a current is run through a coil in a magnetic field to create a force that counterbalances a known physical mass. Then, the coil is moved through the field to create a voltage. By measuring the speed as well as experimental values that relate the voltage and current to Planck's constant, scientists can precisely determine the weight of a mass in kilograms.



KELVIN: ACOUSTIC THERMOMETRY

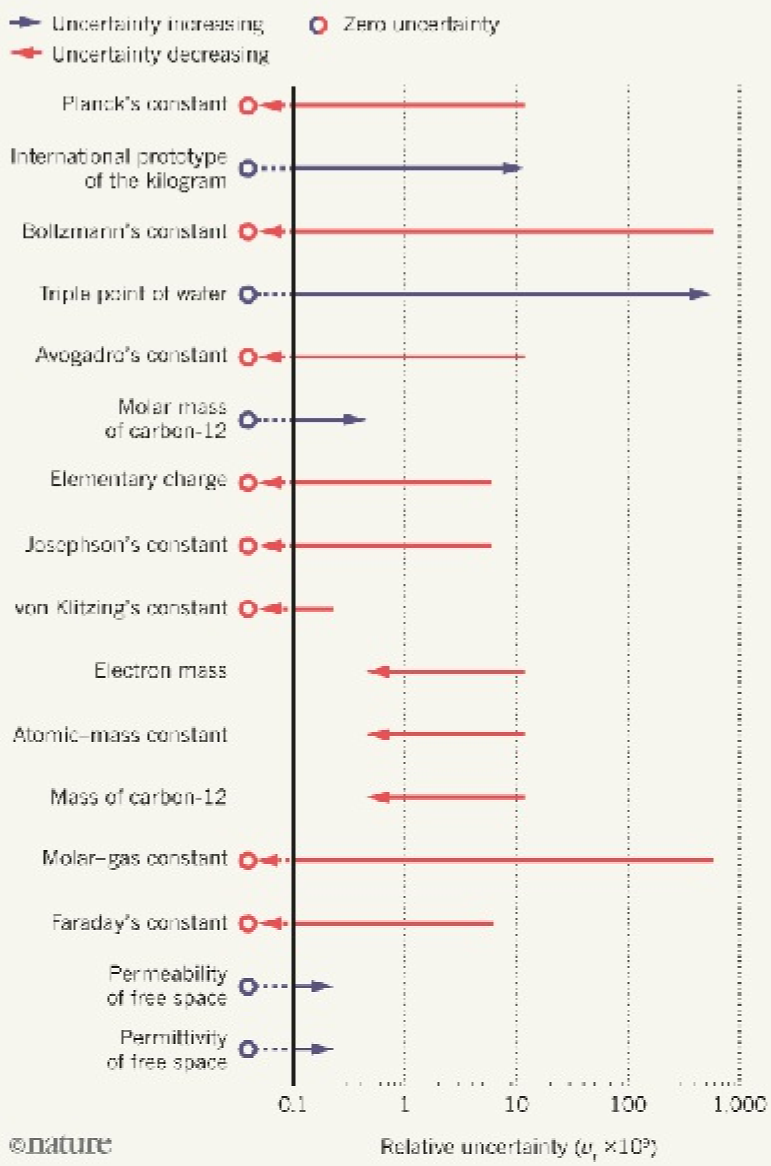
This technique could be used to derive precise temperature measurements. The speed of sound in a gas-filled sphere (which is proportional to the average speed of the atoms in it) can be determined at a fixed temperature, by analysing the frequency of sound waves that resonate within in it and measuring the sphere's volume.



THE FUTURE

Experimental teams have been working for decades to agree on values for the constants on which the definitions will soon hinge. They had to meet strict conditions, which the kilogram teams fulfilled only in 2015. All groups submitted final figures by 1 July. Under the new system, these constants will be stripped of their uncertainties and fixed as exact numbers in May 2019. Their former uncertainties will then be transferred to measurements that use the units defined by the constants. As a consequence, other, related constants, once expressed in the new units, will see their uncertainties reduced as well.

The loser will be the mass of the prototype kilogram in Paris. It currently has an uncertainty of zero but that will soon rise to at least ten parts per billion.



Journal name:

Nature

Volume:

550,
Pages:
312–313
Date published:
(19 October 2017)
DOI:
doi:10.1038/550312a

Comments

Comments

There are currently no comments.

The future of work

Digital technologies are upending the workforce. The right research can tell us how.

18 October 2017

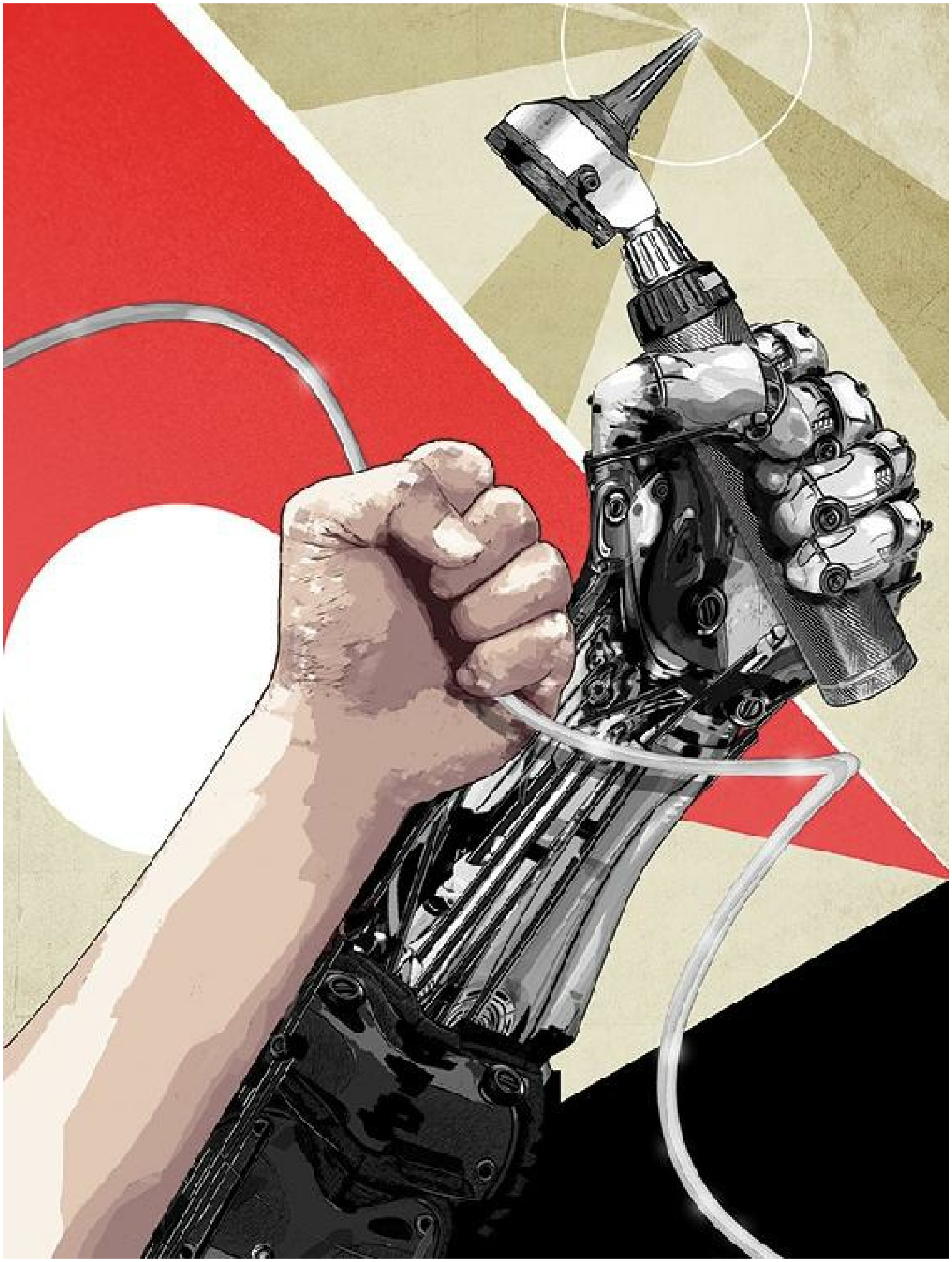


Illustration by Chris Malbon

Robots did not write this sentence, or any other part of *Nature*. But that could

change. Dramatic shifts in labour are reshaping society, the environment and the political landscape. Consider this disorienting estimate from the World Economic Forum: 65% of children entering primary schools now will grow up to work in jobs that do not yet exist. This week, *Nature* asks: what light is research shedding on the future of work, and how will the changes affect scientists' working world?

A News Feature explores which jobs are most at risk of being replaced by artificial intelligence and machine learning; whether a decentralized 'gig economy' will democratize work; and what programmes will best prepare workers. “There's a huge need, a huge opportunity, to study the changes,” says economist Erik Brynjolfsson. And the scientific workforce is feeling these shifts. A Careers Feature reports on people doing research outside the traditional career path. “I love the freedom,” says Cecile Menard, an independent land-surface modeller in Edinburgh, UK, “but for other people, it may be too stressful.”

Important lessons can be drawn from the past. Economic historian Robert Allen synthesizes three centuries of data to see when and where the relationship between wages and productivity was most like today's — and finds that some regions are in uncharted waters. These changes call for new socio-economic models and a revolution in education, concludes historian Yuval Noah Harari. And economist Ian Goldin argues that our era has more parallels with the Renaissance than the Industrial Revolution. This time, he urges, “knowledge and enquiry must find a way to conquer prejudice and ignorance”.

Journal name:
Nature
Volume:
550,
Pages:
315
Date published:
(19 October 2017)
DOI:
doi:10.1038/550315a

Comments

There are currently no comments.

The shape of work to come

Three ways that the digital revolution is reshaping workforces around the world.

18 October 2017

Illustration by Chris Malbon

Last year, entrepreneur Sebastian Thrun set out to augment his sales force with artificial intelligence. Thrun is the founder and president of Udacity, an education company that provides online courses and employs an armada of salespeople who answer questions from potential students through online chats. Thrun, who also runs a computer-science lab at Stanford University in California, worked with one of his students to collect the transcripts of these chats, noting which resulted in students signing up for a course. The pair fed

the chats into a machine-learning system, which was able to glean the most effective responses to a variety of common questions.

Next, they put this digital sales assistant to work alongside human colleagues. When a query came in, the program would suggest an appropriate response, which a salesperson could tailor if necessary. It was an instantaneously reactive sales script with reams of data supporting every part of the pitch. And it worked; the team was able to handle twice as many prospects at once and convert a higher percentage of them into sales. The system, Thrun says, essentially packaged the skills of the company's best salespeople and bequeathed them to the entire team — a process that he views as potentially revolutionary. “Just as much as the steam engine and the car have amplified our muscle power, this could amplify our brainpower and turn us into superhumans intellectually,” he says.

The past decade has seen remarkable advances in digital technologies, including artificial intelligence (AI), robotics, cloud computing, data analytics and mobile communications. Over the coming decades, these technologies will transform nearly every industry — from agriculture, medicine and manufacturing to sales, finance and transportation — and reshape the nature of work. “Millions of jobs will be eliminated, millions of new jobs will be created and needed, and far more jobs will be transformed,” says Erik Brynjolfsson, who directs the Initiative on the Digital Economy at the Massachusetts Institute of Technology in Cambridge.

But making firm predictions is difficult. “The technology is rushing ahead, which in a way is a good thing, but we have a huge gap in understanding its implications,” Brynjolfsson says. “There's a huge need, a huge opportunity, to study the changes.” Researchers are beginning to do just that, and the emerging evidence resists simple storylines. Advances in digital technologies are likely to change work in complex and nuanced ways, creating both opportunities and risks for workers (see 'More research needed').

More research needed

Illustration by Chris Malbon

Scientists are grappling with how technology could alter workplaces.

The changing world of work presents an almost endless number of topics for

scientists to explore. Here are two other workplace trends and the research questions — as yet mostly unanswered — that they raise.

How will workers respond to new forms of tracking and surveillance?

Although employers have long monitored the performance of their staff, workplace surveillance is entering a new era.

Companies can now log workers' keystrokes and remotely take screenshots of their computers, for example, or use motion sensors, biometrics, radio-frequency identification (RFID) chips and the Global Positioning System to track their movements, even after hours.

But it's not yet clear whether workers will show widespread resistance to the increasing use of surveillance technology, or where they might draw the line. And could new forms of surveillance backfire in less obvious ways, undermining trust, morale or innovation?

How will human-enhancement technologies affect worker health and safety?

Technologies for improving human performance — from cognition-boosting drugs to bionic 'exoskeletons' that are designed to make physical labour safer and easier — are beginning to make their way into the workplace.

In some cases, these technologies could help to protect the health and safety of workers. An alertness-enhancing drug, such as modafinil, might help long-haul drivers avoid accidents, and exoskeletons could reduce joint stress and muscle fatigue. But researchers don't know whether the long-term use of these technologies could harm workers, either directly or indirectly, perhaps by encouraging overwork or increased risk-taking.

Here are three pressing questions about the future of work in a digital world and how researchers are beginning to answer them.

Will machine learning displace skilled workers?

In previous waves of automation, technological advances have allowed machines to take over tasks that were simple, repetitive and routine. Machine learning opens up the possibility of automating more complex, non-routine cognitive tasks. “For most of the last 40 or 50 years, it was impossible to automate a task before we understood it extremely well,” Brynjolfsson says. “That's not true anymore. Now machines can learn on their own.”

Machine-learning systems can translate speech, label images, pick stocks, detect fraud and diagnose disease — rivalling human performance in some new and surprising domains. “A machine can actually look at many, many, many more data samples than a human can handle,” says Thrun. Earlier this year, he led a team that demonstrated that some 129,000 images of skin lesions could be used to train a machine to diagnose skin cancer with a level of accuracy that matches that of qualified dermatologists[1].

LISTEN

Reporter Benjamin Thompson finds out how lessons from the past can help explore the future of work.

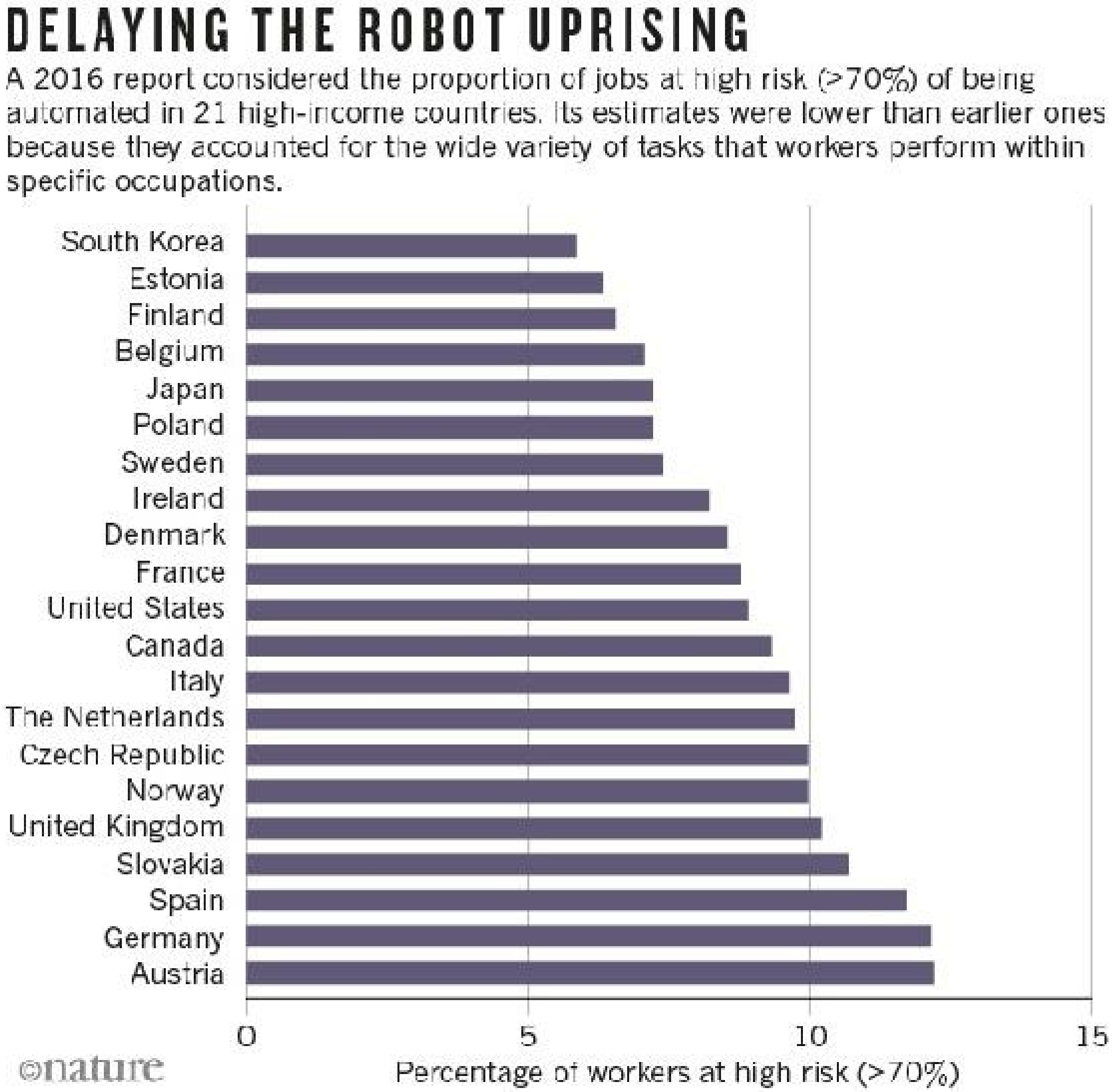
You may need a more recent browser or to install the latest version of the Adobe Flash Plugin.

These advances have raised concerns that such systems could replace human workers in fields that once seemed too complex to be automated. Early estimates seemed dire. In 2013, researchers at the Oxford Martin Programme on Technology and Employment at the University of Oxford, UK, reviewed the advances and lingering challenges in machine learning and mobile robotics to estimate how susceptible 702 different occupations were to automation[2]. Their startling conclusion was that 47% of jobs in the United States were at high risk of computerization, with jobs in transportation, logistics, production and administrative support particularly vulnerable. That spelt trouble for workers such as taxi drivers, legal secretaries and file clerks.

Since then, however, other researchers have argued that the 47% figure is much too high, given the variety of tasks that workers in many occupations

tend to perform. “Once you go deeper, once you look into the task structure of what people really do at work, then you find that the estimates get much lower,” says Ulrich Zierahn, a senior researcher at the Centre for European Economic Research in Mannheim, Germany.

For instance, the Oxford study reported that clerks in bookkeeping, accounting and auditing face an automation risk of 98%. But when Zierahn and his colleagues analysed survey data on what people in those professions actually do, the team found that 76% of them had jobs that required group work or face-to-face interaction. For now at least, such tasks are not easily automated[3]. When the authors extended their approach to other professions, they found less-alarming figures for the number of at-risk jobs in the 21 countries surveyed. In the United States, the share of workers at high risk of automation was just 9%, and the figure ranged from a low of 6% in South Korea and Estonia to a high of 12% in Germany and Austria (see 'Delaying the robot uprising').



Sources: OECD/Ref. [3] (http://go.nature.com/2KK4D4Y)

Brynjolfsson is now working with Tom Mitchell, a computer scientist at Carnegie Mellon University in Pittsburgh, Pennsylvania, to drill deeper into the impact of machine learning. They have developed a rubric outlining the characteristics that make certain tasks especially amenable to this approach. For instance, machine-learning systems are adept at tasks that involve translating one set of inputs — say, images of skin lesions — into another set of outputs, such as cancer diagnoses. They're also most likely to be used for tasks in which the large digital data sets required for training the system are readily available. Brynjolfsson and Mitchell are now going through several

large occupational databases to determine how well a variety of workplace tasks match up with these and other criteria.

Even with these kinds of analysis in hand, determining the consequences for the labour market is complex. Just because a task can be automated doesn't mean that it will be; new technologies often require costly and time-consuming organizational changes. Legal, ethical and societal barriers can also delay or derail their deployment. “AI is not yet an off-the-shelf product,” says Federico Cabitza, who studies health-care informatics at the University of Milano-Bicocca in Italy. Implementing medical machine-learning systems, for instance, requires both technological readiness and willingness to devote the thousands of person-hours necessary to make these systems operational, he says — not to mention buy-in from caregivers and patients.

Research suggests that the workforce is flexible in adapting to new technologies. In the second half of the twentieth century, increasing automation prompted shifts within occupations as employees began performing more complex and non-routine tasks. In some future cases, these shifts could be positive; if automated systems start making routine medical diagnoses, it could free doctors to spend more time interacting with patients and working on complex cases. “The fact that computers are becoming good at medical diagnosis doesn't mean that doctors will disappear as a job category,” Mitchell says. “Maybe it means we'll have better doctors.”

Indeed, many people might find themselves working alongside AI systems, as the Udacity salespeople did, rather than being replaced by them. Self-driving cars, for instance, are not yet able to navigate all situations on their own, so car manufacturer Nissan is developing a human-powered solution. If one of its autonomous cars encounters a situation it doesn't understand, such as roadworks or a traffic accident, it will contact a remote command centre where a human 'mobility manager' can take control until the car has passed the trouble spot. “Machines think in a very different way, fundamentally, than humans do, and each has its strengths,” says Pietro Michelucci, executive director of the Human Computation Institute in Fairfax, Virginia. “So there's a real natural marriage between machines and humans.”

Will the gig economy increase worker

exploitation?

Flexibility, variety and autonomy: these are the promises of the burgeoning gig economy, in which workers use online platforms to find small, short-term jobs. This sort of on-demand, digitally mediated gig work can take a variety of forms, from driving for the taxi service Uber to completing microtasks — including taking surveys, translating a few sentences of text or labelling an image — on a massive crowd-working platform such as Amazon Mechanical Turk.

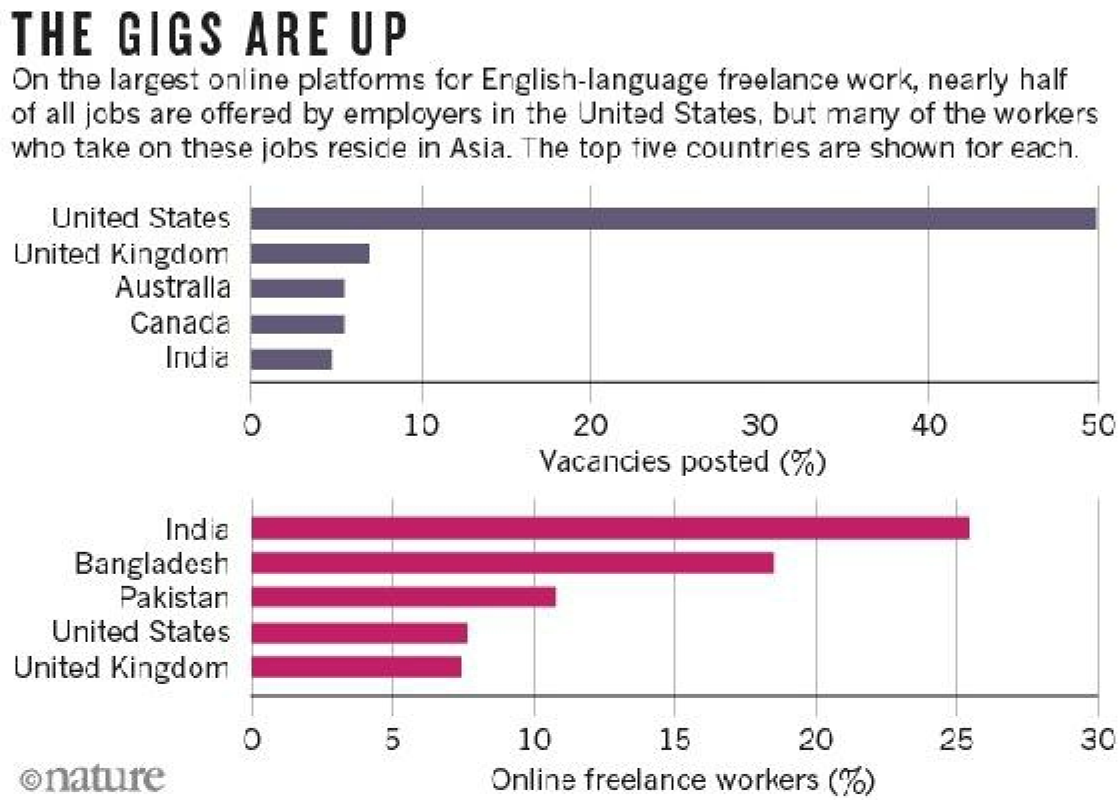
These digital platforms allow workers to complete tasks from anywhere, meaning they could remove some geographical barriers to getting good jobs. “Someone in Nairobi is no longer constrained by the local labour market,” says digital geographer Mark Graham of the University of Oxford.

Graham and his colleagues have spent several years studying the digital, on-demand economy in southeast Asia and sub-Saharan Africa. They have conducted face-to-face interviews with more than 150 gig workers in these regions, surveyed more than 500 people and analysed hundreds of thousands of transactions on online labour platforms.

Their preliminary results show that these jobs do pay off for some gig workers; 68% of the survey respondents said that the work makes up an important part of their household income. And digital platforms provided jobs to a variety of people — including women who were primary caregivers and migrants without work permits — who said that their employment opportunities were otherwise limited. “There are some people who really thrive in this system,” Graham says. “But it's not like that for everyone.”

There is a pronounced oversupply of labour in the gig economy, leading some workers to drop their rates below what they consider fair. Many also work long hours at high speeds and to tight deadlines. “They tend to have a very precarious existence, so they're worried about saying no to jobs that they do get,” Graham says. “We talked to quite a few people who have done things like stay up for 48 hours straight, just working solidly in order to get their contracts done on time.”

Considerable geographical inequities remain. In a 2014 study[4], Graham and several colleagues analysed more than 60,000 transactions on one major platform in March 2013. Most jobs, they found, were listed by employers in high-income countries and completed by workers in low- or middle-income countries (see 'The gigs are up').



Source: Ilabour (http://go.nature.com/2GZE5TZ)

But those who live close to where the jobs are still seem to have an advantage. They win a disproportionate share of jobs and earn significantly more — US$24.13 per hour, on average — than foreign workers, who earned $11.66 per hour for comparable work. And some low- and middle-income nations attracted many more jobs than others; India and the Philippines are the top two recipients in Graham's analysis.

Practical concerns could explain some of these disparities. Language and time-zone differences might make some employers reluctant to hire foreign workers, and the history of outsourcing labour to India and the Philippines

may have helped make workers there more attractive to employers. But discrimination, both conscious and unconscious, could play a part, too; Graham's team found task listings explicitly stating that people from certain countries need not apply. “Even though these technologies have been able to connect different parts of the world, they have not been able to bridge these kinds of differences as much as we hoped,” says Mohammad Amir Anwar, a researcher who works with Graham.

Another large ethnographic study of gig workers is beginning to reveal more about how this work gets done. It also provides some clues about what workers need to succeed. Between 2013 and 2015, two senior researchers at Microsoft Research — anthropologist Mary Gray in Cambridge, Massachusetts, and computational social scientist Siddharth Suri in New York City — surveyed roughly 2,000 gig workers in the United States and India and conducted longer interviews with nearly 200 of them.

One of the first things they discovered was that, although gig workers are often portrayed as independent, autonomous labourers, many of them were in fact communicating and collaborating with each other[5]. Workers helped each other to set up accounts and profiles, shared information about good employers and newly posted jobs, and provided technical and social support. Workers are making a deliberate effort to add human connections back into the system, Suri says, and they're doing it on their own time. “So they clearly must value it.”

In a more quantitative follow-up study[6], in which they mapped the social connections among more than 10,000 Amazon Mechanical Turk workers, Gray, Suri and their colleagues found that this kind of collaboration can have real pay-offs. Workers who had connections to at least one other person on the platform had higher approval rates, were more likely to gain elite 'master' status, and found out about a new task more quickly than unconnected workers. For people to be productive, says Gray, “it turns out that they really need to collaborate. They need each other.”

Can the digital skills gap be closed?

For years, experts have been sounding the alarm about a looming shortage of digital skills. They have warned that there are too few trained workers to fill high-tech jobs, and that a lack of basic digital literacy could prevent workers in certain geographical regions or demographic groups from thriving in the digital economy. In response, various innovative programmes for boosting digital literacy and skills have sprung up worldwide. Research is now starting to provide some clues about what does and doesn't work — and about where skills training might fall short.

There have been some documented successes. More than a decade ago, the US Defense Advanced Research Projects Agency began developing a personalized, interactive and adaptive 'digital tutor' system to train new recruits to the US Navy for jobs as information-systems technology (IT) technicians. Students would work with the tutor one-to-one, completing lessons on different topics and solving related problems. The system prioritized conceptual learning and reflection, regularly prompting students to review what they'd learnt. When the tutoring system judged that a student had mastered the material, it would move on to the next subject.

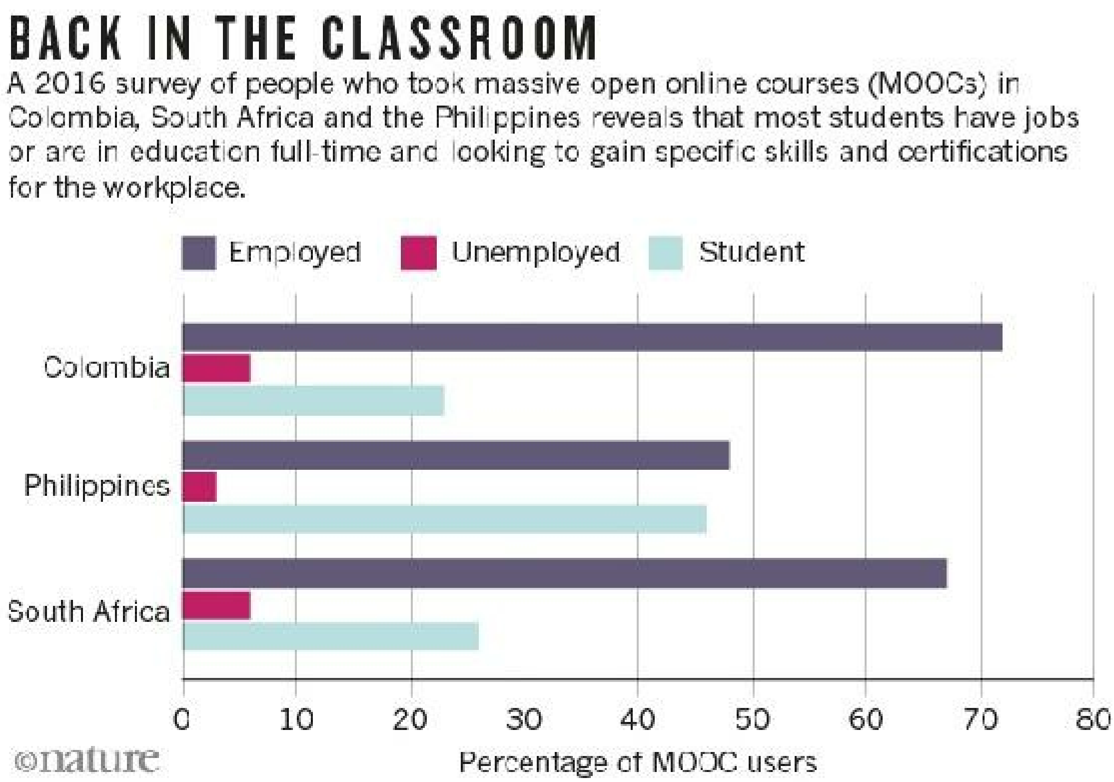
In a 2014 review[7] of the programme, researchers at the Institute for Defense Analyses in Alexandria, Virginia, found that 12 recruits who completed the 16-week course outperformed graduates of conventional, classroom-based US Navy IT training that lasted more than twice as long. The 12 even did better than a group of senior naval IT technicians — who each had an average of nearly ten years' experience — on almost every measure. “If we can do that, why not do more of it?” says Dexter Fletcher, who co-authored the review. “Why not begin to apply this seriously to workforce training?”

In a follow-up study[8], Fletcher found that a slightly modified version of the digital tutor yielded similar results when it was used to train 100 military veterans for civilian jobs in IT. Within six months of completing the programme, 97% of the veterans who wanted IT jobs had landed them, earning an average annual salary roughly equal to that of someone with 3–5 years of experience in the field.

Numerous other strategies have been promoted to improve digital skills and employment, including massive open online courses (MOOCs) — university-

level classes that are delivered over the Internet — and coding bootcamps, which are intensive, short-term training courses that teach the basics of computer programming.

In a 2016 analysis[9] of 1,400 MOOC users in Colombia, the Philippines and South Africa, researchers determined that 80% of students were from low- or middle-income backgrounds and that 41% had only basic computer skills. More than half of the students (56%) were female, and computer science was the most popular MOOC topic. “Women are actually engaging in MOOCs in areas where they are underrepresented,” says Maria Garrido, a co-author of the report at the University of Washington's Information School (see 'Back in the classroom').



Source: Ref. [9] (http://go.nature.com/2YFAPWC)

But the quality of these programmes can vary enormously, and few have been rigorously evaluated. Coding bootcamps can be expensive, require a significant time investment and are located primarily in technology corridors

and urban settings. And achievement gaps remain; in a 2015 study[10] of more than 67,000 MOOC students, two Stanford researchers found that female students and students of both genders from Africa, Asia and Latin America were less likely to reach certain course milestones — such as watching more than 50% of the lectures — and earned lower grades than male students and MOOC students from North America, Europe and Oceania.

Even those who complete digital-skills courses can still face a variety of barriers to employment. When researchers interviewed students in a Kenyan IT programme at Strathmore University in Nairobi in 2004, some of the students said that they were worried about graduating into a local economy that didn't appreciate their expertise or have jobs in which they could put it to use[11]. “And this was especially true for the women,” says Lynette Yarger, an information scientist at Pennsylvania State University in University Park, who was involved in the research. As one student put it: “Because I am a woman, employers may not think that they should give me a job working in IT, so I may never fully get to use all that I have learned to do, work that I want to do.”

One thing the research is already making clear is that even well-designed training programmes might not be sufficient to ensure success in the world of digital work. “The fact that you have better skills and know how to use a computer doesn't necessarily mean that you automatically can get a good job,” Garrido says. “Digital skills are an important piece of the puzzle, but they're not enough.”

Journal name:
Nature
Volume:
550,
Pages:
316–319
Date published:
(19 October 2017)
DOI:
doi:10.1038/550316a

Comments

There are currently no comments.

Lessons from history for the future of work

18 October 2017

Global comparisons of previous social and economic upheavals suggest that what is to come depends on where you are now, argues Robert C. Allen.

Lewis Hine/Pictorial Press Ltd/Alamy

Children working in a cotton mill in Macon, Georgia, in January 1909.

Today is not the first time that people have worried that machines will render

human labour obsolete, making a few very rich and the majority very poor.

Since the Industrial Revolution, mechanization has been controversial. Machines pushed up productivity, raising incomes per capita. But they threatened to put people out of work, to lower their wages and to divert all the gains from growth to the owners of businesses. The stocking-frame operators of Nottingham, UK (the Luddites), wrecked improved knitting machines that threatened their jobs. Mobs burnt down the first mills housing spinning and weaving equipment in the 1760s and 1790s.

Now, it is robots that threaten work, wages and equality[1]. Are the gains of technological progress destined to benefit only the top 1% of earners?

Economists' stock answer to this question is 'no'[2]. Technical progress in the past three centuries has led to incomes in the West (that is, the developed nations of today) that are much higher than they were in 1700 in real terms, and the fraction of the adult population employed in these countries is at record levels. Despite mechanization, automation and computerization, people have found jobs. Somehow the economy has always adjusted; somehow in the future it always will.

I think this answer is too simplistic.

Phase shift

There have been long periods of economic history in which things did not work out well, and we must wonder whether we are in another. Also, the 'future of work' depends very much on where you are in the world. Most discussions in the West focus on how technological evolution in the West affects jobs in the West. This frame is too narrow for the twenty-first century: we must investigate the effect of technological change on work everywhere. For the past three centuries, the global economy has been sufficiently integrated that new technology in one place affects work in others.

LISTEN

Reporter Benjamin Thompson finds out how lessons from the past can help explore the future of work.

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Rather than ask (unanswerable) questions about how machines will affect work over the next centuries, we can ask what the invention of the textile mill meant for a girl growing up in Manchester, UK, in 1800 or the wife of a subsistence rice farmer in China's Yangtze Delta at the same time. Technological change affected their futures of work very differently and often detrimentally. Similar things are happening now.

We need to divide the past into periods defined by trends. The periods I suggest here reflect Western history, which is not as limiting as it sounds: globalization means that developments in one region affect others.

The three phases are: the Industrial Revolution (1750–1830); the Western ascent to affluence (1830–1970); and the problem-ridden present (since 1970). Each holds lessons and pressing research questions for today.

The industrial revolution

The Industrial Revolution was Britain's creative response to the globalization of the world economy that occurred after Columbus's voyage to America in 1492 and Vasco da Gama's sail around Africa to India in 1498. Britain's colonies in North America, the Caribbean and India formed a large market for Britain's handicraft industries. Exports boomed, and by the mid-eighteenth century about one-third of Britain's workforce was employed in making metal goods and cloth.

Large data sets of wages and prices over this period[3] have been assembled since the 1980s and show that real wages rose as a consequence of this export boom[4]. Inventors designed machines to save expensive labour. Mechanization paid in Britain rather than elsewhere because labour was more expensive relative to capital; that is why the Industrial Revolution was

primarily a British affair.

Textiles were the world's most important manufactured product in terms of employment before the Industrial Revolution, and the first to be mechanized. Indian cotton cloth was imported to Europe, where it was a smash hit. English manufacturers struggled to compete because English wages were so high. The invention in the 1760s and 1770s of spinning machines to speed up cloth-making, including Hargreave's spinning jenny, Arkwright's water frame and Crompton's spinning mule, solved the problem. The first victims of technological unemployment were the British women spinning cotton by hand and, later, the much-larger number spinning wool, once machinery was adapted to that fibre.

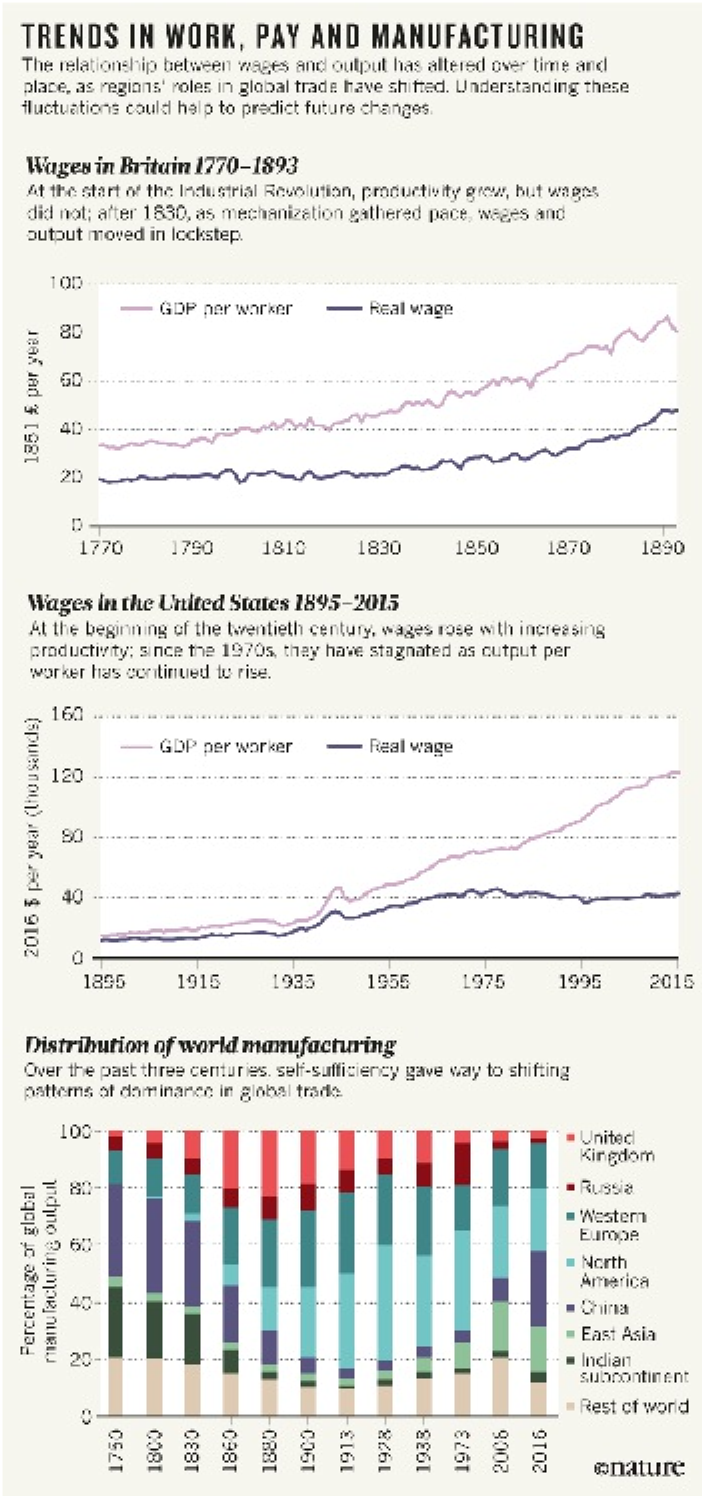
Soon jobs were lost from Casablanca to Canton. Investing in spinning machines made sense only in the high-wage economy of eighteenth-century England, thus they greatly increased English competitiveness without benefiting other nations. As jobs proliferated in the British cotton mills, massive technological unemployment spread across Africa and Asia[5]. The collapse of the Indian cotton trade around the 1830s led the British governor general to remark[6]: “The bones of the cotton-weavers are bleaching the plains of India.”

In 1820, the future of work for the wife of a farm labourer in England was an unhappy one. She had lost the opportunity to increase her family's income by spinning part-time, as her mother had done. The same impoverished fate befell a farmer's wife in the Ganges or Yangtze deltas. Some British women found work in the cotton mills (but a smaller number than had been employed to spin cotton by hand). By contrast, the future of work was auspicious for railway engineers, bricklayers and metal workers, to say nothing of the vast number of middle-class entrepreneurs and professionals who directed and serviced the industrial economy.

Machines were invented to save labour in most sectors of the economy in the first half of the nineteenth century. As one trade after another was eliminated in Britain, earnings collapsed in the affected trade, and that, in itself, lowered average national earnings. The displaced workers shifted into other trades, pushing down those wages. The Luddites and other opponents of

mechanization are often portrayed as irrational enemies of progress, but they were not the people set to benefit from the new machinery, so their opposition makes sense.

The implications were stark (see 'Trends in work, pay and manufacturing'). Although output per worker grew from 1770 to 1890, there was little growth in the real wage from 1770 to about 1830. During the Industrial Revolution (phase one) the 'normal' relationship was booming productivity and constant average wages — rather like the past 40 years.



Sources: See Supplementary Information

The western ascent to affluence

The average real wage only began to rise in the middle of the nineteenth century, when higher-productivity factory work replaced the hand trades. By 1850 Britain was the 'workshop of the world'. Comprising only around 3% of the world's population, the United Kingdom produced about half of the world's iron, for instance.

Industrial pre-eminence saw in the next phase of history. The new normal in the West was productivity and wages advancing together, as the Industrial Revolution spread across Europe and North America. Although there were shocks along the way owing to the depression of the 1930s and the Second World War, the period from the mid-nineteenth century to 1970 was one in which the working class benefited from the growth in productivity. Incomes became more equal. This is the economic performance that many have come to regard as normal.

How this favourable situation arose is a fundamental question. It seems that a positive-feedback system was in operation. Rising incomes led to the demand for fancier manufactured goods (for example, bicycles then cars) and more services (such as travel, retail trade and medical care). These created markets that encouraged technological change and led to jobs that were performed more effectively by educated people[7].

The need for educated workers led to the expansion of state provision of education. The increasing number of educated people prompted the invention of technologies that took advantage of education[8]. Those technologies led to further demand for education. At the same time, the public provision of infrastructure — roads and airports, for instance — was crucial for the development of industries involving cars and aircraft. Public support for research in medicine, agriculture and technologies with military applications, such as electronics and aircraft, underlaid many advances. The welfare state helped to spread the benefits of this economic development across the population.

The upshot was a pattern of economic growth in which technical progress benefited most people in the West.

The same was not true in Asia and Africa. Before the Industrial Revolution, China and India had the largest manufacturing sectors in the world because they had the largest populations, and nations were mostly self-sufficient in the pre-globalization era. As the Industrial Revolution gathered pace, Britain's share of goods manufactured worldwide increased, reaching a peak of about one-quarter in the late nineteenth century. Western Europe's share and that of North America also increased. In the same period, the shares of India and China collapsed. This drop represented absolute de-industrialization and not simply shifting percentages.

The technological revolution that spread prosperity in the West created modern 'underdeveloped countries' in the East (that is, Asia, Africa and South America). It converted them into economies that exported solely primary products — wheat, rice, bauxite, oil — rather than secondary ones such as cloth and porcelain.

By the 1830s, technological progress in the West meant a bleak future of work elsewhere.

The problem-ridden present

The past four decades have seen many job losses in the manufacturing sector in Western countries, static or falling real wages, and rising inequality as the gains from growth accrue to the top 1%. Did the 'new normal' end in 1970, or are the recent trends just a blip? Might what was 'normal' in 1850–1970 return soon — that is, the concurrent advance of productivity and wages?

Some people believe that the feedback loops between education and technology will kick in again, generating new knowledge-based, high-income jobs in the West to replace lost manufacturing jobs. Computers and robots will save us.

I am more pessimistic. The rise in real wages that began in the mid-nineteenth century and tracked the rise in output per worker ended in the 1970s (see 'Trends in work, pay and manufacturing'). Real wages rose at a slower rate than productivity in the 1980s and 1990s — or stagnated

altogether, as in the United States. In some cases (for example, the United Kingdom) wages have actually been falling in real terms over the past decade. A deviation of this magnitude from the trend suggests that the new pattern may not be transitory.

Similarly, the rebound in overall inequality in mature economies, such as the United States, over the past 40 years is unprecedented. Inequality rose in many countries as they industrialized and fell thereafter — this trend is called a Kuznets curve (after the Nobel laureate Simon Kuznets)[9]. The rise in inequality since 1970 has shown that this is a reversible feature of economic history.

Inequality is an area that has seen much recent research, with large data sets assembled and interrogated. Some scholars have focused on the share of total income going to the top 1% or 5%[10]. Others use indices that incorporate information from every level of the income distribution[11]. How we interpret the results depends on our breadth of vision. A common pattern in many countries is a fall in inequality from the early twentieth century to the 1970s and then a rise. This is true of the United States, the United Kingdom and China, for instance. At the global level, inequality increased steadily from 1820 to 1990 and then declined slightly. This pattern takes into account inequality between countries as well as within. Rising per capita incomes in the West in phase two increased global inequality. In phase three, global inequality fell even though inequality increased in many rich and poor countries[12].

Why are the feedback loops that led to general prosperity in the West between 1850 and 1970 seemingly inoperative now[13, 14, 15]? A big change is the industrialization of Asia — first Japan starting in the 1870s, then South Korea and Taiwan since the Second World War, and now China (see 'Trends in work, pay and manufacturing'). These countries have supplanted Western nations as the low-cost producers of manufactured goods. Trade flows have reversed, with Asia shipping textiles and steel to Europe rather than the other way around. Technological progress in Asia has raised incomes and levels of employment dramatically in the region.

The future of work to someone born in China in 1990 is bright indeed —

provided that the country can avoid environmental crises and resource depletion.

Globalization means that Asia's bright future causes havoc elsewhere. Imports of cheap Japanese steel and vehicles caused the collapse of the rust belt in the United States and its counterparts in Western Europe (with Germany as something of an exception). Western de-industrialization was the flip side of the East Asian miracles. And cheap Chinese imports may benefit Africans as consumers, but could blight their employment prospects as African industries struggle to compete. Indeed, China is now purchasing large areas of land in Africa to guarantee access to food and minerals. It is hard to believe that manufacturing or information technology will ever recover in the West, no matter how many robots are installed, visas rescinded, trade agreements ripped up or walls built.

We cannot forecast the future without an understanding of the relationships between science, technology and the economy, because technical change is such an important determinant of the future. I have studied these questions for the Industrial Revolution using business accounts and histories of inventions. The steam engine, for instance, was an application of seventeenth-century science (the discoveries that the atmosphere has weight and that condensing steam creates a vacuum). By contrast, the cotton mills owed little to science and much to attempts to cut costs of relatively expensive employment[16].

How has the balance between knowledge and incentives evolved? The more technology advances in response to economic incentives rather than 'random' scientific discoveries, the more feasible it is to direct the course of technical progress to benefit more people. Furthermore, the cotton mills of the Industrial Revolution increased the demand for workers without education, whereas more-recent technology requires more education. Why the difference? Will the recent trend of needing educated workers persist? If not, then the hope that a knowledge-based future will make everyone better off is doomed.

Journal name:
Nature
Volume:

550,
Pages:
321–324
Date published:
(19 October 2017)
DOI:
doi:10.1038/550321a

Supplementary information

PDF files

1. Supplementary Information 550321a (49K)

Comments

Comments

There are currently no comments.

The second Renaissance

18 October 2017

Ian Goldin calls on scientists to help society to weather the disruptive transformations afoot.

Jay Shaw Baker/NurPhoto/Getty

Workers protest in London in February.

The Renaissance that began in Europe in the mid-1400s and ended in the early 1500s brought a radical transformation of the sciences, the humanities and politics. Building on the invention of the printing press and cheap paper, information was democratized, there was a hunger for literacy and the Catholic Church's near-monopoly on knowledge was challenged. The

resulting breakthroughs took Europe from being one of the more backward regions of the world to being the most advanced by far, within just 80 years.

But it ended in tears. Extremists, pointing to growing inequalities and the corruption of the elite, called for a return to spiritual values. In Italy, thousands of artworks and books were burned, branded as irreverent. Across Europe, rising intolerance of scientists, intellectuals, foreigners and ethnic minorities became the norm, with religious wars and inquisitions playing out over the following centuries.

In my view, many parts of the world are now in the middle of a second Renaissance. This one is seeing even faster change than the last, and across the entire globe. History tells us that it will be disruptive. It will bring immense benefits and it will be highly destabilizing. We should expect more extremism and the rise of potentially catastrophic risks.

Innovation today is happening faster than ever, driven by the unlocking of individual and collective abilities in a booming population. On average, literacy levels, life expectancy and incomes have soared. Flows of goods, services, money, people and, most importantly, ideas across national borders — globalization — has unleashed unprecedented progress and a scientific and broader renaissance. They have also brought growing interdependence and new risks[1, 2].

The Internet helps to harness the global capacity for connectivity and innovation, but also brings us malware, cybercrime and the sacrifice of privacy. Airports are crucial to international integration of science and commerce, but they can also be super-spreaders of pandemics — just as explorers to the new world brought with them fatal diseases. Financial hubs create fresh opportunities for economies to prosper, but they simultaneously allow a financial crisis in one country to destroy jobs and pensions in distant parts of the world[3].

The tension between individual success and collective collapse is growing. As more people escape poverty and climb the energy curve, climate change and biodiversity loss accelerate. As more people benefit from better nutrition, ocean fisheries are at risk of collapse and forests are destroyed for cattle. Improvements in global health could soon be threatened by rapidly rising

antibiotic resistance.

Accelerating technological change will provide solutions for many challenges, from cancer to cleaner sources of energy. But our politics and our institutions are locked in past models that are increasingly unfit for purpose. Deep ethical issues arising from genomics research and the potential dangers of biological pathogens are not being adequately addressed. Improvements in computing and artificial intelligence will kill off many jobs. Breakthroughs in nanotechnology and materials science, augmented and virtual reality, 3D printing and other applications will also radically disrupt society. All are barely understood by politicians and most citizens.

Growing gap

Inequality is rising in almost all countries that are experiencing rapid change. The faster the pace of change, the more rapidly people are being left behind. The share of wealth enjoyed by the top 1% of citizens in the advanced economies has risen from an average of 17% in the late 1980s to more than 23% today (it is 39% in the United States). Countries starting from a more equal distribution of wealth, such as China and the nations of the former Soviet Union, have seen the most rapid rise in inequality[4].

John MacDougall/AFP/Getty

A robot sweeps food towards two dairy cows at an 'automated farm' exhibit at a food and agriculture fair.

Far from levelling the playing field and making the world more 'flat', as is alleged, globalization is making it more mountainous. Place matters more than ever. Cities hold a growing share of wealth and job opportunities, but it is increasingly difficult to afford to live in them. In dynamic ones, such as London, San Francisco, Paris, Berlin, Shanghai and Mumbai, house prices relative to average incomes are at an all-time high.

Technological change is already a key contributor to the growing inequality[5]. This is likely to be exacerbated as machine intelligence and automation take over a growing share of routine tasks in manufacturing and services, including retail, administration and call centres. Over the next 20 years, up to half of US jobs, one-third of jobs in the United Kingdom and the European Union and two-thirds of jobs in China and Mexico may be replaced by computers and robotics[6].

The future will bring new jobs, but their number will be small relative to those lost. And the quality of many of these new jobs will be inferior, in terms of the conditions of work and pay. Although it is tempting to imagine a world in which machines do dangerous and routine jobs, leaving more creative, stimulating and well-paid jobs for humans, this may not come to pass. The pace and scale of technological disruption, which far exceeds that of any previous industrial revolution, raises doubts about our capacity to keep up. We may not be able to redistribute enough funds from the wealthy, or come up with sufficiently creative changes to our systems of work and social safety, to prevent a further rise in inequality[6, 7]. Although this is a major issue for advanced economies, it is even more so for developing countries, because automation may remove key rungs of semi-skilled tasks from the development ladder.

Growing interdependence and complexity also mean that our politicians are increasingly unable to protect or shape our futures. Rather than pursue more cooperative politics, which enhance the benefits of connectivity and mitigate the risks, politicians increasingly blame foreigners and immigrants for the ills. This is profoundly misguided. Immigrants contribute disproportionately to the dynamism of our societies, as can be seen in the talent pool of leading universities, Silicon Valley firms, Nobel prizewinners and patent holders[8].

Those living in the fast-changing cosmopolitan cities of the world are embracing globalization and change: most Londoners did not support Britain's decision to exit from the European Union; people living in dynamic cities tended not to support US President Trump. The populist call for protectionism is driven by those in the United States who fear being left behind. This is not an irrational fear: as is evident from inequality, unemployment and health data, some people are being left behind. There is a correlation, for example, between those who voted for Trump and those whose jobs are vulnerable to having machines take over their jobs[9].

Alongside their anxieties about being left behind by globalization comes a deep mistrust of the 'experts' in charge of the global systems, and a rejection of evidence. Paradoxically, although we know more than ever, rising complexity and speed of change mean that experts are likely to be wrong more often. The financial system, for example, is home to numerous highly

qualified experts, housed in a formidable array of powerful institutions, who are handsomely paid to secure economic stability. Yet, as the 2008 financial crisis demonstrated, they have proved dismally unequal to the task. Similarly, experts in the European Commission seem to have failed to control reporting of emissions from leading car manufacturers. Little wonder that trust in authority has been severely eroded. When the evidence threatens entrenched elites, scepticism regarding expertise becomes particularly poisonous. Trump's dismissal of the science of climate change is an egregious example of this trend.

The flourishing of science was contested in the original Renaissance, too. Printing presses provided the means for experts and intellects to share knowledge, but also allowed fake news to flourish. In Medici Florence, fundamentalist Italian preacher Girolamo Savonarola circumvented the authority of popes and princes with the mass production of one-page pamphlets — the equivalent of today's tweets. Both Savonarola and the clergy denied that Earth went around the Sun, and that the heart was a pump.

Although history does not repeat itself, it does rhyme. In the United Kingdom, campaigners successfully used social media to convince people to support Brexit even when it was against their interests, as in the case of farmers who receive subsidies from the European Union. In the United States, social media that propagated fears rather than facts played a key part in shaping the outcome of the 2016 presidential election[10].

Rapid response

As societies change more rapidly, flexibility becomes more important. For individuals, it becomes more necessary to move to where the jobs are and to reskill. For governments, it is crucial to renew infrastructure and social safety nets. Regulatory frameworks also need to evolve rapidly, to address a widening range of risks — from the genetic enhancement of humans to geoengineering.

Unfortunately, at a time when the need to renew and invest in the future is rising, the ability of governments to keep pace with change is being

undermined. The use of off-shore tax havens — notably by companies at the frontier of technological change — as well as competition by governments to attract increasingly mobile individuals and companies by reducing taxes, together with austerity policies, have reduced the capacity of governments to invest in health, education, infrastructure, social security, research and other expenditures[11]. Lower investment leads to lower growth and political gridlock, as politicians fight over the allocation of fixed or diminishing resources.

Stronger safety nets are necessary to prevent poor and vulnerable individuals and families from being undermined by technological and other changes. If not, social cohesion will be eroded, fanning the flames of populist push-back against change and all things foreign.

Some Silicon Valley billionaires, fearing revolt against the growing wage gap, along with some social activists, have called for the introduction of a Universal Basic Income (UBI) for people working and not. But a UBI is not a panacea. The Organisation for Economic Co-operation and Development has shown that the policy could, perversely, increase inequality and poverty. And, because jobs are so important to our status and self-worth, having money alone does not protect against the increases in morbidity, criminal activity, opioid and alcohol abuse that have been associated with unemployment[12].

Instead, we need a broader change in attitudes towards work. We need to remove the stigmas associated with part-time employment, retirement and volunteer work. We should nurture a greater respect and pay for creative, caring and home-based activities.

There are reasons for optimism. There are more scientists alive today than all those who previously lived; citizen science adds millions more. As well as more minds at work, there are more-diverse collaborations, thanks to greater gender equality and the participation of more nations and peoples. The probability of unlocking mysteries and finding solutions to great challenges is rising, as is the global dissemination of the benefits. Cross-border collaborative projects, from the CERN particle-physics laboratory near Geneva, Switzerland, to the Human Genome Project, highlight the benefits of

cooperative activity, in stark contrast to isolationist politics.

Now, more than ever, scientists must engage and communicate, to ensure that science is not overrun by politics. Renaissance moments are associated with an intensifying battle of ideas. Scientists need to engage in this struggle over the development and application of their expertise and inventions.

In the first Renaissance, extremists won; reason and evidence did not prevail. In our second Renaissance, knowledge and enquiry must find a way to conquer prejudice and ignorance. Scientists know that they can never progress through isolationism or ignorance. Nor can our societies.

Journal name:
Nature
Volume:
550,
Pages:
327–329
Date published:
(19 October 2017)
DOI:
doi:10.1038/550327a

Comments

6 comments

1. *Pentcho Valev* • 2017-10-20 06:53 AM
   Up until recently there was still hope that physics might be resurrected. Scientists had decided to abandon Einstein's absurd spacetime: Nima Arkani-Hamed (06:09): "Almost all of us believe that space-time doesn't really exist, space-time is doomed and has to be replaced by some more primitive building blocks." https://www.youtube.com/watch?v=U47kyV4TMnE Nobel Laureate David Gross observed, "Everyone in string theory is convinced...that spacetime is doomed. But we don't know what it's replaced by." https://www.edge.org/response-detail/26563 What

scientific idea is ready for retirement? Steve Giddings: "Spacetime. Physics has always been regarded as playing out on an underlying stage of space and time. Special relativity joined these into spacetime... [...] The apparent need to retire classical spacetime as a fundamental concept is profound..." https://www.edge.org/response-detail/25477 "Splitting Time from Space - New Quantum Theory Topples Einstein's Spacetime. Buzz about a quantum gravity theory that sends space and time back to their Newtonian roots." https://www.scientificamerican.com/article/splitting-time-from-space/ "And by making the clock's tick relative - what happens simultaneously for one observer might seem sequential to another - Einstein's theory of special relativity not only destroyed any notion of absolute time but made time equivalent to a dimension in space: the future is already out there waiting for us; we just can't see it until we get there. This view is a logical and metaphysical dead end, says Smolin." http://www.guardian.co.uk/books/2013/jun/10/time-reborn-farewell-reality-review Spacetime is a consequence of Einstein's constant-speed-of-light postulate, and since the combination "true postulate, wrong consequence" is forbidden by logic, scientists were actually moving towards the conclusion that the postulate, the "root of all the evil" in fundamental physics, is false: "Special relativity is based on the observation that the speed of light is always the same, independently of who measures it, or how fast the source of the light is moving with respect to the observer. Einstein demonstrated that as an immediate consequence, space and time can no longer be independent, but should rather be considered a new joint entity called "spacetime." http://community.bowdoin.edu/news/2015/04/professor-baumgarte-describes-100-years-of-gravity/ Then extremely dishonest people called LIGO came to power in physics, "discovered" (actually, faked) gravitational waves (ripples in spacetime), and all hope for resurrection of physics died. If you have ripples in spacetime, you cannot claim anymore that "space-time doesn't really exist, space-time is doomed and has to be replaced", can you? Pentcho Valev

2. *Pentcho Valev* • 2017-10-21 06:32 AM

Towards a uniform LIGO science (any theory that in some way contradicts LIGO fakes is doomed): "The simultaneous detection of gravitational waves and light from a cosmic collision has left a few theories of dark matter and dark energy dead in its wake. These theories require gravitational waves - ripples in the fabric of space-time - to travel slower or even faster than the speed of light. But recent observations have proved otherwise. [...] The signals from the smash-up, now named GW170817, show that gravitational waves do indeed travel at the speed of light, to an accuracy of about one in 1 million billion. This seriously undermines some theories that modify Einstein's general relativity to explain the mysterious dark energy thought to be driving the accelerated expansion of our universe, and the invisible dark matter that we detect only through its gravitational pull on ordinary matter." https://www.newscientist.com/article/2151020-dark-energy-survives-neutron-star-crash-test-while-rivals-fail/ Pentcho Valev

3. *Pentcho Valev* • 2017-10-19 06:50 AM

   "Look, my lad, I know a dead parrot when I see one, and I'm looking at one right now." https://www.youtube.com/watch?v=RQhVLHu8HRk Physicists know a dead science when they see one, and they've been looking at one since January 2001: Joao Magueijo, Faster Than the Speed of Light, p. 250: "Lee [Smolin] and I discussed these paradoxes at great length for many months, starting in January 2001. We would meet in cafés in South Kensington or Holland Park to mull over the problem. THE ROOT OF ALL THE EVIL WAS CLEARLY SPECIAL RELATIVITY. All these paradoxes resulted from well known effects such as length contraction, time dilation, or E=mc^2, all basic predictions of special relativity. And all denied the possibility of establishing a well-defined border, common to all observers, capable of containing new quantum gravitational effects." http://www.amazon.com/Faster-Than-Speed-Light-Speculation/dp/0738205257 Neil Turok: "It's the ultimate catastrophe: that theoretical physics has led to this crazy situation where the physicists are utterly confused and seem not to have any predictions at all." http://www2.macleans.ca/2013/09/05/perimeter-institute-and-the-crisis-in-modern-physics/ Frank Close: "In recent

years, however, many physicists have developed theories of great mathematical elegance, but which are beyond the reach of empirical falsification, even in principle. The uncomfortable question that arises is whether they can still be regarded as science. Some scientists are proposing that the definition of what is "scientific" be loosened, while others fear that to do so could open the door for pseudo-scientists or charlatans to mislead the public and claim equal space for their views." http://www.prospectmagazine.co.uk/features/what-happens-when-we-cant-test-scientific-theories Sabine Hossenfelder: "Many of my colleagues believe this forest of theories will eventually be chopped down by data. But in the foundations of physics it has become extremely rare for any model to be ruled out. The accepted practice is instead to adjust the model so that it continues to agree with the lack of empirical support." http://www.nature.com.proxy.readcube.com/nphys/journal/v13/n4/f Sabine Hossenfelder (Bee): "The criticism you raise that there are lots of speculative models that have no known relevance for the description of nature has very little to do with string theory but is a general disease of the research area. Lots of theorists produce lots of models that have no chance of ever being tested or ruled out because that's how they earn a living. The smaller the probability of the model being ruled out in their lifetime, the better. It's basic economics. Survival of the 'fittest' resulting in the natural selection of invincible models that can forever be amended." http://www.math.columbia.edu/~woit/wordpress/?p=9375 Peter Woit: "As far as this stuff goes, we're now not only at John Horgan's "End of Science", but gone past it already and deep into something different." http://www.math.columbia.edu/~woit/wordpress/?p=7266 "But instead of celebrating, physicists are in mourning after a report showed a dramatic decline in the number of pupils studying physics at school. The number taking A-level physics has dropped by 38% over the past 15 years, a catastrophic meltdown that is set to continue over the next few years. The report warns that a shortage of physics teachers and a lack of interest from pupils could mean the end of physics in state schools. Thereafter, physics would be

restricted to only those students who could afford to go to posh schools. Britain was the home of Isaac Newton, Michael Faraday and Paul Dirac, and Brits made world-class contributions to understanding gravity, quantum physics and electromagnetism - and yet the British physicist is now facing extinction. But so what? Physicists are not as cuddly as pandas, so who cares if we disappear?" http://www.guardian.co.uk/science/2005/nov/22/schools.g2 Peter Woit: "If, as seems increasingly all too possible, we're now at an endpoint of fundamental physics, with the field killed off by a pseudo-scientific argument..." http://www.math.columbia.edu/~woit/wordpress/?p=9444 Peter Woit: "I think the worst thing that has happened to theoretical physics over the past 25 years is this descent into ideology, something that has accelerated with the multiverse mania of the last 10-15 years." http://www.math.columbia.edu/~woit/wordpress/?p=9375 The last quotation is correct, except for the number 25 - it should be replaced by 112 (note the "embarrassing question" that will have to be answered soon): "This paper investigates an alternative possibility: that the critics were right and that the success of Einstein's theory in overcoming them was due to its strengths as an ideology rather than as a science. The clock paradox illustrates how relativity theory does indeed contain inconsistencies that make it scientifically problematic. These same inconsistencies, however, make the theory ideologically powerful. [...] The gatekeepers of professional physics in the universities and research institutes are disinclined to support or employ anyone who raises problems over the elementary inconsistencies of relativity. A winnowing out process has made it very difficult for critics of Einstein to achieve or maintain professional status. Relativists are then able to use the argument of authority to discredit these critics. Were relativists to admit that Einstein may have made a series of elementary logical errors, they would be faced with the embarrassing question of why this had not been noticed earlier. Under these circumstances the marginalisation of antirelativists, unjustified on scientific grounds, is eminently justifiable on grounds of realpolitik. Supporters of relativity theory have

protected both the theory and their own reputations by shutting their opponents out of professional discourse. [...] The triumph of relativity theory represents the triumph of ideology not only in the profession of physics bur also in the philosophy of science." Peter Hayes, The Ideology of Relativity: The Case of the Clock Paradox http://www.informaworld.com/smpp/content~content=a909857880 And when ideology replaces science, bureaucrats replace scientists of course: Mike Alder: "It is easy to see the consequences of the takeover by the bureaucrats. Bureaucrats favour uniformity, it simplifies their lives. They want rules to follow. They prefer the dead to the living. They have taken over religions, the universities and now they are taking over Science. And they are killing it in the process. The forms and rituals remain, but the spirit is dead. The cold frozen corpse is so much more appealing to the bureaucratic mind-set than the living spirit of the quest for insight. Bureaucracies put a premium on the old being in charge, which puts a stop to innovation. Something perhaps will remain, but it will no longer attract the best minds. This, essentially, is the Smolin position. He gives details and examples of the death of Physics, although he, being American, is optimistic that it can be reversed. I am not. [...] Developing ideas and applying them is done by a certain kind of temperament in a certain kind of setting, one where there is a good deal of personal freedom and a willingness to take risks. No doubt we still have the people. But the setting is gone and will not come back. Science is a product of the renaissance and an entrepreneurial spirit. It will not survive the triumph of bureacracy. Despite having the infrastructure, China never developed Science. And soon the West won't have it either." https://www.highbeam.com/doc/1G1-172684821.html Pentcho Valev

4. *Pentcho Valev* • 2017-10-18 04:30 PM

   Fundamental physics is paralyzed, even killed, by blind faith in false principles. The falsehood of Einstein's constant-speed-of-light postulate is easy to prove but I'm not going to do this here. Let me just call the attention, by quoting Joao Magueijo, to the validity of the following conditional: If Einstein's constant-speed-of-light postulate is false, fundamental physics is dead. "The speaker Joao

Magueijo, is a Reader in Theoretical Physics at Imperial College, London and author of Faster Than the Speed of Light: The Story of a Scientific Speculation. He opened by explaining how Einstein's theory of relativity is the foundation of every other theory in modern physics and that the assumption that the speed of light is constant is the foundation of that theory. Thus a constant speed of light is embedded in all of modern physics and to propose a varying speed of light (VSL) is worse than swearing! It is like proposing a language without vowels." http://www.thegreatdebate.org.uk/VSLRevPrnt.html "...Dr. Magueijo said. "We need to drop a postulate, perhaps the constancy of the speed of light." http://www.nytimes.com/2002/12/31/science/e-and-mc2-equality-it-seems-is-relative.html "But the researchers said they spent a lot of time working on a theory that wouldn't destabilise our understanding of physics. "The whole of physics is predicated on the constancy of the speed of light," Joao Magueijo told Motherboard. "So we had to find ways to change the speed of light without wrecking the whole thing too much." http://www.telegraph.co.uk/technology/2016/12/06/speed-light-discovered/ Joao Magueijo, Faster Than the Speed of Light, p. 250: "Lee [Smolin] and I discussed these paradoxes at great length for many months, starting in January 2001. We would meet in cafés in South Kensington or Holland Park to mull over the problem. THE ROOT OF ALL THE EVIL WAS CLEARLY SPECIAL RELATIVITY. All these paradoxes resulted from well known effects such as length contraction, time dilation, or E=mc^2, all basic predictions of special relativity. And all denied the possibility of establishing a well-defined border, common to all observers, capable of containing new quantum gravitational effects." http://www.amazon.com/Faster-Than-Speed-Light-Speculation/dp/0738205257 Pentcho Valev

5. *Pentcho Valev* • 2017-10-18 05:19 PM

   Another science killer is the false second law of thermodynamics. Systems violating the second law are commonplace but scientists always turn the blind spot of the eye to them. Here is vigorous motion of water in an electric field, obviously able to produce work

- e.g. by rotating a waterwheel: "The Formation of the Floating Water Bridge including electric breakdowns" https://www.youtube.com/watch?v=17UD1goTFhQ "The water movement is bidirectional, i.e., it simultaneously flows in both directions." https://www.wetsus.nl/home/wetsus-news/more-than-just-a-party-trick-the-floating-water-bridge-holds-insight-into-nature-and-human-innovation/1 The work (rotating a waterwheel) will be done at the expense of what energy? The first hypothesis that comes to mind is: At the expense of electric energy. The system is, essentially, an electric motor. However close inspection would suggest that the hypothesis is untenable. Scientists use triply distilled water to reduce the conductivity and the electric current passing through the system to minimum. If, for some reason, the current is increased, the motion stops - such system cannot be an electric motor. If the system is not an electric motor, then it is a heat engine violating the second law of thermodynamics. Here arguments describing such heat engines as impossible, idiotic, etc. are irrelevant - the following conditional is valid: IF THE SYSTEM IS NOT AN ELECTRIC MOTOR, then it is a a heat engine violating the second law of thermodynamics. In other words, if the work is not done at the expense of electric energy, it is done at the expense of ambient heat. No third source of energy is conceivable. In the electric field between the plates of a capacitor, the same turbulent motion can be seen: " Liquid Dielectric Capacitor" http://www.youtube.com/watch?v=T6KAH1JpdPg In the capacitor system the rising water can repeatedly do work, e.g. by lifting floating weights. The crucial question is: The work (lifting floating weights) will be done at the expense of what energy? Obviously "electric energy" is not the correct answer - the capacitor is not an electric motor. Then the only possible answer remains "ambient heat". The system is a heat engine violating the second law of thermodynamics! Pentcho Valev

6. *Pentcho Valev* • 2017-10-19 07:03 AM

   Why scientists are unable to see the obvious violations of the second law of thermodynamics: Clifford Truesdell, The Tragicomical History of Thermodynamics, 1822-1854, p. 6: "Finally, I confess to a heartfelt hope - very slender but tough - that

even some thermodynamicists of the old tribe will study this book, master the contents, and so share in my discovery: Thermodynamics need never have been the Dismal Swamp of Obscurity that from the first it was and that today in common instruction it is; in consequence, it need not so remain." [...] p. 333: "Clausius' verbal statement of the "Second Law" makes no sense, for "some other change connected therewith" introduces two new and unexplained concepts: "other change" and "connection" of changes. Neither of these finds any place in Clausius' formal structure. All that remains is a Mosaic prohibition. A century of philosophers and journalists have acclaimed this commandment; a century of mathematicians have shuddered and averted their eyes from the unclean." https://www.amazon.com/Tragicomical-Thermodynamics-1822-1854-Mathematics-Physical/dp/1461394465 Jos Uffink, Bluff your way in the Second Law of Thermodynamics: "I therefore argue for the view that the second law has nothing to do with the arrow of time. [...] Before one can claim that acquaintance with the Second Law is as indispensable to a cultural education as Macbeth or Hamlet, it should obviously be clear what this law states. This question is surprisingly difficult. The Second Law made its appearance in physics around 1850, but a half century later it was already surrounded by so much confusion that the British Association for the Advancement of Science decided to appoint a special committee with the task of providing clarity about the meaning of this law. However, its final report (Bryan 1891) did not settle the issue. Half a century later, the physicist/philosopher Bridgman still complained that there are almost as many formulations of the second law as there have been discussions of it. And even today, the Second Law remains so obscure that it continues to attract new efforts at clarification." http://philsci-archive.pitt.edu/313/1/engtot.pdf Pentcho Valev

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Brazilian Amazon still plagued by illegal use of natural resources

Practices such as poaching and illegal logging are concentrated near inhabited areas and along rivers, study finds.

17 October 2017

Jeff Hutchens/Getty

An official with Brazil's environmental enforcement agency arrests poachers caught near Manaus.

Despite Brazil’s efforts to safeguard the Amazon rainforest by establishing protected areas and boosting law enforcement, illegal use of the region’s natural resources is still widespread, according to a study[1] published on 10

October in *PeerJ*.

The researchers looked at 4,243 law-enforcement records from between 2010 and 2015, across 118 federally protected areas of the Brazilian Amazon. Although the overall number of citations decreased over those five years, illegal activities still occurred in nearly every protected area. The analysis highlighted the need for improved monitoring and enforcement, says study co-author Érico Kauano, a conservation biologist at the Chico Mendes Institute for Biodiversity Conservation (ICMBio), the Brazilian agency responsible for the management of the federal protected areas.

Kauano and his colleagues grouped illegal activities into ten categories, and found that 37% of the infractions fell into the "suppression and degradation of vegetation" group, which included deforestation, logging of endangered tree species and the unauthorized use of fire. Illegal fishing was the next most common citation at 27%, followed by hunting at 18%. Most of the illegal activity occured in more accessible and densely populated areas.

Roads have a major role in opening up the tropics to colonization and exploitation[2]. Deforestation of the Brazilian Amazon increased after the construction of the Belém–Brasília Highway in the 1960s, and continued with the opening of the Trans-Amazonian Highway in 1970s. A 2014 study[2] using satellite images found that around 95% of the deforestation in Brazil's Amazon occurred within 5.5 kilometres of a road and within 1 kilometre of a navigable river.

Caught in the act

The availability and use of government data are what sets this study apart from others, says Emilio Bruna, a tropical ecologist at the University of Florida in Gainesville, who was not involved in the study. Past studies, including a paper[3] published last month in *Biotropica* (where Bruna is editor-in-chief), struggled to obtain even the most basic information, such as how many staff members were employed by the agency that manages protected areas, and how much they were paid, Bruna says.

Data from efforts on the ground are important because, although remote-sensing instruments such as satellites can detect deforestation, for example, they fail to identify threats present beneath the forest canopy. Law-enforcement records, when available, can complement remote-sensing data sets, the study authors say.

“You can actually tell what it is they’re writing infractions for, and that’s valuable,” says Bruna. But he points out that, without knowing where law-enforcement efforts are being allocated, it’s only a partial picture. “It could be that the reason certain protected areas have the most infractions is because those are the places that are under the greatest threat,” he says. “Or it could be because that’s where the greatest enforcement is being focused.”

Greater enforcement

“We are still far from having adequate staff in the protected areas,” Kauano says. In 2014, a local news outlet reported that the Brazilian Institute of Environment and Renewable Natural Resources had only 47 agents to monitor environmental crimes in Amazonas, the country’s largest state in the Amazon region, which covers an area of about 1.6 million square kilometres.

Hiring more enforcement officials looks unlikely in the short term, however, owing to Brazil’s ongoing political and economic crisis, says Kauano. “What ICMBio seeks to do to overcome this is to prioritize some regions with greater problems.”

Bruna cautions against jumping to conclusions from the study’s results, however. “Not all infractions are created equal,” he says. It’s important to differentiate between a resident fishing out of season and a fishing charter operator. Bruna worries that some may look at this study and think that the people living near protected areas are the problem. But they aren’t the only ones breaking the law, he says. And the demand for the fruits of this illegal labour comes from all over the world.

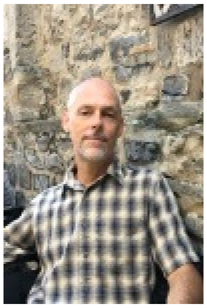
Local people can, in fact, be part of the solution. There is some evidence that people living in or near protected areas are helping with conservation, says

Kauano. But he adds that the government needs to make a greater effort to work with local communities.

Journal name:
Nature
DOI:
doi:10.1038/nature.2017.22830

Comments

Commenting is currently unavailable.



Ellie R. Martinson

Give researchers a lifetime word limit

Brian C. Martinson[1] imagines how rationing the number of publications a scientist could put out might improve the scientific literature.

17 October 2017

A dirty truth pervades academic publishing: we write papers to gain credit in an academic marketplace. Almost a quarter of a century ago, academic worthies lamented that scholarly publications had become “the coins academics must use to get through the tollgates on their way to academic promotion” (D. Rennie and A. Flanagin *J. Am. Med. Assoc.* **271**, 469–471; 1994). In some cases, papers in flashy journals truly do bring in hard cash — reportedly more than US$40,000 at some universities in China. And plenty of people reading this will have felt they’d better squeeze a paper or two out soon to have any chance of getting their next grant proposal funded.

The purpose of authorship has shifted. Once, its primary role was to share knowledge. Now it is to get a publication — ‘pubcoin’ if you will. Authorship has become a valuable commodity. And as with all valuable commodities, it is bought, sold, traded and stolen. Marketplaces allow

unscrupulous researchers to purchase authorship on a paper they had nothing to do with, or even to commission a paper on the topic of their choice. ‘Predatory publishers’ strive to collect fees without ensuring quality.

I have spent much of my career studying how academic and clinical workplaces influence how carefully researchers conduct their studies. The commodification of authorship encourages all manner of corner-cutting, sloppiness in research, and other degradations in the quality of publications, not to mention an obvious motive for plagiarism. A quest for high-profile papers leads researchers to favour a spectacular result, even if it is specious. Authors cite themselves to boost the impact of publications, and cite colleagues to curry favour.

At this point, it is hard even to envisage a world in which the communication of knowledge could return to its rightful place as the focus of academic authorship. But if we cannot imagine something, we cannot attain it. So let me try. Imagine a world in which each scientist is allotted a fixed number of words that they can publish over her or his career. I’m not the first person to suggest this: the Australian writer Michael McGirr has proposed a word limit for every person.

What would happen? Might authorship regain its original purpose?

Lifetime limits would create a natural incentive to do research that matters. Researchers would have to ask themselves, “Is this project I’m pursuing worth the words it will cost me?” I see several articles in my own CV that did not contribute much knowledge to the world. I cannot help but think that I might have pursued better questions had a word limit been in place.

Ideally, limits would encourage researchers to ensure that research is conducted with the utmost care. (Imagine losing part of your allotment of words to a paper that is discredited or even retracted.) This would provide a counterweight to the pressure to publish quickly for priority. It would also lead to increased value being placed on concision and clarity, improving readability and efficiency. Honorary authorship would become much less attractive.

With less time needing to be spent on papers of low quality or containing

little new information, readers and editors would be able to give the smaller number of articles more attention. Editorial workload would be reduced by virtue of the lower volume and the higher quality of material. This might reduce editorial costs, enhance quality, and quite possibly enhance the job satisfaction and quality of life of editors and readers. Predatory publishers would vanish.

With a boost in the quality of scientific papers, the communal work of peer review would get easier. Individual researchers would be asked to carry out fewer reviews. Reviewing invitations would be for work of higher quality, making the job more enjoyable and less aggravating. And knowing the stakes for the authors in expending their precious words, reviewers themselves might be inclined to put more time and effort into their reviews, further improving quality.

The task of evaluating candidates for jobs, advancement and prizes would become less scattershot. With fewer publications per candidate, promotion and tenure committees could become less reliant on tallying counts of first-authored publications, and devote time to reading and critiquing the published work. This, in turn, should reduce their use of journal impact factors as proxies for quality.

Limits would of course bring a new set of problems: if we don't also address our own cognitive biases and penchant for compelling narratives, word limits could exacerbate tendencies to publish only positive findings, leading researchers to explore blind alleys that others' negative results could have illuminated. Researchers might skimp on a full description of caveats, previous work and methods. Some subjects and pursuits might be inherently wordier than others. Exceptions might have to be made for experts such as statisticians and bioinformaticians whose skills are required on many papers — but perhaps this would boost the quality of collaborations. Perhaps researchers could apply for word bonuses for careful reproductions, cautious interpretations and meticulously described methods.

Would these drawbacks be worse than the current incentives to publish as much as you can? We have lost sight of information sharing as the primary reason for publishing. Perhaps my flight of fancy is a rose-tinted remembrance of times past. Or perhaps it can serve as a guide to restore the

exchange of ideas to its rightful, pithy, place.

Journal name:
Nature
Volume:
550,
Pages:
303
Date published:
(19 October 2017)
DOI:
doi:10.1038/550303a

Comments

Commenting is currently unavailable.

Japanese research leaders warn about national science decline

Concern mounts over budget cuts and other changes that undermine basic science.

17 October 2017 Corrected:

1. 20 October 2017

Toru Hanai/Reuters

People gather for a rally in Fukushima, Japan, for Prime Minister Shinzo Abe and the Liberal Democratic Party.

As Japan heads towards a national election on 22 October, scientific leaders worry that the outcome will do little to address long-standing concerns about the country's deteriorating research landscape. They say that a decline in funding and a shift away from basic research has undermined Japan's capacity to compete against both established scientific powerhouses and emerging ones such as China.

Since 25 September, when Prime Minister Shinzo Abe called for a snap election, science has barely featured in the campaign. Debate has focused on the government's plan to amend the constitution and increase taxes. The latest polls suggest that Abe's conservative Liberal Democratic Party could lose some seats, but will retain enough to lead a coalition government.

If Abe is re-elected, he says, his government will pursue an innovation agenda. At a meeting of global science leaders in Kyoto on 1 October, Abe reaffirmed his pledge to turn Japan into "a cradle of innovation" by cutting regulations that impede new technologies.

Despite Abe's lofty ambitions, the ruling party coalition has decreased the science and technology budget by more than 5% overall since it came to power in 2012. And the budget for universities has dropped by about 1% a year for a decade. "This has been pointed out as the major cause of the deterioration of research performance and, eventually, the global rank of Japanese universities," says Takashi Onishi, president of Toyohashi University of Technology and a former president of the Science Council of Japan, which advises the government. In the past two decades, the country's share of highly cited papers has stagnated, whereas those of many other leading nations are rising, according to publisher Elsevier's Scopus database.

In an attempt to elevate Japan's top research universities, the government has introduced reforms that categorize institutions according to their research or teaching focus, and that allocate funding on the basis of performance. The government wants leading research institutions to compete globally for the best students and faculty.

Atsushi Sunami, a science-policy specialist at the National Graduate Institute for Policy Studies (GRIPS) in Tokyo, agrees with this aim, but says that to succeed, the government will need to increase its research funding. And

money alone will not be enough, says Hiroshi Nagano, also a science-policy specialist at GRIPS. For universities to become world class, they need autonomy to decide their research and teaching focus, he says. “The current policy is oriented in the opposite direction.”

Basic research left behind

Changes to the university system implemented by Abe’s government are designed to make academia more responsive to the needs of society and industry, in the hope that it will boost low private-sector investment in research. Although scientists broadly encourage this increased collaboration, some say that it has compromised support for basic research. “The government should focus on the development of basic research to supply seeds or ideas to applied sciences,” says Onishi.

Science leaders point to other big concerns about the future of Japanese research. Michinari Hamaguchi, head of the Japan Science and Technology Agency in Tokyo, says that the domestic workforce will be insufficient to keep up with changes in science, technology and innovation, given the country’s rapidly ageing population. He says that policies are urgently needed to encourage more women and foreigners into science and to boost the number of students in doctoral courses, which has dropped by 18% since 2003.

Students who pursue research careers are finding it harder to get jobs. Budget cuts have depleted permanent research positions at universities, and fewer younger researchers are securing permanent posts: the number of research associates on short-term contracts more than doubled from 2007 to 2013.

Biologist and 2016 Nobel prizewinner Yoshinori Ohsumi has warned that the situation for young researchers will jeopardize the country’s chances of winning future Nobel prizes. Japan has the second-highest number of science laureates in the twenty-first century after the United States — but, Ohsumi says, that record is unlikely to hold.

Journal name:

Nature
Volume:
550,
Pages:
310–311
Date published:
(19 October 2017)
DOI:
doi:10.1038/550310a

Corrections

Corrected:

An earlier version of this story misspelled the name of Michinari Hamaguchi. Also, he is based in Tokyo, not in Kawaguchi.

Comments

Comments

There are currently no comments.

Reboot for the AI revolution

17 October 2017

As artificial intelligence puts many out of work, we must forge new economic, social and educational systems, argues Yuval Noah Harari.

Laura Lezza/Getty

A robot conducts the Orchestra Filarmonica di Lucca at Teatro Verdi in Pisa, Italy, this September.

The ongoing artificial-intelligence revolution will change almost every line of work, creating enormous social and economic opportunities — and challenges. Some believe that intelligent computers will push humans out of the job market and create a new 'useless class'; others maintain that

automation will generate a wide range of new human jobs and greater prosperity for all. Almost everybody agrees that we should take action to prevent the worst-case scenarios.

The automation revolution is emerging from the confluence of two scientific tidal waves. Computer scientists are developing artificial intelligence (AI) algorithms that can learn, analyse massive amounts of data and recognize patterns with superhuman efficiency. At the same time, biologists and social scientists are deciphering human emotions, desires and intuitions. The merger of infotech and biotech is giving rise to algorithms that can successfully analyse us and communicate with us, and that may soon outperform human doctors, drivers, soldiers and bankers in such tasks. These algorithms could eventually push hundreds of millions out of the job market.

Governments might decide to deliberately slow down the pace of automation, to lessen the resulting shocks and allow time for readjustments. But it will probably be both impossible and undesirable to prevent automation and job loss completely. That would mean giving up the immense positive potential of AI and robotics. If self-driving vehicles drive more safely and cheaply than humans, it would be counterproductive to ban them just to protect the jobs of taxi and lorry drivers.

A more sensible strategy is to create new jobs. In particular, as routine jobs are automated, opportunities for new non-routine jobs will mushroom. For example, general physicians who focus on diagnosing known diseases and administering familiar treatments will probably be replaced by AI doctors. Precisely because of that, there will be more money to pay human experts to do groundbreaking medical research, develop new medications and pioneer innovative surgical techniques.

This calls for economic entrepreneurship and legal dexterity. Above all, it necessitates a revolution in education.

Lifelong learning

To make use of the new opportunities, people will need radical, lifelong

retraining. The AI revolution won't be a single event after which the job market and the educational system will settle into a new equilibrium. Rather, it will be a cascade of ever-bigger disruptions. Even today, few employees expect to work in the same job for their entire life (see go.nature.com/2ymdvjs). By 2050, not just the idea of 'a job for life', but even the idea of 'a profession for life' might seem antediluvian. It will become increasingly difficult to know what to teach schoolchildren and university students.

Predicting the future was never easy. If you lived in China 1,000 years ago, there were many things you didn't know: the empire might collapse in 50 years; the Khitans might invade, or a new plague might kill millions. Nevertheless, you did know that most people would still work as farmers and weavers, rulers would still need men to fight in their armies and administer their taxes, women would still have few opportunities beyond marriage and life expectancy would still be about 40 years.

LISTEN

Reporter Benjamin Thompson finds out how lessons from the past can help explore the future of work.

You may need a more recent browser or to install the latest version of the Adobe Flash Plugin.

Hence, in 1017, poor Chinese parents taught their children how to plant rice or weave silk, and wealthier parents taught their boys how to read and write, or to fight on horseback, and their girls to be modest and obedient housewives. It was obvious that these skills would still be needed. In 2017, by contrast, we have no such certainties about the future of jobs, gender, economics or even death.

Human psychology, too, might turn out to be a key hurdle. Change is always stressful. Already we face an epidemic of stress and anxiety (see go.nature.com/2z96s57). As the volatility of the job market and of individual careers increases, we may wonder whether everyone will have the emotional

stamina necessary for a life of constant flux. We may need more-effective stress-reduction techniques — ranging from drugs through neurofeedback to meditation — to cope.

Creating new jobs might prove easier than retraining people to fill them. A huge useless class might appear, owing to both an absolute lack of jobs and a lack of relevant education and mental flexibility.

Test cases

It is particularly important to identify as early as possible the potential winners and losers from new technologies. Rosy overall statistics can hide growing gaps between disparate groups. Automation might have a very different impact on men and women, on 40-somethings and 20-somethings, on the university-educated and the illiterate.

The winners and losers are not the usual suspects. In the clinic, for example, automation might prove more of a threat to doctors than to nurses. Many physicians focus almost exclusively on processing information: they absorb medical data, analyse them and produce a diagnosis. Nurses also need good motor and emotional skills, to give a painful injection, replace a bandage and listen with care. We will probably have an AI family doctor on our smartphone years before we have a reliable nurse robot[1].

Exploring the relationship between intelligence and consciousness will also be crucial to understanding the economic, professional and ethical rapport between future computers and humans. We are seeing a tremendous development in computer intelligence, but zero development in computer consciousness. Just as aeroplanes fly faster than birds without ever developing feathers, so computers could come to solve problems and even to analyse human feelings much better than humans, without ever developing feelings. Studying these differences will help us to predict what AI can and cannot do, and to decide what should be kept out of its control.

There are a few areas in which AI has already made significant strides that, in my view, offer test cases for the impact of modern automation on the world

of work.

In chess, it has been 20 years since IBM's Deep Blue computer thrashed Gary Kasparov. Yet humans still play chess, and 'centaur' teams of humans-plus-AIs can outperform both. This seems at first to bode well for the future: the job market could nurture people who can leverage, rather than compete with, AI. Yet the balance of power in centaur teams is constantly shifting. Computers are becoming so good at chess that the humans are gradually losing value, and could soon become irrelevant. The same thing might happen in other human–AI teams[2].

Laura Lezza/Getty

A woman with a robot at an Italian nursing home in 2015.

Self-driving vehicles are another important test case. The race to produce self-driving vehicles now pits old steel giants such as Mercedes-Benz against new silicon giants such as Google. Transport leverages one of the core advantages of AI: connectivity. Even if a single computer-driven car is less

competent than a good human driver, a network of computer-driven cars is still likely to be much safer and more efficient than the chaos of fallible human drivers that currently dominates the roads.

Today, about 1.25 million people are killed annually in car accidents[3], more than 90% of which are estimated to be caused by human errors[4]. When two human drivers approach the same junction, they might miscommunicate and collide. But computer-driven vehicles can be connected — the chances that they might miscommunicate and collide are therefore much smaller. Similarly, it is easier to ensure that automated vehicles comply with rules such as speed limits (not to mention the ban on drink driving), even as those rules change[5, 6, 7].

Self-driving vehicles illustrate two important points. First, that in some fields it might make sense to replace all humans with robots and computers, even if individually some humans do a better job. Second, that when change comes to some realms, it might do so suddenly, not step-wise.

The military is another important bellwether, because armies are early adopters of much technology. Human soldiers carry a very high economic and political price tag, so replacing people with computers on the battlefield has proved attractive. The most advanced armies now increasingly rely on relatively small numbers of experts coupled with sophisticated and autonomous technologies, such as drones, robots, smart bombs, cyberworms and algorithms that sift through a mass of data[8, 9].

This shift has produced new classes of military jobs in maintenance, remote control, programming and cybersecurity. The US armed forces need 30 people to operate every Predator or Reaper drone flying over Syria, and analysing the harvest of information occupies at least 80 more. A careful study of the military job market might tell us a lot about potential future developments in the civilian economy.

New order

With insights gleaned from early warning signs and test cases, scholars

should strive to develop new socio-economic models. The old ones no longer hold. For example, twentieth-century socialism assumed that the working class was crucial to the economy, and socialist thinkers tried to teach the proletariat how to translate its immense economic power into political clout. In the twenty-first century, if the masses lose their economic value they might have to struggle against irrelevance rather than exploitation.

One new model has been gaining increasing attention and popularity: universal basic income (UBI). UBI suggests that the government should tax the rich and big corporations to provide every person with a stipend covering his or her basic needs. This will cushion the poor against job loss and economic dislocation, and protect the rich from populist rage. It will also free the masses to engage in more creative forms of work that might not currently have economic value, or to pursue further education.

In January 2017, Finland began a 2-year experiment, providing 2,000 unemployed citizens with €560 (US$657) per month, irrespective of whether they work. Similar experiments are under way in the Canadian province of Ontario, in the Italian city of Livorno and in several Dutch cities[10].

Of course, such national and municipal schemes might not solve the worst problems. Globalization has made people in one country utterly dependent on markets in others, and automation might unravel large parts of this global trade network with disastrous consequences for the weakest links. AI might generate immense wealth in hi-tech hubs such as Silicon Valley and Bangalore, while devastating the economies of underdeveloped countries that rely on cheap labour, such as Honduras and Bangladesh.

US voters might conceivably agree that taxes paid by tech giants Amazon and Google for their US business should be used to give stipends to unemployed coalminers in Pennsylvania or jobless taxi-drivers in New York. But they are unlikely to send their taxes to Honduras. We are still far from having any feasible models for a post-work economy, society or political system, and we don't have much time to formulate them.

In the nineteenth century, the Industrial Revolution created new conditions and problems that none of the existing social, economic and political models could cope with. Consequently, humankind had to develop completely new

models — liberal democracies, communist dictatorships and fascist regimes. It took more than a century of terrible wars and revolutions to experiment with these, separate the wheat from the chaff and implement the best solutions.

The challenges posed in the twenty-first century by the merger of infotech and biotech are arguably bigger than those thrown up by steam engines, railways, electricity and fossil fuels. Given the immense destructive power of our modern civilization, we cannot afford more failed models, world wars and bloody revolutions. We have to do better this time.

Journal name:
Nature
Volume:
550,
Pages:
324–327
Date published:
(19 October 2017)
DOI:
doi:10.1038/550324a

Comments

Comments

There are currently no comments.

Eye in the sky offers clearest vision of Earth

The world's latest carbon-monitoring satellite has advanced our understanding of how the planet functions. US politicians should take note.

16 October 2017

Bill Ingalls/NASA

Launched in 2014, the OCO-2 satellite has offered unprecedented views of carbon flow on Earth.

When a rocket failure saw NASA's first carbon-monitoring satellite plunge

into the ocean in 2009, it was a major blow for climate scientists. Space-based greenhouse-gas monitoring was a promising new frontier — and perhaps an eventual tool for monitoring international climate commitments. It took several years to get a replacement into space, but the Orbiting Carbon Observatory-2 (OCO-2) began taking measurements in 2014. The first major scientific results were published last week in *Science*[1–5], and there can be no doubt that the mission is delivering. No doubts, either, that the US government should launch a successor.

The results give an unprecedented insight into one of the most important planetary phenomena: El Niño, the subtle but massively influential gathering of warm waters in the tropical Pacific Ocean. The 2015–16 El Niño was a monster, changing weather patterns and driving the largest and longest coral-reef-bleaching event on record. Through it all, scientists used OCO-2 to watch carbon move through oceans and ecosystems.

The overall trend came as little surprise — a massive increase in global atmospheric carbon levels. Scientists have measured similar rises in carbon dioxide during past El Niños. But the precise mechanism was elusive. OCO-2 helped clarify the matter by producing detailed maps. Researchers saw an initial decrease in the amount of CO_2 coming out of the tropical Pacific Ocean, a dip later swamped by CO_2 originating from Africa, South America and southeast Asia as the event wore on.

Tracking carbon is just the first step. Those data feed into atmospheric models that can provide a more comprehensive explanation for the origin — and destination — of any given CO_2 molecule. Fortunately, sensors on board OCO-2 can assess the amount of photosynthesis using methods other than measuring carbon flux. They detect a photosynthesis-linked signal called solar-induced chlorophyll fluorescence, which gives an independent measure of how much CO_2 plants are taking up.

With this suite of tools, scientists have managed to paint a finer picture of how the 2015–16 El Niño affected individual regions. Heat and drought set the stage for the massive wildfires that ravaged Indonesia during the event, whereas drought-stricken trees in the Amazon rainforest took up less carbon than usual. In Africa, the higher temperatures probably boosted plant

respiration. All three mechanisms for increasing atmospheric CO_2 have been proposed in the past, but it was a surprise to see all play out on different continents simultaneously.

Plenty of questions remain. The satellite measurements are not as precise as scientists would like, and they don't always align perfectly with data from the ground. And getting the models right is a never-ending challenge. It will be some time before satellites are able to provide the precision needed to quantify the natural carbon cycle, let alone to separate out human emissions with enough confidence to verify whether countries are meeting their obligations to cut greenhouse-gas emissions. But OCO-2 is further validation that the effort is worth pursuing.

US politicians should take note. President Donald Trump has proposed scrapping a follow-on mission, OCO-3, presumably because it falls under the rubric of climate — a topic that is anathema to this administration. That would be a self-defeating and damaging move. The bulk of the budget for OCO-3 — which was built from the spare parts of its predecessor — has already been spent; all that's left is the expense of launch and operation. Killing the mission now would waste time and money. But more importantly, as these latest studies show, humanity can learn from the measurements that it will make.

OCO-2 is an affirmation of climate science that everybody should be able to appreciate, regardless of political leanings. Trump might not like talking about climate. But surely his administration — and the lawmakers on Capitol Hill who will decide whether OCO-3 survives — cares about the weather.

El Niño has an impact on weather systems around the world. It raises the likelihood of heavy rainfall from California to the Gulf of Mexico, while increasing the chances of drought and extreme heat in areas farther north. El Niño and its opposite sister system La Niña factor heavily in longer-term seasonal forecasts, which can help governments prepare for fires like those tearing through California at the moment. The more we understand this system, the better we will be at forecasting changes in the weather, the climate — and the economy. A 2014 report from the International Monetary Fund argued that effects of El Niño should be taken into account when

nations plan their finances. This has nothing to do with politics, and everything to do with understanding the world in which we live.

Journal name:
Nature
Volume:
550,
Pages:
301
Date published:
(19 October 2017)
DOI:
doi:10.1038/550301a

Comments

Comments

There are currently no comments.

Colliding stars spark rush to solve cosmic mysteries

Stellar collision confirms theoretical predictions about the periodic table.

16 October 2017

Cosmic furnace

A simulation of the merger of two neutron stars, leading to the formation of a black hole. About 2% of the stars' mass gets ejected at high speed, producing radioactive, heavy atoms.

Credit: W. Kastaun/T. Kawamura/B. Giacomazzo/R. Ciolfi/A. Endrizzi via Caltech

Gold, platinum, uranium and many of the rare-earth elements that are crucial to today's high-tech gadgets are generated during the formation of black holes, astronomers have said. The collision of two small but dense stars simultaneously solved several cosmic mysteries, researchers announced at a press conference in Washington DC on 16 October. More than 30 papers have been published so far in five journals — *Physical Review Letters, Science*, *Nature*, *Nature Astronomy* and *Astrophysical Journal Letters.*

Astronomers watched as two neutron stars — small but very dense objects formed after the collapse of stars bigger than the Sun — collided and merged, forming a black hole, in a galaxy 40 million parsecs (130 million light years) away, according to two dozen researchers interviewed by *Nature*'s News team.

The collision generated the strongest and longest-lasting gravitational-wave signal ever seen on Earth. And the visible-light signal generated during the

collision closely matches predictions made in recent years by theoretical astrophysicists, who hold that many elements of the periodic table that are heavier than iron are formed as a result of such stellar collisions.

Neutron-star mergers are also thought to trigger previously mysterious short γ-ray bursts, a hypothesis that now also seems to have been confirmed.

Astronomers have good reasons to believe that they are looking at the same source of both the gravitational waves and the short γ-ray bursts, says Cole Miller, an astronomer at the University of Maryland in College Park, who was not involved in the research but who has seen some of the papers ahead of their publication.

Bright object

The event was detected on Earth on 17 August, and triggered weeks of febrile, round-the-clock activity on all 7 continents, as more than 70 teams of researchers scrambled to observe the aftermath.

The collision was felt first as a space-time tremor by the Laser Interferometer Gravitational-wave Observatory (LIGO) in the United States and by its Italy-based counterpart Virgo, and seen seconds afterwards as a smattering of high-energy photons by NASA's Fermi Gamma-ray Space Telescope.

Alerted by the LIGO–Virgo team, astronomers then raced to find and study what was seen as a bright object in the sky using telescopes big and small, famous and obscure, on land and in orbit, and spanning the spectrum of electromagnetic radiation, from radio waves to X-rays.

Cody Messick was at his home at 08:41 local time (12:41 UT) on 17 August when he first found out about the event. "I remember standing on my stairs and looking at my phone, thinking: 'Wow!" he says. Messick, who is a physicist at Pennsylvania State University in University Park, belongs to a small team of LIGO first-responders who receive frequent automated alerts from the two interferometers, which are based in Livingston, Louisiana, and Hanford, Washington. Normally, LIGO's algorithms flag a potential signal in real time only if both interferometers detect it. Messick was surprised,

because the message on his smartphone mentioned a strong signal — but one seen only at the Hanford site.

Messick quickly got on a conference call with his team leader, Chad Hanna, also at Pennsylvania State, and other colleagues. Together, they examined the data online. The Hanford signal looked like a textbook example of the waveform of the gravitational waves emitted by two compact objects, each slightly more massive than the Sun, as they spiral into each other, he says. In particular, the waves lasted much longer — about 100 seconds — and had a higher pitch than the signals from the much more massive black-hole mergers that LIGO had previously detected.

When they looked at the data stream coming from Livingston, the LIGO researchers found a similar signal there as well, but one with a loud, spurious glitch towards the end. It was that anomaly that had caused the real-time-analysis software to ignore the signal, says David Shoemaker, a physicist at the Massachusetts Institute of Technology in Cambridge who is LIGO’s spokesperson.

Meanwhile, researchers received another alert: Fermi had detected a short γ-ray burst that had occurred 1.7 seconds after the gravitational waves had ended. Called GRB170817A, it was unusually faint for such a burst.

Second signal

In Italy, another technical glitch had suspended the continuous stream of data normally sent out by Virgo. So it took another 40 minutes for researchers to realize that they, too, had a signal — albeit a faint one. It transpired that the waves had travelled close to one of the interferometer’s four blind spots, says Jo van den Brand, a physicist at the Vrije Universiteit Amsterdam and spokesperson for the Virgo Collaboration.

By 13:21 UT, 40 minutes after the event, the LIGO–Virgo team had decided to notify its roughly 70 follow-up partners — teams of astronomers on standby to look for related events using conventional telescopes.

Four and a half hours later, the team sent a second, much more useful alert.

The timing of Virgo's feeble signal had been sufficient for the LIGO-Virgo team to identify the source of the waves. It pointed to a region of the sky spanning an angle of just a few degrees, in the southern sky. They called the event GW170817, after the date it was detected.

Virgo had joined LIGO's observation campaign only on 1 August, after a five-year shutdown for upgrades. And just three days before the event's detection, on 14 August, LIGO and Virgo had made their first joint detection. It enabled them to rehearse the more precise identification of the patch of sky of interest. The event on 17 August enabled them to narrow it down even further. And the estimated distance was ten times closer to Earth than in the previous events. They could tell this because of how loud and persistent the waves were: it was the strongest signal LIGO had ever sensed. After the fact, Hanna's team was able to extract a signal that lasted a full six minutes.

Together, the alerts from LIGO–Virgo and Fermi sent astronomers into a frenzied rush. Each team wanted to be first to spot the fireworks produced by a neutron-star merger. It was daytime on most of the world's land mass, so teams began to formulate strategies for their nocturnal observations. They knew that, at that time of the year, the region to search was not far from the Sun. That left a window of observation of a couple of hours after dusk, before the region of sky would set below the horizon.

"We had a complicated, choreographed dance of telescopes that night," says Iair Arcavi, an astrophysicist at the University of California, Santa Barbara, whose team made non-stop observations using the Las Cumbres Observatory, a worldwide network of robotic telescopes. It began by activating a number of telescopes in Chile.

Three messengers

The first person to see the event may have been Charles Kilpatrick, an astronomer at the University of California, Santa Cruz. He was part of a team that was scanning the sky with the more modest means of the single one-metre Swope Telescope in Chile. Like his competitors, Kilpatrick was closely watching the exposures one by one as they came out, comparing them with

archival images of the same patch of sky. By the ninth exposure, he saw something very conspicuous in a galaxy called NGC 4993. “It looked exactly like a point source in this image that wasn’t in the reference image,” Kilpatrick says. The team named it SSS17a.

At least two other groups say they spotted the bright dot independently. They and other teams also made sure that there were no other plausible candidates within the search region. GW170817, GRB170817A and SSS17a really seemed to be three different messengers from the same source.

LIGO and Virgo lacked a sufficiently detailed signal of the final instants of the collision to be certain that the objects were neutron stars, Shoemaker says. From gravitational-wave data alone, they could have been two unusually small black holes. But the presence of visible light strongly suggested that at least one of the objects in the merger was a neutron star, he and other researchers say.

The group at the University of California, Santa Cruz, was also the first to measure the optical spectrum of SSS17a. On the first night, the dot was bright blue, says astronomer Ryan Foley, who led that effort. NASA’s Swift telescope also detected blue, as well as ultraviolet, light. But during the next few nights of observation, those colours faded away, and the object became more red, according to multiple teams.

Colliding neutron stars should spread debris — a mix of neutrons, but also some protons — in three ways, says Brian Metzger, a theoretical astrophysicist at Columbia University in New York City. First, they fling matter out from their outer layers during the final orbits. Then some matter gets squeezed out in the actual collision. Finally, as the two stars begin to collapse into a black hole, it forms an accretion disk of matter, some of which flies out instead of falling in.

Over the past decade or so, astrophysicists had come to believe that this was the most plausible mechanism to explain the abundance of the heavier elements of the periodic table[1]. The theory held that, overall, about 2% of the combined mass of the stars would escape the fate of the rest. Within one second of the collision, this material would have expanded to become a cloud tens of thousands of kilometres across, but still about as dense as the Sun. In

this cauldron, protons and neutrons would immediately clump together to form neutron-heavy nuclei, which would then begin to decay radioactively. This radioactivity would keep the cloud glowing hot for several days, even as it reached the size of the Solar System. Within a million years, it would spread across an entire galaxy.

As predicted

Metzger says that the switch from blue to red was just what he expected to see. His models suggest that nuclei in this early cloud would reach the masses of many of the elements beyond iron, although not the heaviest ones. This chemical composition would cause the cloud to glow blue.

But the real smoking gun for this model, the signatures of the formation of the heaviest elements, would be a cloud that glowed in the red and infrared. These would be elements forged in a separate wave of the explosion, probably the one coming from the accretion disk, says Metzger.

“We had predicted exactly what kind of red,” says Daniel Kasen, a theoretical astrophysicist at the University of California in Berkeley. Jennifer Barnes, another theorist then in Kasen’s team who is now at Columbia University, had run the supercomputer simulations that predicted the experimental signatures in 2013[2]. “I had just finished my PhD thesis predicting what these things would look like,” she says.

Eleonora Troja, an astronomer at NASA Goddard Space Flight Center in Greenbelt, Maryland, was part of one of the first teams to use the Hubble Space Telescope to view the event. “The spectra were phenomenal,” she adds, and almost indistinguishable from the theoretical predictions. “You could clearly see the fingerprints of the metals that had formed.”

But Troja and other observers were also puzzled, because they couldn't find any signal in the X-ray and radio regions of the spectrum. These would be expected during the formation of a black hole, which is thought to shoot jets of out of its poles at close to the speed of light. Nine days later, Troja’s team was the first to find the X-rays.

Alessandra Corsi, an astronomer at Texas Tech University in Lubbock, and her collaborators kept looking for radio emissions using the Very Large Array in New Mexico. Day after day, the dishes recorded nothing. “It turned out we had to wait 16 very long days in order to see the first radio glow,” she says.

The late onset of the radio and X-ray signals, together with the weakness of the initial γ-rays, suggest that the jets were pointed away from the line of sight to Earth. Gamma-ray bursts that happen to be pointed in the right direction can look very bright even from billions of parsecs away.

After a few weeks, most observatories had to stop looking at the object, because that part of the sky had got too close to the Sun. But radio telescopes are still tracking it to this day, Corsi says. More discoveries might yet be made.

“The idea that all this stuff has happened, it’s too much. It is just hard to process,” says Daniel Holz at the University of Chicago in Illinois. “It’s unreasonable that we have done so much with just one event of its kind.”

“All our hopes and dreams have basically come true,” says Jocelyn Read, an astrophysicist at California State University, Fullerton. “All this time we have been saying, look at this amazing thing we are going to be able to see. And it is still hard to believe when it actually happens.”

Journal name:
    Nature
Volume:
    550,
Pages:
    309–310
Date published:
    (19 October 2017)
DOI:
    doi:10.1038/550309a

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