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HUMANS

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Scientific American September 2018

A Singular Species: The Science of Being Human

- By THE EDITORS

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1. What Made Us Unique
by Kevin Laland

Evolution

What Made Us Unique

How we became a different kind of animal

- By Kevin Laland | Scientific American September 2018 Issue

Credit: Victo Ngai

Most people on this planet blithely assume, largely without any valid scientific rationale, that humans are special creatures, distinct from other animals. Curiously, the scientists best qualified to evaluate this claim have often appeared reticent to acknowledge the uniqueness of *Homo sapiens*, perhaps for fear of reinforcing the idea of human exceptionalism put forward in religious doctrines. Yet hard scientific data have been amassed across fields ranging from ecology to cognitive psychology affirming that humans truly *are* a remarkable species.

The density of human populations far exceeds what would be typical for an

animal of our size. We live across an extraordinary geographical range and control unprecedented flows of energy and matter: our global impact is beyond question. When one also considers our intelligence, powers of communication, capacity for knowledge acquisition and sharing—along with magnificent works of art, architecture and music we create—humans genuinely do stand out as a very different kind of animal. Our culture seems to separate us from the rest of nature, and yet that culture, too, must be a product of evolution.

The challenge of providing a satisfactory scientific explanation for the evolution of our species' cognitive abilities and their expression in our culture is what I call "Darwin's Unfinished Symphony." That is because Charles Darwin began the investigation of these topics some 150 years ago, but as he himself confessed, his understanding of how we evolved these attributes was in his own words "imperfect" and "fragmentary." Fortunately, other scientists have taken up the baton, and there is an increasing feeling among those of us who conduct research in this field that we are closing in on an answer.

The emerging consensus is that humanity's accomplishments derive from an ability to acquire knowledge and skills from other people. Individuals then build iteratively on that reservoir of pooled knowledge over long periods. This communal store of experience enables creation of ever more efficient and diverse solutions to life's challenges. It was not our large brains, intelligence or language that gave us culture but rather our culture that gave us large brains, intelligence and language. For our species and perhaps a small number of other species, too, culture transformed the evolutionary process.

The term "culture" implies fashion or haute cuisine, but boiled down to its scientific essence, culture comprises behavior patterns shared by members of a community that rely on socially transmitted information. Whether we consider automobile designs, popular music styles, scientific theories or the foraging of small-scale societies, all evolve through endless rounds of innovations that add incremental refinements to an initial baseline of knowledge. Perpetual, relentless copying and innovation—that is the secret of our species' success.

Animal Talents

Comparing humans with other animals allows scientists to determine the ways in which we excel, the qualities we share with other species and when particular traits evolved. A first step to understanding how humans got to be so different, then, is to take this comparative perspective and investigate the social learning and innovation of other creatures, a search that leads ultimately to the subtle but critical differences that make us unique.

Many animals copy the behavior of other individuals and in this way learn about diet, feeding techniques, predator avoidance, or calls and songs. The distinctive tool-using traditions of different populations of chimpanzees throughout Africa is a famous example. In each community, youngsters learn the local behavior—be it cracking open nuts with a stone hammer or fishing for ants with a stick—by copying more experienced individuals. But social learning is not restricted to primates, large-brained animals or even vertebrates. Thousands of experimental studies have demonstrated copying of behavior in hundreds of species of mammals, birds, fishes and insects. Experiments even show that young female fruit flies select as mates males that older females have chosen.

FOLLOWING in the steps of others—social learning—has been a key to the success of *Homo sapiens* as long as it has existed as a separate species. Here members of the San group in Namibia walk the dunes single file. Credit: Kerstin Geier *Getty Images*

A diverse range of behaviors are learned socially. Dolphins possess traditions for foraging using sea sponges to flush out fish hiding on the ocean floor. Killer whales have seal-hunting traditions, including the practice of knocking seals off ice floes by charging toward them in unison and creating a giant wave. Even chickens acquire cannibalistic tendencies through social learning from other chickens. Most of the knowledge transmitted through animal populations concerns food—what to eat and where to find it—but there are also extraordinary social conventions. One troop of capuchin monkeys in Costa Rica has devised the bizarre habit of inserting fingers into the eye sockets or nostrils of other monkeys or hands into their mouths, sitting together in this manner for long periods and gently swaying—conventions that are thought to test the strength of social bonds.

Animals also "innovate." When prompted to name an innovation, we might think of the invention of penicillin by Alexander Fleming or the construction of the World Wide Web by Tim Berners-Lee. The animal equivalents are no less fascinating. My favorite concerns a young chimpanzee called Mike, whom primatologist Jane Goodall observed devising a noisy dominance display that involved banging two empty kerosene cans together. This exhibition thoroughly intimidated Mike's rivals and led to him shooting up the social rankings to become alpha male in record time. Then there is the invention by Japanese carrion crows of using cars to crack open nuts. Walnuts shells are too tough for crows to crack in their beaks, but they nonetheless feed on these nuts by placing them in the road for cars to run over, returning to retrieve their treats when the lights turn red. And a group of starlings—birds famously fond of shiny objects used as nest decorations—started raiding a coin machine at a car wash in Fredericksburg, Va., and made off with, quite literally, hundreds of dollars in quarters. [For further examples of how animals adjust to urban environments, see "Darwin in the City."]

Such stories are more than just enchanting snippets of natural history. Comparative analyses reveal intriguing patterns in the social learning and

innovation exhibited by animals. The most significant of these discoveries finds that innovative species, as well as animals most reliant on copying, possess unusually large brains (both in absolute terms and relative to body size). The correlation between rates of innovation and brain size was initially observed in birds, but this research has since been replicated in primates. These findings support a hypothesis known as cultural drive, first proposed by University of California, Berkeley, biochemist Allan C. Wilson in the 1980s.

Wilson argued that the ability to solve problems or to copy the innovations of others would give individuals an edge in the struggle to survive. Assuming these abilities had some basis in neurobiology, they would generate natural selection favoring ever larger brains—a runaway process culminating in the huge organs that orchestrate humans' unbounded creativity and all-encompassing culture.

Initially scientists were skeptical of Wilson's argument. If fruit flies, with their tiny brains, could copy perfectly well, then why should selection for more and more copying generate the proportionately gigantic brains seen in primates? This conundrum endured for years, until an answer arose from an unexpected source.

Copycats

The Social Learning Strategies Tournament was a competition that my colleagues and I organized that was designed to work out the best way to learn in a complex, changing environment. We envisaged a hypothetical world in which individuals—or agents as they are called—could perform a large number of possible behaviors, each with its own characteristic payoff that changed over time. The challenge was to work out which actions would give the best returns and to track how these changed. Individuals could either learn a new behavior or perform a previously learned one, and learning could occur through trial-and-error or through copying other individuals. Rather than trying to solve the puzzle ourselves, we described the problem and specified a set of rules, inviting anyone interested to have a go at solving it. All the entries—submitted as software code that specified how the agents

should behave—competed against one another in a computer simulation, and the best performer won a €10,000 prize. The results were highly instructive. We found a strong positive relation between how well an entry performed and how well it required agents to learn socially. The winning entry did not require agents to learn often, but when they did, it was almost always through copying, which was always performed accurately and efficiently.

The tournament taught us how to interpret the positive relation between social learning and brain size observed in primates. The results suggested that natural selection does not favor more and more social learning but rather a tendency toward better and better social learning. Animals do not need a big brain to copy, but they do need a big brain to copy well.

This insight stimulated research into the empirical basis of the cultural drive hypothesis. It led to the expectation that natural selection ought to favor anatomical structures or functional capabilities in the primate brain that promote accurate, efficient copying. Examples might include better visual perception if that allows copying over greater distances or imitating fine-motor actions. In addition, selection should foster greater connections between perceptual and motor structures in the brain, helping individuals to translate the sight of others performing a skill into their producing a matching performance by moving their body in a corresponding way.

The same cultural drive hypothesis also predicted that selection for improved social learning should have influenced other aspects of social behavior and life history, including living in social groups and using tools. The reasoning was that the bigger the group and the more time spent in the company of others, the greater the opportunities for effective social learning. Through copying, monkeys and apes acquire diverse foraging skills ranging from extractive foraging methods such as digging grubs out of bark to sophisticated tool-using techniques such as fishing for termites with sticks. If social learning is what allows primates to pick up difficult-to-learn but productive food-procurement methods, any species proficient in social learning should show elevated levels of extractive foraging and tool use. They should possess a richer diet and have longer lives, if that gives more time for learning new skills and passing them on to descendants. In sum, cultural drive predicts that rates of social learning will correlate not only with

brain size but also with a host of measures related to cognitive performance.

Rigorous comparative analyses have borne out these predictions. Those primates that excel at social learning and innovation are the same species that have the most diverse diets, use tools and extractive foraging, and exhibit the most complex social behavior. In fact, statistical analyses suggest that these abilities vary in lockstep so tightly that one can align primates along a single dimension of general cognitive performance, which we call primate intelligence (loosely analogous to IQ in humans).

Chimpanzees and orangutans excel in all these performance measures and have high primate intelligence, whereas some nocturnal prosimians are poor at most of them and have a lower metric. The strong correlations between primate intelligence and both brain size measures and performance in laboratory tests of learning and cognition validate the use of the metric as a measure of intelligence. The interpretation also fits with neuroscientific analyses showing that the size of individual brain components can be accurately predicted with knowledge of overall brain size. Associated with the evolution of large primate brains are bigger and better-connected regions —neocortices and cerebellums—that allow executive control of actions and increased cortical projections to the motor neurons of the limbs, facilitating controlled and precise movements. This helps us to understand why big-brained animals show complex cognition and tool use. [For more on primate brains, see "Are We Wired Differently?"]

Plotting the intelligence measure on a primate family tree reveals evolution for higher intelligence taking place independently in four distinct primate groups: the capuchins, macaques, baboons and great apes—precisely those species renowned for their social learning and traditions. This finding is exactly the pattern expected if cultural processes really were driving the evolution of brain and cognition. Further analyses, using better data and cutting-edge statistical methods, reinforce these conclusions, as do models that make quantitative predictions for brain and body size based on estimates of the brain's metabolic costs.

Cultural drive is not the only cause of primate brain evolution: diet and sociality are also important because fruit-eating primates and those living in large, complex groups possess large brains. It is difficult, however, to escape

the conclusion that high intelligence and longer lives co-evolved in some primates because their cultural capabilities allowed them to exploit high-quality but difficult-to-access food resources, with the nutrients gleaned "paying" for brain growth. Brains are energetically costly organs, and social learning is paramount to animals gathering the resources necessary to grow and maintain a large brain efficiently.

No Chimp Mobiles

Why, then, don't other primates have complex culture like us? Why haven't chimpanzees sequenced genomes or built space rockets? Mathematical theory has provided some answers. The secret comes down to the fidelity of information transmission from one member of a species to another, the accuracy with which learned information passes between transmitter and receiver. The size of a species' cultural repertoire and how long cultural traits persist in a population both increase exponentially with transmission fidelity. Above a certain threshold, culture begins to ratchet up in complexity and diversity. Without accurate transmission, cumulative culture is impossible. But once a given threshold is surpassed, even modest amounts of novel invention and refinement lead rapidly to massive cultural change. Humans are the only living species to have passed this threshold.

Our ancestors achieved high-fidelity transmission through teaching—behavior that functions to facilitate a pupil's learning. Whereas copying is widespread in nature, teaching is rare, and yet teaching is universal in human societies once the many subtle forms this practice takes are recognized. Mathematical analyses reveal tough conditions that must be met for teaching to evolve, but they show that cumulative culture relaxes these conditions. The modeling implies that teaching and cumulative culture co-evolved in our ancestors, creating for the first time in the history of life on our planet a species whose members taught their relatives a broad range of skills, perhaps cemented through goal-oriented "deliberate" practice [see "Inside Our Heads."]

CHIMPS AND HUMANS are both toolmakers. Chimpanzees use sticks to hunt for a meal of termites and pass this technique along to their kin. Unlike chimps, humans transmit cultural knowledge to offspring with a high degree of precision that enables the making of sophisticated technologies. Credit: Steve Bloom *Alamy* (*chimpanzees*); Chris Gunn *NASA* (*telescope mirror*)

The teaching of cultural knowledge by hominins (humans and their extinct close relatives) included foraging, food processing, learned calls, toolmaking, and so forth and provided the context in which language first appeared. Why our ancestors alone evolved language is one of the great unresolved questions. One possibility is that language developed to reduce the costs, increase the accuracy and expand the domains of teaching. Human language may be unique, at least among extant species, because only humans constructed a sufficiently diverse and dynamic cultural world that demanded talking about. This explanation has the advantage that it accounts for many of the characteristic properties of language, including its distinctiveness, its power of generalization and why it is learned [see "Talking through Time."]

Language began as just a handful of shared symbols. But once started, the use of protolanguage imposed selection on hominin brains for language-learning skills and on languages themselves to favor easy-to-learn structures. That our ancestors' cultural activities imposed selection on their bodies and minds—a process known as gene culture co-evolution—is now well supported. Theoretical, anthropological and genomic analyses all demonstrate how socially transmitted knowledge, including that expressed in the manufacture and use of tools, generated natural selection that transformed human anatomy and cognition. This evolutionary feedback shaped the emergence of the modern human mind, generating an evolved psychology that spurred a motivation to teach, speak, imitate, emulate, and share the goals and intentions of others. It also produced enhanced learning and computational abilities. These capabilities evolved with cumulative culture because they enhance the fidelity of information transmission.

Teaching and language were evolutionary game changers for our lineage. Large-scale cooperation arose in human societies because of our uniquely potent capacities for social learning and teaching, as theoretical and experimental data attest. Culture took human populations down novel

evolutionary pathways, both by creating conditions that promoted established mechanisms for cooperation witnessed in other animals (such as helping those that reciprocate) and by generating novel cooperative mechanisms not seen elsewhere. Cultural group selection—practices that help a group cooperate and compete with other groups (forming an army or building an irrigation system)—spread as they proved their worth [see "The Origins of Morality."]

Culture provided our ancestors with food-procurement and survival tricks, and as each new invention arose, a given population was able to exploit its environment more efficiently. This occurrence fueled not only brain expansion but population growth as well. Increases in both human numbers and societal complexity followed our domestication of plants and animals. Agriculture freed societies from the constraints that the peripatetic lives of hunter-gatherers imposed on population size and any inclinations to create new technologies. In the absence of this constraint, agricultural societies flourished, both because they outgrew hunter-gatherer communities through allowing an increase in the carrying capacity of a particular area for food production and because agriculture triggered a raft of associated innovations that dramatically changed human society. In the larger societies supported by increasing farming yields, beneficial innovations were more likely to spread and be retained. Agriculture precipitated a revolution not only by triggering the invention of related technologies—ploughs or irrigation technology, among others—but also by spawning entirely unanticipated initiatives, such as the wheel, city-states and religions.

The emerging picture of human cognitive evolution suggests that we are largely creatures of our own making. The distinctive features of humanity—our intelligence, creativity, language, as well as our ecological and demographic success—are either evolutionary adaptations to our ancestors' own cultural activities or direct consequences of those adaptations. For our species' evolution, cultural inheritance appears every bit as important as genetic inheritance.

We tend to think of evolution through natural selection as a process in which changes in the external environment, such as predators, climate or disease, trigger evolutionary refinements in an organism's traits. Yet the human mind

did not evolve in this straightforward way. Rather our mental abilities arose through a convoluted, reciprocal process in which our ancestors constantly constructed niches (aspects of their physical and social environments) that fed back to impose selection on their bodies and minds, in endless cycles. Scientists can now comprehend the divergence of humans from other primates as reflecting the operation of a broad array of feedback mechanisms in the hominin lineage. Similar to a self-sustaining chemical reaction, a runaway process ensued that propelled human cognition and culture forward. Humanity's place in the evolutionary tree of life is beyond question. But our ability to think, learn, communicate and control our environment makes humanity genuinely different from all other animals.

A Visit from E.T.

Imagine an extraterrestrial intelligence studying Earth's biosphere. Which of all the species would it identify as differing from the rest? The answer is humanity. Here are a few reasons:

Population size. Our numbers are out of kilter with global patterns for vertebrate populations. There are several orders of magnitude more humans than expected for a mammal of our size.

Ecological range. Our species distribution is extraordinary. Humans have colonized virtually every region of the terrestrial globe.

Environmental regulation. Humans control vast and diverse flows of energy and matter on unprecedented scales.

Global impact. Human activities threaten and are driving extinct unmatched numbers of species while eliciting strong evolutionary change across the biosphere.

Cognition, communication and intelligence. Experiments demonstrate superior performance by humans across diverse tests of learning and cognition. Human language is infinitely flexible, unlike the communication of other animals.

Knowledge acquisition and sharing. Humans acquire, share and store information on never-before-seen scales and build on their pooled cultural knowledge cumulatively from generation to generation.

Technology. Humans invent and mass-produce infinitely more complex and diverse artifacts than other animals.

The extraterrestrials might well be charmed by the elephant's trunk and impressed by the giraffe's neck, but it is humans that they would single out. —*K.L.*

Kevin Laland

Kevin Laland is a professor of behavioral and evolutionary biology at the University of St. Andrews in Scotland and author of *Darwin's Unfinished Symphony: How Culture Made the Human Mind* (Princeton University Press, 2017).

Credit: Nick Higgins

Scientific American September 2018

The Ancient Roots of the Internal Combustion Engine

Taking apart the internal combustion engine reveals our collective genius

- By Lewis Dartnell, José Miguel Mayo, Matthew Twombly

Humans demonstrate not only an extraordinary capacity for transferring knowledge from one generation to the next, they are also supremely skilled in building on this know-how to create novel technology, whether it be an Acheulean hand ax or the modern electrical grid. This vast web of interconnected knowledge and practical capability has required the labors of millions over the millennia. The subtleties of technologies from stone flaking to high-voltage transmission lines could take a substantial time to recover if humanity were ever forced to reboot civilization after a nuclear conflagration, an asteroid strike or some other global catastrophe.

Scientific American September 2018

2 Mental Abilities Separate Humans from Animals

Two key features created the human mind

- By Thomas Suddendorf

Why are we, and not the gorillas, running the zoos?

Scientific American September 2018

Are Humans the Only Conscious Animal?

Decoding the puzzle of human consciousness

- By Susan Blackmore

Might we humans be the only species on this planet to be truly conscious? Might lobsters and lions, beetles and bats be unconscious automata, responding to their worlds with no hint of conscious experience? Aristotle thought so, claiming that humans have rational souls but that other animals have only the instincts needed to survive. In medieval Christianity the “great chain of being” placed humans on a level above soulless animals and below only God and the angels. And in the 17th century French philosopher René Descartes argued that other animals have only reflex behaviors. Yet the more biology we learn, the more obvious it is that we share not only anatomy, physiology and genetics with other animals but also systems of vision, hearing, memory and emotional expression. Could it really be that we alone have an extra special something—this marvelous inner world of subjective experience?

Scientific American September 2018

The Cultural Origins of Language

What makes language distinctly human

- By Christine Kenneally

Dolphins name one another, and they click and whistle about their lives or the dangers posed by sharks and humans. They also pass on useful bits of know-how from mother to child, such as how to catch fish or how to flee. If they had language in the same sense that we do, however, they would not only pass down little bits of information but also aggregate them into a broad body of knowledge about the world. Over the span of generations clever practices, complex knowledge and technology based on two, three or several components would develop. Dolphins would have history—and with history, they would learn about the journeys and ideas of other dolphin groups, and any one individual could inherit a fragment of language, say, a story or poem, from another individual who had lived hundreds of years before. That dolphin would be touched, through language, by the wisdom of another dolphin, who was in every other way long gone.

Scientific American September 2018

What Makes the Human Brain Special

Parts of the brain involved in language and cognition have enlarged greatly over an evolutionary timescale

- By Chet C. Sherwood, Mesa Schumacher

Humans are off the scale. Modern human brains are about threefold larger than those of our earliest hominin ancestors and living great ape relatives. Across animals, brain size is tightly correlated with body size. But humans are the extreme outlier when gauged against this typical scaling relation. The average adult human brain is roughly three pounds, which is approximately 2 percent of body size. But it consumes an outsized 20 percent of the body's energy budget because of high levels of electrical activity by neurons and the metabolic fuel it takes to transmit chemical signals from one brain cell to the next.

Scientific American September 2018

Why Is *Homo sapiens* the Sole Surviving Member of the Human Family?

Recent fossil, archaeological and genetic discoveries are revising the rise of our species

- By Kate Wong

At the dawning of *Homo sapiens*, our ancestors were born into a world we would find utterly surreal. It's not so much that the climate and sea levels or the plants and the animals were different, although of course they were—it's that there were other kinds of humans alive at the same time. For most of *H. sapiens*' existence, in fact, multiple human species walked the earth. In Africa, where our species got its start, large-brained *Homo heidelbergensis* and small-brained *Homo naledi* also roamed. In Asia, there was *Homo erectus*, a mysterious group dubbed the Denisovans and, later, *Homo floresiensis*—a hobbitlike creature, tiny but for its large feet. The stocky, heavy-browed Neandertals, for their part, ruled Europe and western Asia. And there were probably even more forms, as yet undiscovered.

Scientific American September 2018

The Origins of Human Morality

How we learned to put our fate in one another’s hands

- By Michael Tomasello

If evolution is about survival of the fittest, how did humans ever become moral creatures? If evolution is each individual maximizing their own fitness, how did humans come to feel that they really ought to help others and be fair to them?

Scientific American September 2018

War Is Not Part of Human Nature

War may not be in our nature after all

- By R. Brian Ferguson

Do people, or perhaps just males, have an evolved predisposition to kill members of other groups? Not just a capacity to kill but an innate propensity to take up arms, tilting us toward collective violence? The word “collective” is key. People fight and kill for personal reasons, but homicide is not war. War is social, with groups organized to kill people from other groups. Today controversy over the historical roots of warfare revolves around two polar positions. In one, war is an evolved propensity to eliminate any potential competitors. In this scenario, humans all the way back to our common ancestors with chimpanzees have always made war. The other position holds that armed conflict has only emerged over recent millennia, as changing social conditions provided the motivation and organization to collectively kill. The two sides separate into what the late anthropologist Keith Otterbein called hawks and doves. (This debate also ties into the question of whether instinctive, warlike tendencies can be detected in chimpanzees [*see sidebar below*].)

Scientific American September 2018

Cities Are Forcing a New Era of Rapid Evolution

Humans are changing the course of evolution

- By Menno Schilthuizen

“Whoosh!” exclaims my friend Frank, as he thrusts his cupped hands upward, nearly knocking over his drink on the table between us. We are sitting in my backyard in Leiden, the Netherlands. Frank is demonstrating how, once or twice each day, a peregrine falcon swoops upward past his hospital office window with a freshly killed pigeon in its talons, headed for its lair underneath the giant illuminated logo at the top of the building. A few seconds later plucked feathers come drifting down.

Scientific American September 2018

Artificial Intelligence Will Serve Humans, Not Enslave Them

AI will serve our species, not control it

- By Pedro Domingos

Humans are the only animals that build machines. By doing so, we expand our capabilities beyond our biological limits. Tools turn our hands into more versatile appendages. Cars let us travel faster, and airplanes give us wings. Computers endow us with bigger brains and memory capacity, and smartphones orchestrate daily life. Now we are creating technology that can evolve on its own by encoding into it an ability to learn through data and effort. Will it ultimately supplant us? Or will it augment our abilities, enhancing our humanness in unprecedented ways?

Scientific American September 2018

Are Humans Alone in the Milky Way?

Why we are probably the only intelligent life in the galaxy

- By John Gribbin

Astronomers have now found thousands of planets orbiting other stars in the Milky Way, and 100 billion more stars in the galaxy presumably host planets of their own. Given the sheer number of worlds out there, scientists find it easy to hope that some of them must be harboring sentient beings. After all, could Earth really be unique among so many planets?

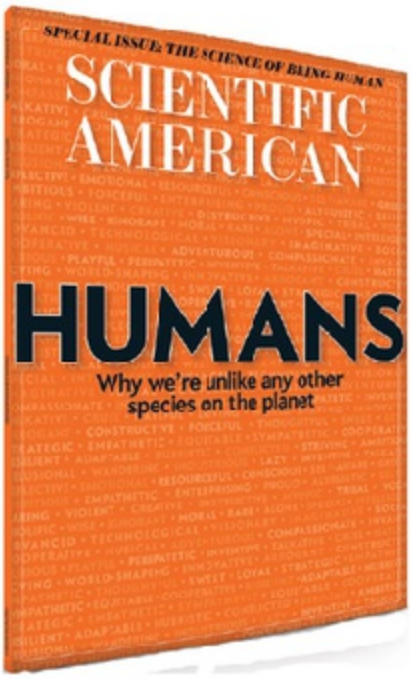
From the Editor

- **A Very Human Story: Why Our Species Is Special** [周一, 03 9月 06:02]

Evolution

A Very Human Story: Why Our Species Is Special

- By Mariette DiChristina | Scientific American September 2018 Issue



“What a piece of work is a man,” proclaimed Hamlet in the play of the same name, partly in admiration over our nobility and intelligence, partly in despair over our flaws. We *Scientific American* editors have to agree with Shakespeare's sentiments, and in this special single-topic issue, we join him in his apparent obsession to try to understand our species anyway.

We do have the benefit of perspective gained from the process of science instead of relying on storytelling alone. For instance, there's the matter of how *Homo sapiens* came to be the only human species on the earth when we were once just one of a diverse array of bipedal species. In her article, “Last

Hominin Standing," senior editor Kate Wong paints the picture of our rise.

Although we do seem to share many cognitive traits with animals, our intellectual capabilities have no equal on this planet ("Inside Our Heads"). Humans are apparent standouts because of the richness of our subjective experience ("The Hardest Problem") and an ability to communicate thoughts to others ("Talking through Time"). A defining characteristic of our species is that we can transmit knowledge from one generation to the next and then build and innovate on these cultural bequests from our ancestors. All of this, in turn, selects for better cognitive skills and bigger brains ("An Evolved Uniqueness"). We demonstrate our communal cleverness by devising machines that combine numerous past innovations. The internal-combustion engine is just such a stellar example ("Techno *Sapiens*"). As a species whose members number in the billions and are extensively settled across nearly all the continents, we have an inclination to establish norms and conventions that regulate our behavior when living in large groups ("The Origins of Morality").

Looking ahead, we may even, through AI, or artificial intelligence, design a master algorithm that could enable models of ourselves to act as the ultimate personal assistant that performs many of our everyday tasks ("Our Digital Doubles"). As we continue an influx into cities, animals around us are necessarily adapting rapidly to a more urban world ("Darwin in the City"). Seeds are reshaping on dandelions. Instead of being distributed on the winds, they drop straight down onto precious, limited soil. Peregrine falcons are settling in, snapping up plentiful pigeons. What is to come? Perhaps only we can imagine where the complex changes we've set in motion may lead. And if we don't like what we envision, only we have the knowledge and the power to refashion the world for a more hopeful future. That's an awful lot of responsibility for a physically weak, though cognitively powerful, biped, but we'll have to shoulder it.

Mariette DiChristina

-

Mariette DiChristina is editor in chief of *Scientific American*.

Credit: Nick Higgins

Recent Articles

- A Sense of Discovery: How the Immune System Works with the Brain
- Barriers between Realities: Irrational Thinking and the Quantum–Classical Divide
- AI, Robotics and Your Health

Letters

- **Readers Respond to the May 2018 Issue** [周一, 03 9月 06:02]

Arts & Culture

Readers Respond to the May 2018 Issue

Letters to the editor from the May 2018 issue of *Scientific American*

Credit: Scientific American May 2018

SOCIETY'S ILLNESS

"American Epidemic," by Melinda Wenner Moyer, is very timely and relevant in describing how resurgent infectious disease outbreaks in U.S. cities are tied to increasing economic inequality.

I am a paraplegic who is retired because of health problems, and most of my medical bills are paid through Medicare. I also receive other government support, such as Social Security, food stamps and a housing subsidy. There is an agenda against such funding for the poor and the disabled, as has been evident in the Trump administration's attempts to cut Medicaid.

Although I cannot even stand and must use a wheelchair, I have been harassed by people who seem to believe that I don't deserve the support I get from the government. The Americans with Disabilities Act (ADA) was supposed to remedy the exclusion of disabled people from public services and employment, but because of opposition from the very people who insist that people like myself should be employed, it has not delivered on most of its promises.

I have tried to explain to many such people that we are a society and must work together for the common good. If some people suffer in our society, then we may all suffer because we have an effect on others. Moyer's article really helps to back up what I argue. The same individuals who don't seem to care if the poor and homeless get sick will ultimately reap the results of their own callous attitudes when diseases caused by poverty spread to the wealthy. Maybe if we can get people to realize that they have a stake in good welfare, then they will begin to care about themselves, if not others.

JOSEPH JAGELLA *via e-mail*

"American Epidemic" should be required reading for every politician in this country. Moyer does an excellent job of pulling together disparate strands of information and weaving them into powerful conclusions that suddenly seem so simple and obvious. I hope she expands this article into a book. It could be a very important one.

ERIC SMITH *Woodbury, Minn.*

SMOKING PROBLEM

In arguing that federal marijuana laws are too harsh in "End the War on Weed" [Science Agenda], the Editors assert that the drug is "relatively safe

for adult recreational use.” While that may indeed be so, I have to ask: Do any of them live in an apartment?

I voted against “legalization” here in California because nobody seems to have considered the exposure of nonconsenting adults and children with developing brains to secondhand marijuana smoke. Advocating a policy of legalization for recreational purposes seems premature until you consider the rights of those who do not wish to be compelled to partake in the drug use of others and the welfare of children who live in proximity. But I have no objections to the legalization of ingested marijuana for both medical and recreational purposes for adults.

DONALD D. DEROSIER *via e-mail*

POWERING EDUCATION

“The Suns in Our Daughters” [Forum], Lisa Einstein’s commentary on her experiences teaching young girls in Guinea through the Let Girls Learn program, brought tears to my eyes. It truly illustrates untapped human potential restrained or blocked by custom and social oppression that exists almost everywhere.

ROBERT SVEC *Portland, Ore.*

CHEATING DILEMMA

In “You Kant Be Serious” [Skeptic], Michael Shermer discusses different approaches to morality and mentions the well-known dilemma in which a runaway trolley will kill five people unless you switch it to a side track, where it will kill one person. A humorous accompanying illustration shows a means of cheating the problem with a helicopter. (There’s an easier way: derail the trolley by throwing the switch before the rear wheels go through.) Shermer’s example of a doctor who can save five patients by harvesting organs from one could be similarly cheated if the doctor can manufacture organs from stem cells.

I suspect that most, if not all, such moral dilemmas could be cheated through the appropriate technology today, so such dilemmas do go away as we advance.

DENNIS ANTHONY *via e-mail*

SHERMER REPLIES: *The point of philosophical thought experiments such as the trolley problem is that you're not allowed to cheat, thereby forcing you to choose one evil over another and then inquire about your reasoning or feelings behind your decision. But in the real world, many workarounds abound, such as those Anthony proposes (or an even easier solution in the case of the trolley problem: shout, "There's a train coming!" to the workers). And with the right knowledge and technology, most moral dilemmas can indeed be reconfigured as soluble problems.*

In my Skeptic column on abortion in this issue, for example, I argue that instead of intractable moral problems of determining when life begins or when it is permissible to take a life, we should treat unwanted pregnancies as a problem to be solved through birth control and comprehensive sex education. The animal-rights debate over factory farming will disappear when synthetic meat becomes economically viable. Income inequality will vanish as a problem when poverty is completely eradicated and everyone has abundance. Not all moral issues are so readily soluble, but many are, which is why science and technology should be in the moral philosopher's toolkit.

OBJECTIVE MEMORY

In "Our Stuff, Ourselves," Francine Russo reports on research showing a connection between low emotional security and greater attachment to inanimate objects, including a 2015 study involving young children and their favorite possession.

Russo does not describe the experimenters as having accounted for the feelings or significance that the adult providers of those youngsters may have had toward objects. As a child of the Depression, I did not have as many possessions to attach my affections to as children do today. My relationship

with my mom was clearly established, and she did not seem to attach a great deal of extramaternal meaning to her gifts of time or kitchen tidbits. Things that gave meaning to my life in those days were things more related to a child's developing skills than to possession: climbing trees, riding a trike, creating imaginary landscapes out of mud or melting ice, singing songs, skipping rope. Possessions still mean little to me. My furniture is old and unfinished and serves only the purposes for which it is used.

I wish Russo's article had considered adult providers and the present-day culture they represent, which could have exposed deeper issues than an individual child's mental equilibrium.

JUNE HARNER *via e-mail*

CLARIFICATION

"Our Planet, Ourselves," by Mariette DiChristina [From the Editor], referred to mosquitoes and the viruses they carry spreading diseases such as malaria and Rift Valley fever. And "Catching Fever," by Lois Parshley, noted that the expansion of habitats of mosquitoes and other insects has exposed new populations to viruses, as well as that malaria is globally on the rise. To clarify, Rift Valley fever is caused by a virus, and malaria is caused by a parasite.

Advances

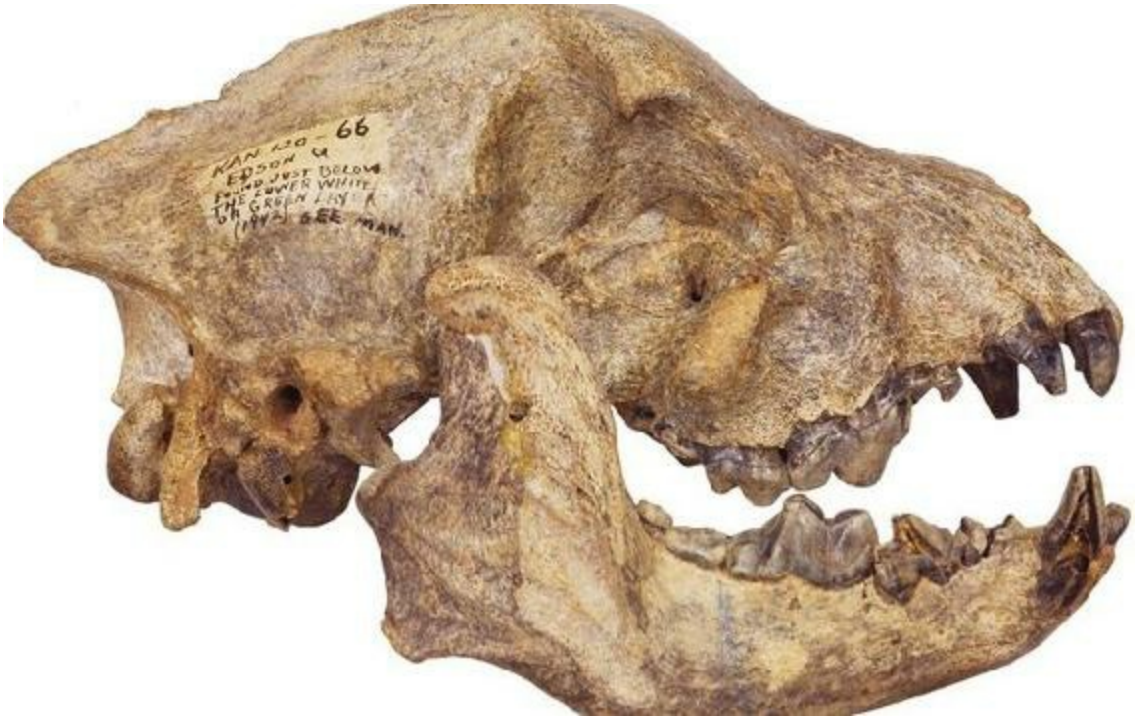
- "Bone-Crushing" Dogs Left Evidence in Their Poop [周一, 03 9月 06:02]
- Honest Liars: Dishonest Leaders May Be Perceived as Authentic [周一, 03 9月 06:02]
- Rescuing Ancient Art from Microbes [周一, 03 9月 06:02]
- Missing Tape Discovery Solves 40-Year Lunar Mystery [周一, 03 9月 06:02]
- Nuclear Bomb Sensors Eavesdrop on Whales [周一, 03 9月 06:02]
- "Death Masks" Reveal How Earliest Complex Organisms Became Fossils [周一, 03 9月 06:02]
- In Case You Missed It [周一, 03 9月 06:02]
- Vintner's Dream: Oil Additive Could Aid in Wine Production [周一, 03 9月 06:02]
- Colon Cancer Screening Guidelines May Need Revising [周一, 03 9月 06:02]
- Facebook Use Linked to Gender Equality [周一, 03 9月 06:02]

Evolution

“Bone-Crushing” Dogs Left Evidence in Their Poop

Like hyenas, the ancient canines apparently ate their food bones and all

- By Diana Crow | Scientific American September 2018 Issue



Borophagus dogs such as *B. secundus* (*fossil shown*) were thought to have had jaws strong enough to crunch through bone. *Credit: from “First Bone-Cracking Dog Coprolites Provide New Insight into Bone Consumption in Borophagus and Their Unique Ecological Niche,” by Xiaoming Wang et al., in eLife, Vol. 7, Article No. E34773; May 22, 2018*

An extinct group of brawny carnivores could bite through bone, a cache of six-million-year-old fossilized feces reveals. The bone-crushing dogs, which include the genus *Borophagus* (“gluttonous eater”), occupied a niche in North

America that has not been filled since.

Most carnivores, including today's dogs, sport long, pointy teeth that would likely shatter under the bite force needed to crack open large bones. In contrast, their *Borophagus* kin had thicker, flattened teeth, as well as shorter snouts that maximized their jaw power. “There is no modern dog that looks like these bone crushers,” says Xiaoming Wang, a paleontologist at the Natural History Museum of Los Angeles County and co-author of a study on the find. “The only analogue that you can try to envision is the spotted hyena in Africa.”

Coprolites, or poop fossils, provide direct evidence of bone-crushing dogs. Credit: Natural History Museum of Los Angeles County

Scientists first noticed the *Borophagus*' resemblance to hyenas in the late 19th century. Pioneering paleontologist Edward Drinker Cope wrote in an 1893 description of one of the species: “Its dental structure is adapted for crushing bones, while its canine teeth served their usual purpose of tearing.” This was conjecture based only on anatomy, however. The “bone-crushing” nickname stuck, but scientists had no direct evidence that the carnivores could chomp through large femurs and ribs—until now.

Fossil collector and retired soil scientist Dennis Garber says he found the fossilized excrement serendipitously. He was boating on Turlock Lake in California's San Joaquin Valley in 1995 when he spotted a bluish-gray object on the shore. Garber, who has been gathering fossils in that area since 1956, quickly recognized it as a fossilized animal dropping, or coprolite. Because it had bone fragments visible near the surface, it most likely came from a large carnivore—and the *Borophagus* were the only such creatures known from that area at the time, he says: “I started digging around, and I found quite a few more.”

The study's paleontologist co-authors think what Garber found was a “latrine” area, suggesting that the *Borophagus* lived in packs and pooped in the same spot, as many modern social carnivores do. The finding, which was published in May in eLife, “gives us an insight, not only into the physiology of these extinct carnivores but also into their social systems,” says paleontologist Julie Meachen of Des Moines University, who was not involved in the study.

To peer inside the coprolites, the study authors enlisted researchers at the University of California, Los Angeles, School of Dentistry to run CT scans. The resulting images revealed skeletal fragments within each lump. These included a large piece of rib from a deer-size herbivore, which the scientists estimate could have weighed up to four times as much as one of its attackers. This adds to the evidence that the *Borophagus* were pack hunters—but it does not completely rule out scavenging, Wang says. “What surprised me is the number of bones,” he adds. That quantity, combined with the dogs' jaw adaptations, indicates that biting through and swallowing large chunks of

bone seem to have constituted part of their routine.

Wang suggests that in addition to being pack hunters, endurance runners and social poopers, the *Borophagus* may have been competitive eaters. Hyena packs can devour entire wildebeests—bones and all—in a few minutes, and the carcass is first come, first served. When every meal is a race, being able to crunch straight through femurs and tear off a large hunk of leg for oneself is a big advantage. The *Borophagus* may have had similar dining etiquette. Meachen agrees with this assessment. “All these carnivores [would] have [had] the same constraints in terms of ‘you must gulp your food down, or it will all be gone,’” she says.

The ancient dogs may also have boosted certain nutrient cycles. Modern hyenas break down skeletal matter much faster than microbes do and leave nutrients such as calcium scattered across the savanna in their chalky, white feces. In contrast, Wang says the *Borophagus*' digestion was apparently less thorough. “Unlike hyenas, they don't have the kind of advanced, highly acidic digestive system to help them really—shall we say—melt down the bones inside the digestive system,” he says. But crushing up and transporting tiny fragments across the grassland may have had a similar nutrient-spreading effect, he notes.

The borophagine lineage died off mysteriously about two million years ago, leaving no descendants. But it was a major group of carnivores, with dozens of species spanning about 30 million years of North American fossil history. “There's really nothing like this group of animals around today, and yet they lived in North America and potentially had a really important role in the ecosystem, especially allowing for increased processing of carcasses or recycling of nutrients,” says paleoecologist Larisa DeSantis of Vanderbilt University, who was not involved in the study. “So this is a bit of a detective mystery in trying to reconstruct the ecology of these animals.”

Diana Crow

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Behavior & Society

Honest Liars: Dishonest Leaders May Be Perceived as Authentic

Donald Trump’s election suggests supporters view an outsider’s lies as symbolic protests against the establishment

- By Matthew Hutson | Scientific American September 2018 Issue

Credit: Thomas Fuchs

Last year Donald Trump falsely claimed that the size of his inauguration audience was “the biggest ever,” despite photographic evidence to the contrary—one of his many demonstrable whoppers. Of course, neither candidate in the 2016 presidential election was seen as a paragon of honesty. Yet that seemed to hurt Hillary Clinton more than Trump. Why? New research suggests that sometimes lying can actually make a politician seem

more authentic: followers see bald-faced lies by an interloper as symbolic protests against a crooked establishment.

In an online study, 424 participants read about a hypothetical race for a college student body president. The fictional candidate running against the incumbent had no student government experience. During a debate, the incumbent mentioned research supporting a campus alcohol ban. Half of the study subjects read that the research was not in a peer-reviewed journal and that the outsider candidate had noted this. The other half read that it *was* peer-reviewed, but the outsider lied and said it was not—an easily checkable claim—and that the outsider made a sexist remark about the researchers, violating another social norm.

Within each of those two groups, half also read that the incumbent's legitimacy was in question. The other half read that he was a good student representative. Study participants also completed a personality test and were randomly told the result matched either the incumbent's or the outsider's. Finally, they rated the outsider's authenticity.

When subjects were told they shared the outsider's personality type and the incumbent's legitimacy was in question, both men and women rated the lying, misogynistic outsider as more authentic than the honest outsider. The research appeared in the February issue of *American Sociological Review*.

Hypothetical student governments “are a far cry from studying the American public and real political issues, so I'd hesitate to generalize,” says Diana Mutz, a political scientist at the University of Pennsylvania, who has studied Trump's supporters and was not involved in this study. But “the idea is interesting,” she adds.

The researchers did tie the study to the 2016 election by surveying 402 participants, who were told that one of Trump's tweets about global warming being a hoax had been definitively debunked. Trump supporters were more likely than Clinton supporters to see the tweet as not literal but as a challenge to the elite. They were also twice as likely to rate their preferred candidate as highly “authentic.”

Oliver Hahl, a management researcher at Carnegie Mellon University and the

paper's lead author, says his studies have helped him understand Trump's supporters: “It gives me the sense that the world is still rational to some degree.”

Matthew Hutson

Recent Articles

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Biology

Rescuing Ancient Art from Microbes

An effort to develop new products to conserve a collection of lithographs has revealed two new species of fungi

- By Debbie Ponchner | Scientific American September 2018 Issue

Fungal samples (*2*) isolated from a lithograph by Bernard Romain Julien (*1*). *Credit: "Two New Cellulolytic Fungal Species Isolated from a 19th-Century Art Collection," by Carolina Coronado-Ruiz et al., in Scientific Reports, Vol. 8, Article No. 7492; May 10, 2018*

Scientists in Costa Rica have found some new species of fungi thriving in an odd place: on a collection of lithographs by 19th-century French artist Bernard Romain Julien. The microorganisms are speeding the degradation of

the printed artworks, which are among the oldest items in the University of Costa Rica's art collection and were acquired as a tool to teach drawing techniques.

To preserve the lithographs, Geraldine Conejo-Barboza, a researcher at the university's chemistry department and its Institute of Art Research, and her colleagues are developing a spray that could eliminate or slow the fungi's growth and stop natural acidification processes that are destroying the artwork. “Our idea is to take the biomolecule hydroxyapatite, which has been reported to improve the acidity of paper, and develop a hybrid [molecule] that can also eliminate the fungi,” Conejo-Barboza says. She plans to add zinc oxide and zinc ions to the molecule's surface to act as antifungal agents.

Before applying a medicine, however, one must identify the disease. To find out what microbes are attacking the artwork, Max Chavarría, a molecular biologist at Costa Rica's National Center for Biotechnological Innovation, studied 20 out of more than 1,000 lithographs in the collection. He extracted 21 fungi samples, two of which were unknown to science. “It was a surprise to find two new species in such a limited environment,” Chavarría says. The discovered species, *Periconia epilithographicola* and *Coniochaeta cipronana*, were described in May in *Scientific Reports*.

Conejo-Barboza has already synthesized a few fungi-fighting products that she aims to test in the laboratory. Salomón Chaves, subdirector of the Institute of Research in Art, has spent the past five years restoring the lithographs. The new product has the advantage of being a spray, he says. Protecting paper from acidification currently requires bathing it in alkaline substances and then carefully drying it—which can shrink the paper if not done correctly. The researchers hope the new chemicals will fight the microbes and acidification effectively and prove useful for preserving collections elsewhere.

Such fungi are not all bad, however: their ability to degrade cellulose—a tough substance found in plant cell walls—could be useful for treating agricultural waste from crops such as pineapple, coffee and sugarcane.

Debbie Ponchner

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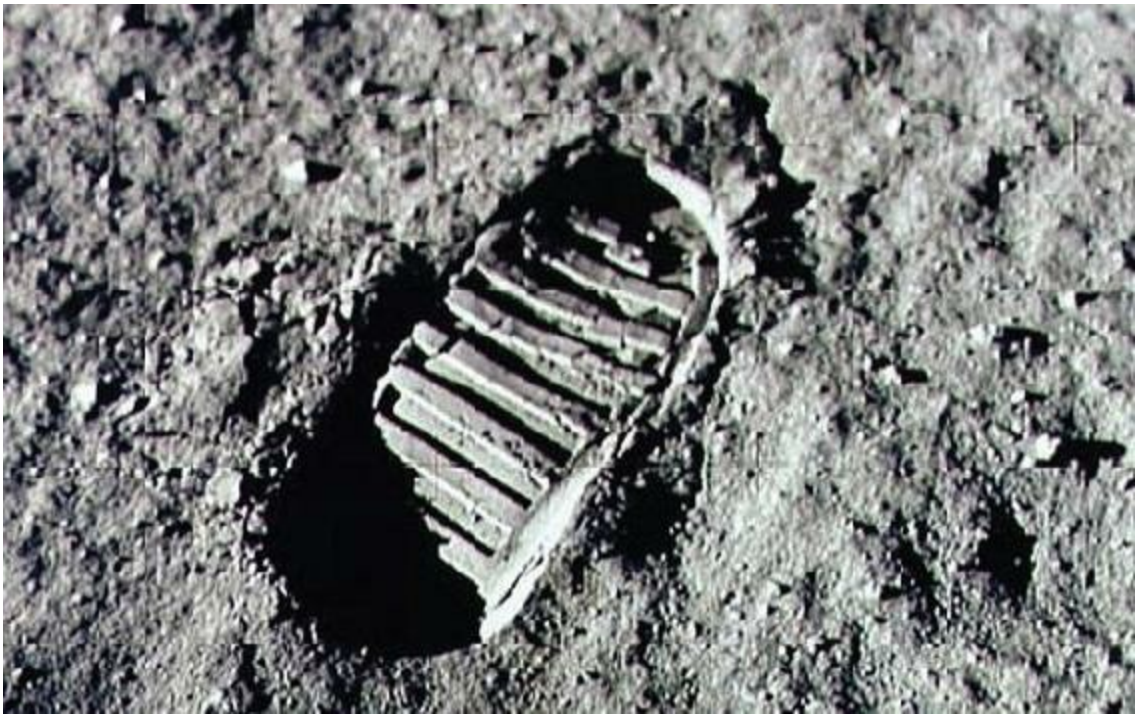
Space

Missing Tape Discovery Solves 40-Year Lunar Mystery

Traces of the Apollo astronauts' presence lingered long after they left

- By Nola Taylor Redd | Scientific American September 2018 Issue



Credit: Getty Images

When Apollo astronauts returned from the moon in the 1970s, they left behind two pairs of temperature probes drilled into the surface. The sensors measured how easily the soil radiated heat, in the hope of learning how much radioactive heating the moon produced and details about its recent geological activity.

The nuclear-powered lunar heat flow probes broadcast data back to Earth,

where they were stored on tapes, until 1977. But the experiments' principal investigator Marcus Langseth studied it only through December 1974. The remaining tapes were thought to be lost because sloppy paperwork failed to document their location. But over the past decade an effort to scour attics, garages and government facilities for information led to the recovery of a handful of the missing tapes.

Langseth's report on the original data revealed that heat was moving downward from the moon's surface, rather than up from the core as would be expected. Several theories emerged to explain the phenomenon: that the astronauts' presence had somehow warmed the surface; that the instruments themselves had produced excess heat; or that the moon was going through a long-term warming cycle. The uncertainty meant scientists could not trust the experiments' results.

But the newly recovered tapes reveal that heat traveled all the way from the lunar surface to the bottoms of the boreholes, ruling out every explanation except for surface disturbance by the astronauts. As they explored the moon, their footprints and rover tracks compressed and darkened its surface. “It was the [absorption of] sunlight from where the astronauts were walking around that caused the moon to get hotter in those specific locations,” says study co-author Walter Kiefer of the Lunar and Planetary Institute in Houston. The results were published in May in the *Journal of Geophysical Research: Planets*.

The findings suggest that measurements taken at the start of the experiments —when the heat was still near the surface—were the most reliable, making the original data correct. “We now know we can trust those measurements in a way that we were not sure of a few years ago,” Kiefer says.

Nola Taylor Redd

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Conservation

Nuclear Bomb Sensors Eavesdrop on Whales

A network of hydrophones intended to monitor nuclear tests may prove useful for conservation

- By Daniel Ackerman on July 20, 2018

Credit: Reinhard Dirscherl Getty Images

An unlikely source is revealing some secretive habits of whales: the group tasked with monitoring nuclear weapons testing. The underwater hydrophone network of the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) was designed to listen for massive explosions, but its sonic sensors more often pick up the peaceful rumblings of the world's largest animals. Now scientists are exploiting this unique data set

to estimate fin whale population sizes and movements, which could improve the species' uncertain conservation prospects.

In the past 20 years the CTBTO has installed 11 acoustic stations throughout the world, including six in the oceans. Each contains two sets of three hydrophones that receive signals and determine their origin. CTBTO observations helped to detect North Korea's 2017 nuclear tests and have yielded a treasure trove of scientific data.

These recordings are producing revelations about endangered fin whales, a species rebounding from hunting during the 20th century. Tarun Chandrayadula, an ocean engineer at the Indian Institute of Technology Madras, and his colleagues recently detected fin whales in CTBTO recordings off the southern tip of India—a region the species was not known to frequent. The finding, which Chandrayadula is working to publish, is helping boost his efforts to build a “whale atlas” detailing the annual movements of Indian Ocean cetaceans.

CTBTO data can also help determine whales' population sizes—a prerequisite for effective conservation efforts. Danielle Harris, a marine biologist at the University of St. Andrews in Scotland, led a study published in May presenting a new method for estimating whale numbers using CTBTO's sparse hydrophone array. Harris calculates there is approximately one fin whale per 2,000 square kilometers near Wake Island, a coral atoll in the central Pacific Ocean.

“The first step is knowing how many animals you're trying to conserve,” says Sean Wiggins, a project scientist at the Scripps Institution of Oceanography, who was not involved in either Harris's or Chandrayadula's studies. But the CTBTO data have their limitations, Wiggins adds. The hydrophones detect sounds below 100 hertz, so they cannot sense the vocalizations of small whales or dolphins. Furthermore, the vast spaces between hydrophone stations make it difficult to pinpoint a whale's distance from a sensor—a problem Harris's new method attempts to resolve.

Still, CTBTO's 15-year record of global whale chatter is a boon for marine biologists, and the recordings can spark joy. “I thought it was the most fun thing,” Chandrayadula says, “just sitting at my desk and listening to these

otherworldly creatures.”

Daniel Ackerman

Daniel Ackerman is an ecologist and science writer based in Minneapolis, Minn.

Credit: Sarah Nalven

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Evolution

“Death Masks” Reveal How Earliest Complex Organisms Became Fossils

A new experiment suggests our picture of the so-called Ediacarans may be incomplete

- By Lucas Joel | Scientific American September 2018 Issue

Fossil of the species *Dickinsonia costata*. *Credit: Getty Images*

Imagine a mask made when you die that could preserve your face for millions of years. In a way, this is what happened to some of our planet's oldest known animals. Encased in “death masks” made of the mineral pyrite (“fool's gold”), these soft-bodied organisms avoided rot and decay long enough to make it into the fossil record, paleontologists say.

The creatures are known to have thrived around the world roughly 575 million to 541 million years ago, during the Ediacaran period. They looked like aliens: one, *Kimberella,* resembled an avocado wearing a garter; another, *Dickinsonia,* could pass for a cross between a pancake and an earthworm. Where this group fits on the evolutionary tree is a mystery—not all its members were animals, but some were, and those species most likely include ancestors or close relatives of all subsequent animal life. Another nagging mystery has been how Ediacaran organisms became fossils in the first place because most are thought to have been soft-bodied. Such squishy critters are prone to immediate consumption or decay, so they rarely fossilize when they die.

To investigate these questions, a team led by paleontologist Brandt Gibson of Vanderbilt University euthanized sea anemones and mollusks, the modern animals whose bodies are thought to be most similar to Ediacaran biota. They put the corpses in seawater tanks to mimic the ancient ocean's chemistry and watched as iron-rich pyrite was deposited around the bodies over the course of about a month. The study, published in May in *PALAIOS,* was the first to observe these death masks forming in the laboratory.

The shrouds did not completely impede decay, however. Sea anemone tentacles, for instance, “disappeared rapidly,” Gibson notes. This result suggests Ediacaran fossils may not be complete pictures of the original organisms. Filling in that information could be key to understanding how these strange creatures fit into the tree of life.

Alex Liu, a paleobiologist at the University of Cambridge, who was not involved in the research, says the study “adds to a growing realization that the Ediacaran period is not the ‘enigmatic’ interval it has been portrayed as for decades ... and the questions within it are tractable.”

Lucas Joel

Recent Articles

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- Mysterious Insect Fossil Gap Explained

Policy & Ethics

In Case You Missed It

Top news from around the world

- By Maya Miller | Scientific American September 2018 Issue

CHINA

A chemical that helped to create a hole in the ozone layer is reappearing. An international investigation traced the resurgence of the banned gas, known as CFC-11, to factories in a town in the eastern province of Shandong.

CHILE

The National Congress of Chile passed a bill outlining plans to establish a ministry of science. The goal is to invest more in research, as part of a shift toward an economy of “knowledge and creativity.”

IRAQI KURDISTAN

Archaeologists found remnants of a city that dates back 4,800 years in the autonomous Kurdish region of northern Iraq. Among the ruins were 92 clay tablets—some of which contained the city's name, Mardaman.

NAMIBIA

About 100 high school girls from Ethiopia, Kenya and Swaziland joined girls in Namibia for a two-week “boot camp” to learn how to write code and

develop mobile apps. They also got a crash course in basic sciences.

THAILAND

A pilot whale washed ashore in Thailand's southern Songkhla province with nearly 18 pounds of plastic in its stomach. The whale died days later, renewing concerns about the amount of such waste humans have put into the world's waterways.

U.S.

A judge dismissed two environmental lawsuits against five of the world's largest oil companies. During the trial, however, the companies' representatives said they recognize and agree with the scientific consensus that humans have caused unprecedented climate changes.

Maya Miller

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Maya Miller is an editorial intern for *Scientific American*.

Recent Articles

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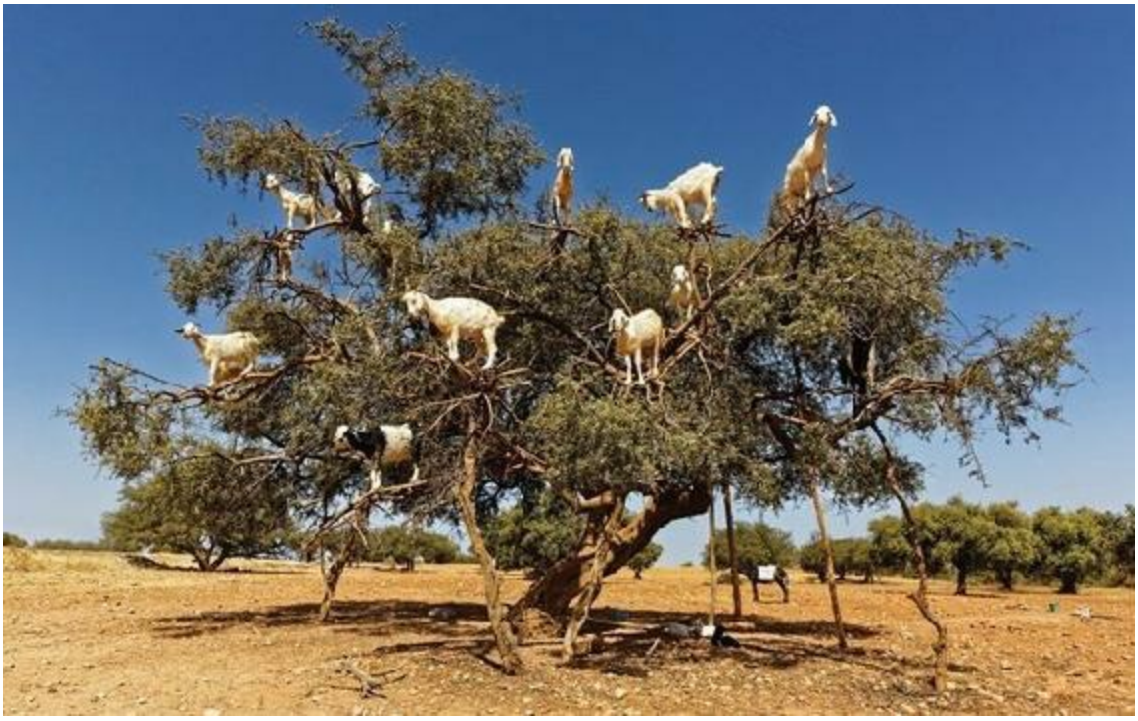
- In Case You Missed It

Chemistry

Vintner’s Dream: Oil Additive Could Aid in Wine Production

Argan oil helps to protect yeasts from harsh industrial processes

- By Lucas Laursen | Scientific American September 2018 Issue



Tree-climbing goats in an argan tree. *Credit: Yavuz Sariyildiz Getty Images*

Every great bottle of wine begins with a humble fungal infection. Historically, winemakers relied on naturally occurring yeasts to convert grape sugars into alcohol; modern vintners typically buy one of just a few laboratory-grown strains. Now, to set their products apart, some of the best winemakers are revisiting nature's lesser-used microbial engineers. Not all these strains can withstand industrial production processes and retain their efficacy—but a natural additive offers a possible solution, new research

suggests.

Industrial growers produce yeast in the presence of oxygen, which can damage cell walls and other important proteins during a process called oxidation. This can make it harder for yeasts—which are dehydrated for shipping—to perform when winemakers revive them. Biochemist Emilia Matallana of the University of Valencia in Spain and her colleagues have been exploring practical ways to fend off such oxidation for years. After showing that pure antioxidants worked, they began searching for a more affordable natural source. They found it in argan, an olivelike fruit used for food and cosmetics. The trees it grows on are famously frequented by domesticated goats.

Matallana and her team treated three varieties of wine yeast (*Saccharomyces cerevisiae*) with argan oil, dehydrated them and later rehydrated them. The oil protected important proteins in the yeasts from oxidation and boosted wine fermentation, the researchers reported in a study published online in June in *Innovative Food Science & Emerging Technologies*.

Microbiologists are now interested in studying how and why each yeast strain responded to the argan oil as it did, says enologist Ramón González of the Institute of Grapevine and Wine Sciences in Logroño, Spain, who was not involved in the work. The oil may one day enable vintners to use a wider range of specialized yeasts, putting more varied wines on the menu. As for how the oil affected the wine's taste, Matallana says it was “nothing weird.”

Lucas Laursen

Recent Articles

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Wellness

Colon Cancer Screening Guidelines May Need Revising

Doctors recommend a first colonoscopy at age 50, but that could be too late for some men

- By Heather Stringer | Scientific American September 2018 Issue

Credit: VOISIN/PHANIE Getty Images

No one looks forward to that first colonoscopy, but this glimpse into the gut is one of the most powerful existing weapons against colon cancer. Yet current protocol for when to start checking for the disease may be too late for many men and may put many women through an expensive and unnecessary ordeal, a new study suggests.

Doctors currently advise men and women with no family history of colon cancer or other risk factors to start undergoing screening at age 50, and sooner for those deemed more at risk. But this sweeping guideline does not account for individual genetic and lifestyle differences. To calculate the ideal age for the first screening, researchers at the Fred Hutchinson Cancer Research Center in Seattle and their colleagues analyzed patient data detailing 19 behavioral patterns—including exercise, alcohol and red meat consumption, body mass index and aspirin use—and 63 genetic markers associated with colorectal cancer.

The results suggest that 15 percent of men with no family history of the disease should start getting scoped before age 45, whereas half of women with no family history could wait until they are at least 56—and 10 percent of those could start as late as 64. Thirteen years of data from participants of European descent showed that hormone replacement therapy reduced women's cancer risk, that men were more likely to engage in risky behaviors such as drinking and smoking, and that being overweight was a higher risk for men than women.

The study's findings, published in June in *Gastroenterology*, also call into question the assumption that a family history of the disease always calls for early screening. The researchers found that more than half of women—and 15 percent of men—with a family history could wait until 50 for a first colonoscopy. These findings are a step toward individualized screening guidelines but should not be considered medical advice, says Jihyoun Jeon of the University of Michigan, the study's lead author.

“The study is significant because [disease] models don't usually combine both genetics and habits to predict colon cancer risk,” says Brian Wells, a biostatistician at the Wake Forest School of Medicine, who was not involved in the work. “But the authors did not tell us how many colonoscopies could be avoided and how many colorectal cancers could be prevented using this model and how this compares with the current guidelines. This comparison is needed to evaluate risks versus benefits for the real world.”

Heather Stringer

cancer-screening-guidelines-may-need-revising/

Behavior & Society

Facebook Use Linked to Gender Equality

Social network activity may reduce the male-female power imbalance

- By Matthew Hutson | Scientific American September 2018 Issue

Credit: Getty Images

In addition to purveying cat videos and baby pictures, social networks can provide useful demographic information. A new study finds that worldwide, Facebook use by women is associated with greater gender equality.

Researchers looked at the anonymized data of 1.4 billion users in 217 countries, territories and autonomous regions and calculated the proportion of women and men ages 13 to 65 who actively used the social network. Places

with a lower female-to-male usage ratio, such as Afghanistan, were deemed to have a greater “Facebook gender divide” (*chart and map*). The team also collected World Economic Forum data on countries' gender equality in terms of economic opportunity, education and health. The study found that the smaller a country's Facebook gender divide in 2015, the more economic gender equality increased the following year. In contrast, an increase in economic gender equality in 2015 was not associated with a reduction in the Facebook gender divide during 2016. This finding suggests that a smaller Facebook gender gap is more likely a contributor to—rather than a result of—economic gender equality. The results were published in July in the *Proceedings of the National Academy of Sciences USA*.

Ridhi Kashyap, a demographer at the University of Oxford, who was not involved in the study, has published a separate map of the Internet gender gap, also using Facebook data. She found that gender gaps in Facebook use proved to be a good measure of gender gaps in Internet use in general; data on the latter are often unavailable. Kashyap says the Internet can provide users with valuable health and employment information and “can also be a great way to enhance skills.” David Garcia, a computational social scientist at the Medical University of Vienna and the lead author of the *PNAS* study, says Facebook data could help policy makers estimate gender inequality in poor countries and could track its evolution on a daily basis.

Credit: Amanda Montañez; Sources: “Analyzing Gender Inequality through Large-Scale Facebook Advertising Data,” by David Garcia et al., in *Proceedings of the National Academy of Sciences USA*, Vol. 115, No. 27; July 3, 2018 (*Facebook gender gap data*); The Global Gender Gap Report 2016. World Economic Forum, 2016 (*education gender gap data*)

Matthew Hutson

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- **Alzheimer's Hits Men and Women Differently, and We Need to Understand Why** [周一, 03 9月 06:02]

Neurological Health

Alzheimer’s Hits Men and Women Differently, and We Need to Understand Why

To fight the disease, we need to look at sex-specific risks

- By Rebecca Nebel | Scientific American September 2018 Issue

Credit: Cornelia Li

Growing older may be inevitable, but getting Alzheimer’s disease is not. Although we can’t stop the aging process, which is the biggest risk factor for Alzheimer’s, there are many other factors that *can* be modified to lower the risk of dementia.

Yet our ability to reduce Alzheimer's risk and devise new strategies for prevention and treatment is impeded by a lack of knowledge about how and why the disease differs between women and men. There are tantalizing hints in the literature about factors that act differently between the sexes, including hormones and specific genes, and these differences could be important avenues of research. Unfortunately, in my experience, most studies of Alzheimer's risk combine data for women and men.

For that reason, researchers at the Society for Women's Health Research Interdisciplinary Network on Alzheimer's Disease recently published a review paper in *Alzheimer's & Dementia: The Journal of the Alzheimer's Association* that calls for greater analysis of research data by sex to stimulate new approaches that will improve prevention, diagnosis and treatment of Alzheimer's.

We have some evidence, for example, that sex hormones such as estrogen influence the course of the disease, but we do not understand enough about why and how. Ovaries are the primary source of estrogen for premenopausal women, and surgical removal of a woman's ovaries before menopause is associated with a higher risk of dementia. But using estrogen therapy after surgery until age 50 negates that risk. This fact suggests that estrogen may be protective in premenopausal women.

In men, there are conflicting studies as to whether androgen-deprivation therapy, which is used to treat prostate cancer, increases the risk for Alzheimer's. Further investigation is needed into the role of sex hormones, the use of different hormonal treatments and the ways they each impact Alzheimer's risk.

Among risk factors that affect both women and men, some are more common in one sex. For example, depression and sleep apnea are both risk factors for dementia, but depression is twice as common in women, and sleep apnea is much more common in men. Similarly, low education and poor job attainment are Alzheimer's risk factors, but traditionally women have not had the same access to education and job opportunities as men, which puts them at increased risk.

The e4 allele of the *APOE* gene is the strongest and most common genetic

risk factor for Alzheimer's in both women and men, but it confers a greater risk in women. Women with *APOE* e4 are at increased risk of developing Alzheimer's, compared with women without the allele and men with and without it.

Learning how sex impacts risk factors at various times across a life span is also critical. For example, in cardiovascular disease, taking aspirin helps to reduce heart attack and stroke risk in women aged 65 years and older. This effect is not seen in younger women. It is possible that certain Alzheimer's risk factors may be strongest at certain points during our lives, and exploring this correlation is key for prevention and early intervention.

Risk factors are just one of the areas in which we need more research into the differences between the sexes in Alzheimer's. Scientists have often overlooked sex differences in diagnosis, clinical trial design, treatment outcomes and caregiving. This bias has impeded progress in detection and care.

Approaches that incorporate sex differences into research have advanced innovation in respect to many diseases. We need to do the same in Alzheimer's. Looking at these differences will greatly enhance our understanding of this thief of minds and improve health outlooks for all.

Rebecca Nebel

Rebecca Nebel is director of scientific programs at the Society for Women's Health Research, a national nonprofit organization.

Credit: Nick Higgins

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Medicine

The So-Called Right to Try Law Gives Patients False Hope

A new law to let dying patients access unapproved drugs raises false hope

- By Claudia Wallis | Scientific American September 2018 Issue

Credit: Celia Krampien

There's no question about it: the new law sounds just great. President Donald Trump, who knows a thing or two about marketing, gushed about its name when he signed the “Right to Try” bill into law on May 30. He was surrounded by patients with incurable diseases, including a second grader with Duchenne muscular dystrophy, who got up from his small wheelchair to hug the president. The law aims to give such patients easier access to experimental drugs by bypassing the Food and Drug Administration.

The crowd-pleasing name and concept are why 40 states had already passed similar laws, although they were largely symbolic until the federal government got onboard. The laws vary but generally say that dying patients may seek from drugmakers any medicine that has passed a phase I trial—a minimal test of safety. “We're going to be saving tremendous numbers of lives,” Trump said. “The current FDA approval process can take many, many years. For countless patients, time is not what they have.”

But the new law won't do what the president claims. Instead it gives false hope to the most vulnerable patients. “This is a right to ask, not a right to try,” says Alison Bateman-House, a medical ethicist at New York University and an expert on the compassionate use of experimental drugs. The right to ask was already firmly in place. “If I had a magic wand,” she says, “rather than passing a new law, I would have figured out a way to educate people about the system we already have.”

In fact, for decades pharmaceutical companies have made unapproved drugs available through programs overseen by the FDA. This “expanded access” is aimed at extremely ill patients who, for one reason or another, do not qualify for formal drug studies. A 2016 report shows that the FDA receives more than 1,000 annual requests on behalf of such patients and approves 99.7 percent of them. It acts immediately in emergency cases or else within days, according to FDA commissioner Scott Gottlieb.

Of course, there are barriers to getting medicines that may not be effective or safe. Some patients cannot find a doctor to administer them or an institution that will let them be used on-site. And many of these drugs are simply not made available. Drugmakers cannot be compelled to do so: a 2007 federal court decision found “there is no fundamental right ... of access to experimental drugs for the terminally ill.” The new law changes none of this.

Pharma companies have many reasons to be cautious about providing what is in their labs. A drug in early stages of testing may have risks and benefits that are wildly uncertain. Supplies may be limited and production costly, so a company may wish to save its precious stock for clinical trials. Developers may also be concerned that their drugs will do poorly in fragile, dying patients, word will get out, and the consequences will be dire: patients will be scared away from studies, investors will retreat, stocks will tank. Thus, work

on a potentially valuable new medicine might get derailed by acts of compassion.

“If you said patients could just call up and say, ‘I want the drug—give it to me,’ how could you ever run a clinical trial?” asks Kenneth Moch, president and CEO of Cognition Therapeutics in Pittsburgh. “What happens for future patients?” In a long career, Moch has had a hand in making drugs available for compassionate use and holding them back. “There are no simple, monolithic solutions,” he says. He doubts his industry will embrace “Right to Try” and said so at a congressional hearing on the bill: “My comment was that no ethical developer of an experimental medicine I know of would let it be used outside of the FDA's regulatory oversight.”

Unethical companies, however, may find fresh opportunities to prey on desperate patients under the new law. It releases doctors, hospitals and drugmakers from liability. And although it stipulates that manufacturers can charge patients only what it costs to provide the drug, there is no required preapproval of these charges by the FDA, as there is with expanded access. Such issues led dozens of major patient-advocacy groups to oppose the legislation, which was originally drafted and promoted by the Goldwater Institute, a libertarian think tank.

Vibhav Rangarajan, an Illinois cardiologist, had hoped the law would help his two-year-old daughter, Radha, gain access to an experimental drug for a rare disease called metachromatic leukodystrophy that is destroying her nervous system. He wrote movingly about her plight in a recent piece published online in Stat and says he is saddened that this law lacks meaningful incentives for drug companies: “It's not really going to change the landscape.”

Claudia Wallis

Claudia Wallis is an award-winning science journalist whose work has appeared in the *New York Times*, *Time*, *Fortune* and the *New Republic*. She

was science editor at *Time* and managing editor of *Scientific American Mind*.

Credit: Nick Higgins

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- **Clinical Trials Have Far Too Little Racial and Ethnic Diversity** [周一, 03 9月 06:02]

Policy & Ethics

Clinical Trials Have Far Too Little Racial and Ethnic Diversity

It’s unethical and risky to ignore racial and ethnic minorities

- By THE EDITORS | Scientific American September 2018 Issue

Credit: Lisk Feng

Nearly 40 percent of Americans belong to a racial or ethnic minority, but the patients who participate in clinical trials for new drugs skew heavily white—in some cases, 80 to 90 percent. Yet nonwhite patients will ultimately take the drugs that come out of clinical studies, and that leads to a real problem. The symptoms of conditions such as heart disease, cancer and diabetes, as well as the contributing factors, vary across lines of ethnicity, as they do between the sexes. If diverse groups aren’t part of these studies, we can’t be

sure whether the treatment will work in all populations or what side effects might emerge in one group or another.

This isn't a new concern. In 1993 Congress passed the National Institutes of Health Revitalization Act, which required the agency to include more women and people of color in their research studies. It was a step in the right direction, and to be sure, the percentage of women in clinical trials has grown significantly since then.

But participation by minorities has not increased much at all: a 2014 study found that fewer than 2 percent of more than 10,000 cancer clinical trials funded by the National Cancer Institute focused on a racial or ethnic minority. And even if the other trials fulfilled those goals, the 1993 law regulates only studies funded by the NIH, which represent a mere 6 percent of all clinical trials.

The shortfall is especially troubling when it comes to trials for diseases that particularly affect marginalized racial and ethnic groups. For example, Americans of African descent are more likely to suffer from respiratory ailments than white Americans are; however, as of 2015, only 1.9 percent of all studies of respiratory disease included minority subjects, and fewer than 5 percent of NIH-funded respiratory research included racial minorities.

The problem is not necessarily that researchers are unwilling to diversify their studies. Members of minority groups are often reluctant to participate. Fear of discrimination by medical professionals is one reason. Another is that many ethnic and racial minorities do not have access to the specialty care centers that recruit subjects for trials. Some may also fear possible exploitation, thanks to a history of unethical medical testing in the U.S. (the infamous Tuskegee experiments, in which black men were deliberately left untreated for syphilis, are perhaps the best-known example). And some minorities simply lack the time or financial resources to participate.

The problem is not confined to the U.S., either. A recent study of trials involving some 150,000 patients in 29 countries at five different time points over the past 21 years showed that the ethnic makeup of the trials was about 86 percent white.

Drug regulators such as the FDA should create and enforce tougher requirements: for a drug to be approved for market, the patient panels of its clinical trials should closely resemble the makeup of the patient populations who will actually use the candidate medicine. And drugmakers should adopt their own testing policies, including strong standards for diverse patient groups.

The FDA currently requires drug developers to provide extra test results for a candidate drug that may have applications in a special age population—say, older patients. It could apply those same criteria regarding race and ethnicity. These requirements could even extend to a more diverse array of genetic subtypes. Some medicines are ineffective or dangerous in certain genetic populations. For example, carbamazepine, a medication used to treat epilepsy, can cause a severe skin disorder in patients of Asian heritage with a particular gene variant.

In 2015 the FDA launched the Drug Trials Snapshots program, which makes public the demographic details of clinical trial participants, including their age, sex and race. But the onus is on the patients and their doctors to seek out that information.

It’s unethical and dangerous to approve drugs without making every attempt to certify their safety and efficacy. Yet by failing to include members of racial and ethnic minorities in clinical trials, that is just what the FDA is doing.

THE EDITORS

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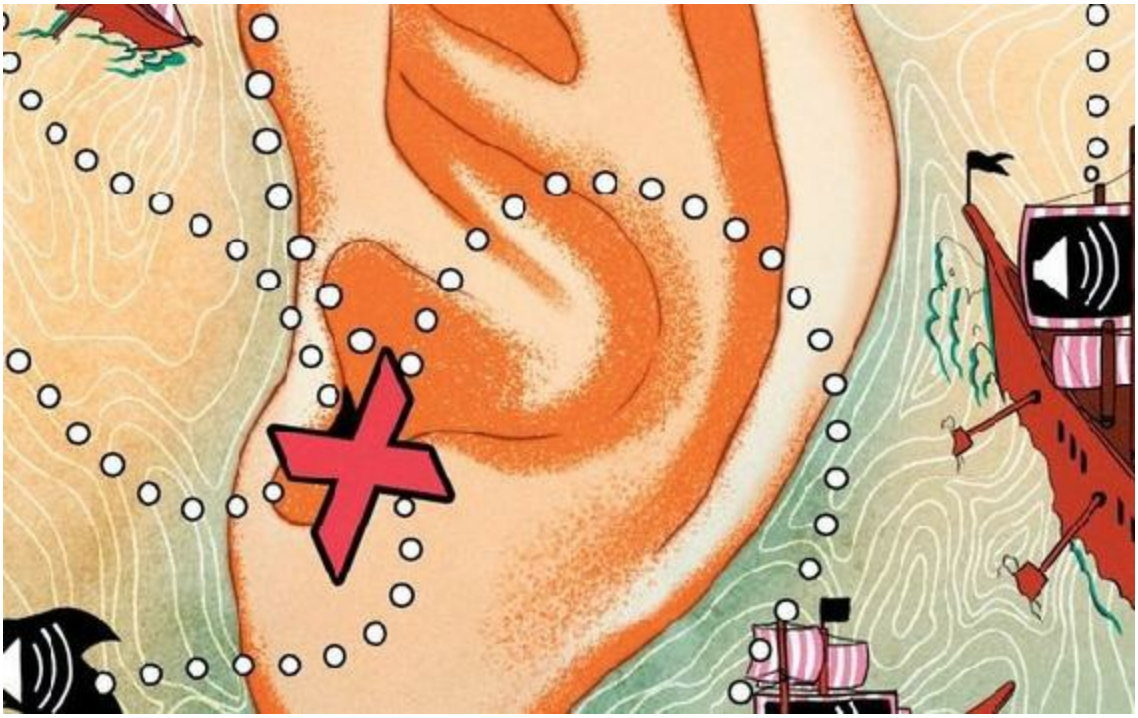
- **Hearing Aids Are Finally Entering the 21st Century** [周一, 03 9月 06:02]

Medical & Biotech

Hearing Aids Are Finally Entering the 21st Century

This outdated, expensive tech is getting a big makeover

- By David Pogue | Scientific American September 2018 Issue



Credit: Jay Bendt

Most people probably associate three things with hearing aids: an elderly demographic, beige plastic construction and high-pitched feedback in public places. As it turns out, all those notions are now obsolete—or will be soon.

The most popular hearing-aid style is still the one that rests over your ear—a design that debuted in the 1950s. You know what else is decades old? Our country's system for getting and paying for hearing aids.

Basic Medicare and most other insurance providers have never paid for adult hearing aids. At an average cost of $4,700 a pair, that makes hearing aids the third-largest purchase in most people's lives after a house and a car.

The channel for buying hearing aids hasn't changed in 60 years, either: You must buy them from an audiologist or doctor. They're not available over the counter or by mail order.

Only six companies make most of the world's hearing aids, and they sell them directly through hearing specialists. (You can buy "personal sound amplification products" in stores, but they can't be marketed as hearing aids. In any case, most are fairly crude and ineffective for severe hearing loss.)

That's one reason the price of hearing aids hasn't dropped over time, the way most electronics do: the medical professionals you have to go through account for a significant fraction of the cost. Bottom line: many people who need them don't get them.

"This is the sad part," says Frank Lin, director of the Cochlear Center for Hearing and Public Health at the Johns Hopkins Bloomberg School of Public Health. "About 20 percent of adults who have a hearing loss actually use a hearing aid. I mean, 20 percent. And this figure hasn't changed in decades."

The other 80 percent may wind up missing out on a lot more than conversation in a noisy restaurant. Lin's studies, which followed older adults for many years, revealed that hearing loss is "incredibly strongly" linked to serious outcomes, including impaired thinking, greater risk of hospitalization, even dementia.

Appalled at these findings, Lin teamed up with the President's Council of Advisors on Science and Technology, under Barack Obama, and other groups to pursue a radical agenda: deregulating hearing aids. The result passed last year with bipartisan support. It requires that the FDA develop a new category of over-the-counter hearing aids, including safety and reliability standards.

The new law, Lin says, will lower the price and remove obstacles to innovation—and so help more patients. "People widely expect that companies like Bose, Samsung and Apple could all enter the market now," he

observes. Obviously the concept of over-the-counter aids isn't popular with today's manufacturers, who will lose their exclusivity.

"The concern is people trying to self-diagnose, people trying to self-program," says Chris McCormick, chief marketing officer at Starkey Hearing Technologies, the only U.S.-based company among the big six hearing-aid makers. "The products will have to be standardized, and the problem is that everybody's hearing is different." Even so, Starkey and others are preparing for the new marketplace. Part of that is taking the hearing aid well beyond the realm of sound processing.

Later this year Starkey will release a new model that incorporates Fitbit-like health and heart rate monitoring and another that will automatically notify a loved one if you fall and can't get up. Bose already sells something called Hearphones—with noise cancellation, directional microphones and various sound-processing options—that are moderate-strength hearing aids in all but name.

As for those popular misconceptions: Many hearing aids today *aren't* beige (turns out that matching them to your hair color is better camouflage). Most have antifeedback circuitry.

And now, thanks partly to the new law, older people may not be the primary customer demographic. Your ear turns out to be a great, inconspicuous place for a computer to hide, as the movie *Her* brilliantly depicted. Hearing aids may mostly aid your hearing—but soon they'll help with directions, read our messages, play our music and track our health, all without the distraction of a smartphone screen. This could be the dawn of a new ear era.

David Pogue

David Pogue is the anchor columnist for Yahoo Tech and host of several *NOVA* miniseries on PBS.

Credit: Nick Higgins

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- **Essential Seaweed, the History of Cardiology, Neil deGrasse Tyson on Astrophysics and War and Other New Science Books** [周一, 03 9月 06:02]

Arts & Culture

Essential Seaweed, the History of Cardiology, Neil deGrasse Tyson on Astrophysics and War and Other New Science Books

Book Recommendations from the Editors of *Scientific American*

- By Andrea Gawrylewski | Scientific American September 2018 Issue

BLADDER WRACK seaweed on the Orkney Islands in Scotland. *Credit: Iain Sarjeant Getty Images*

Seaweed Chronicles: A World at the Water's Edge
by Susan Hand Shetterly.

Algonquin Books, 2018 ($24.95).

With the word "weed" in its name, seaweed certainly seems like a resource as unnecessary as it is inexhaustible. But nature writer Shetterly details why this hardy alga deserves safeguarding. In evocative prose, she describes seaweed's role in the environment, especially in her coastal home of "Downeast Maine," and the people who study, harvest, sell, eat and protect it. She profiles fishers who because their fishery has been depleted have switched to gathering a variety known as rockweed for industrial and culinary uses, as well as activists fighting to regulate the harvest to prevent rockweed from disappearing as the fish did. Shetterly also takes a seaweed cooking class, visits a factory for "Kelp Krunch bars" and travels with a biologist who studies how baby eider ducks depend on seaweed to survive. —*Clara Moskowitz*

Ticker: The Quest to Create an Artificial Heart
by Mimi Swartz.
Crown, 2018 ($27).

It was 1963, and O. H. "Bud" Frazier, then a medical student, had his hands wrapped around a patient's heart—his forceful massage the sole act keeping the man alive. Journalist Swartz chronicles the decades-long evolution of top U.S. cardiac surgery programs through intimate profiles of the field's most prominent practitioners as they race to build an artificial heart. She captures details of the profession with panache: a split-second decision to put a sheep's heart into a human body, the challenge of engineering a device that can maintain blood temperature for hours. Ultimately, she contends, cardiology was at the mercy of outside forces. When the *Challenger* shuttle exploded in 1986, Swartz writes, that failure translated into more skepticism toward all technology-based fields and a long-term dip in funding for heart surgery programs. Even matters of the heart do not unfold in isolation.
—*Maya Miller*

Accessory to War: The Unspoken Alliance between Astrophysics and the Military
by Neil deGrasse Tyson and Avis Lang.
W. W. Norton, 2018 ($30)

“The roster of nations that have wielded the most power on the world stage... are precisely those nations whose scientists knew the most about the universe at any given time,” assert astrophysicist Tyson and writer Lang in this comprehensive exploration of the long-standing synergy between astronomy and warfare. The stars guided prophesying seers and bloodthirsty raiders in remote antiquity; telescopes were beloved tools in the academies and battlefields of Renaissance Europe; rockets and satellites are now vital for both generals and Nobel Prize–winning academics. Understanding how and why “the soft power of cosmic discovery” promotes military might, the authors contend, is crucial for stimulating further progress in space science—and perhaps even lasting peace on Earth. —*Lee Billings*

Autonomy: The Quest to Build the Driverless Car—And How It Will Reshape Our World
by Lawrence D. Burns, with Christopher Shulgan.
Ecco, 2018 ($27.99)

Self-driving cars, once heroic engineering prototypes confined to desert race courses, are now being tested around the Phoenix, Ariz., metropolitan area—arguably, the greatest transition in mobility since the automobile began. Burns, who led R&D at General Motors for years and consulted on Google’s autonomous car project, is an unabashed booster for the technology. But he and writer Shulgan vividly recount the painful birth of the first robotic racers and highlight the missteps, egos and legal battles that have hampered its progress. Insider drama aside, they present a compelling vision of a future with many fewer cars, less pollution, less congestion—and more freedom to move than ever before. —*W. Wayt Gibbs*

Andrea Gawrylewski

Andrea Gawrylewski is the collections editor at *Scientific American*.

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Skeptic

- **Abortion Is a Problem to Be Solved, Not a Moral Issue**
  [周一, 03 9月 06:02]

Public Health

Abortion Is a Problem to Be Solved, Not a Moral Issue

Education and birth control are slowly making the politics less relevant

- By Michael Shermer | Scientific American September 2018 Issue

Credit: Izhar Cohen

In May of this year the pro-life/pro-choice controversy leapt back into headlines when Ireland overwhelmingly approved a referendum to end its constitutional ban on abortion. Around the same time, the Trump administration proposed that Title X federal funding be withheld from abortion clinics as a tactic to reduce the practice, a strategy similar to that of Texas and other states to shut down clinics by burying them in an avalanche of regulations, which the U.S. Supreme Court struck down in 2016 as an

undue burden on women for a constitutionally guaranteed right. If the goal is to attenuate abortions, a better strategy is to reduce unwanted pregnancies. Two methods have been proposed: abstinence and birth control.

Abstinence would obviate abortions just as starvation would forestall obesity. There is a reason no one has proposed chastity as a solution to overpopulation. Sexual asceticism doesn't work, because physical desire is nearly as fundamental as food to our survival and flourishing. A 2008 study published in the *Journal of Adolescent Health* entitled "Abstinence-Only and Comprehensive Sex Education and the Initiation of Sexual Activity and Teen Pregnancy" found that among American adolescents ages 15 to 19, "abstinence-only education did not reduce the likelihood of engaging in vaginal intercourse" and that "adolescents who received comprehensive sex education had a lower risk of pregnancy than adolescents who received abstinence-only or no sex education." A 2011 *PLOS ONE* paper analyzing "Abstinence-Only Education and Teen Pregnancy Rates" in 48 U.S. states concluded that "increasing emphasis on abstinence education is positively correlated with teenage pregnancy and birth rates," controlling for socioeconomic status, educational attainment and ethnicity.

Most telling, a 2013 paper entitled "Like a Virgin (Mother): Analysis of Data from a Longitudinal, US Population Representative Sample Survey," published in *BMJ* reported that 45 of the 7,870 American women studied between 1995 and 2009 said they become pregnant *without sex*. Who were these immaculately conceiving parthenogenetic Marys? They were twice as likely as other pregnant women to have signed a chastity pledge, and they were significantly more likely to report that their parents had difficulties discussing sex or birth control with them.

When women are educated and have access to birth-control technologies, pregnancies and, eventually, abortions decrease. A 2003 study on the "Relationships between Contraception and Abortion," published in *International Family Planning Perspectives*, concluded that abortion rates declined as contraceptive use increased in seven countries (Kazakhstan, Kyrgyzstan, Uzbekistan, Bulgaria, Turkey, Tunisia and Switzerland). In six other nations (Cuba, Denmark, the Netherlands, Singapore, South Korea and the U.S.), contraceptive use and abortion rates rose simultaneously, but

overall levels of fertility were falling during the period studied. After fertility levels stabilized, contraceptive use continued to increase, and abortion rates fell.

Something similar happened in Turkey between 1988 and 1998, when abortion rates declined by almost half when unreliable forms of birth control (for one, the rhythm method) were replaced by more modern technologies (for example, condoms). Public health consultant Pinar Senlet, who conducted the 2001 study published in *International Family Planning Perspectives*, and her colleagues reported that "marked reductions in the number of abortions have been achieved in Turkey through improved contraceptive use rather than increased use."

To be fair, the multivariable mesh of correlations in all these studies makes inferring direct causal links difficult for social scientists to untangle. But as I read the research, when women have limited sex education and no access to contraception, they are more likely to get pregnant, which leads to higher abortion rates. When women are educated about and have access to effective contraception, as well as legal and medically safe abortions, they initially use both strategies to control family size, after which contraception alone is often all that is needed and abortion rates decline.

Admittedly, deeply divisive moral issues are involved. Abortion does end a human life, so it should not be done without grave consideration for what is at stake, as we do with capital punishment and war. Likewise, the recognition of equal rights, especially reproductive rights, should be acknowledged by all liberty-loving people. But perhaps progress for all human life could be more readily realized if we were to treat abortion as a problem to be solved rather than a moral issue over which to condemn others. As gratifying as the emotion of moral outrage is, it does little to bend the moral arc toward justice.

Michael Shermer

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Michael Shermer is publisher of *Skeptic* magazine (www.skeptic.com) and a Presidential Fellow at Chapman University. His new book is *Heavens on Earth: The Scientific Search for the Afterlife, Immortality, and Utopia* (Henry Holt, 2018).

Credit: Nick Higgins

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- **Beavers Made America Great, a New Book Explains** [周一, 03 9月 06:02]

Conservation

Beavers Made America Great, a New Book Explains

Castor canadensis constructed a continent

- By Steve Mirsky | Scientific American September 2018 Issue

Credit: Matt Collins

The Hoover Dam on the border of Nevada and Arizona is 726 feet high and 1,244 feet across. But another dam in Michigan's Upper Peninsula is more impressive. Made of wood, mud, rocks and whatever other materials were available, this dam is six feet high and more than 260 feet long. And it's more impressive because the builders had no printed plans, heavy equipment or opposable thumbs. They lacked hard hats but had hard teeth. To accomplish the feat, they also relied on their feet, the rear two of which are webbed. And

their determined brains come hardwired for aquatic architecture. You probably don't need to be slapped with its broad, flat tail to have by now sussed out that we're talking about *Castor canadensis*, aka the North American beaver.

The Michigan dam description comes from environmental journalist Ben Goldfarb's engrossing and elegantly written new book *Eager: The Surprising, Secret Life of Beavers and Why They Matter*. People have used them for food, currency and hat-making material—the human desire for warm and stylish chapeaus almost wiped beavers out. But their population is rebounding as we recognize that beavers can restore ecosystems. Goldfarb quotes one scientist's wise counsel: “Let the rodent do the work.”

Before the near clear-cutting of the species, beavers engineered great swaths of North America: a study found that prior to the arrival of undocumented immigrants from Europe, the continent was the site of between 15 million and 250 million beaver ponds.

Goldfarb guesstimates, using midrange numbers and pond sizes, that beavers submerged some 234,000 square miles. Real estate busts don't leave that much property underwater. A lot of that saturated, wet, moist or merely damp land dried up after “trappers de-beavered North America,” as Goldfarb puts it, which “left behind some of the finest soil a farmer could till.” The bountiful agricultural output of the young U.S. and Canada rested on the shoulders of rodent giants.

The ghosts of beavers past still haunt New York City, where *Scientific American* is based. Our official city seal features two beavers. The walls of the Astor Place subway station include bas-relief beavers gnawing on terra-cotta tree trunks. (John Jacob Astor made his financial killing on beaver furs.) And a few short blocks north of our current offices, you can stroll down Beaver Street. Or flee down it, depending on the situation. What I didn't know until I read Goldfarb's book was that when the Dutch bought Manhattan from the Lenape in 1626, the island “was little more than a pot-sweetener: The real prizes were the 7,246 beaver skins that sailed to Europe.” I now choose to think that self-portraits by the hatted Vermeer and Rembrandt include New York City beavers on the masters' heads.

Within its wide scope, *Eager* includes other nuggets sure to make you the most fascinating conversationalist at your next party. Which, if it's in Sweden, could include the drink brand BVR HJT (pronounced *bäverhojt* or called “beaver shout”). It's schnapps flavored with beaver musk. One blogger wrote that the drink wasn't strong, but the smell that soon seeped from her skin was.

Nugget: Beavers engage in “caecotrophy, eating their own pudding-like excretions to extract every last iota of nutrition.” Goldfarb notes that after the second go-through, what comes out of the beaver is “nearly sawdust.” Perhaps an enterprising ecology Ph.D. candidate can one day quantify “nearly.”

Nugget: Beavers have a second set of lips behind their teeth, thereby “permitting them to chew and drag wood without drowning.” Once exposed to that information, the reader will immediately recognize the necessity of that evolutionary innovation. The reader could also be creeped out.

Nugget: In 2016 canoeists noticed a prosthetic leg, presumably load-bearing, in a beaver dam in Wisconsin. They plucked it out, found the owner via a Craigslist ad and returned it. He'd lost it a few weeks earlier when his canoe tipped over. As he told a local news outlet, “I wasn't overly worried about it, because I use my older model for fishing and hunting.... It wasn't my everyday leg.” Seems he took the whole episode in stride.

Steve Mirsky

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Steve Mirsky has been writing the Anti Gravity column since a typical tectonic plate was about 36 inches from its current location. He also hosts the *Scientific American* podcast Science Talk.

Credit: Nick Higgins

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- Out with the Bad Science

50, 100 & 150 Years Ago

- **Dikes for Keeping Out the Zuyder Zee; the Victorian Fear of Being Buried Alive** [周一, 03 9月 06:02]

Engineering

Dikes for Keeping Out the Zuyder Zee; the Victorian Fear of Being Buried Alive

Innovation and discovery as chronicled in *Scientific American*

- By Daniel C. Schlenoff | Scientific American September 2018 Issue

1918: Aerial combat was an evolving invention in the First World War. Here two airplanes fight it out in the sky. *Credit: Scientific American, Vol. CXIX, No. 10; September 7, 1918*

1968

Advanced Lasers

“There are now hundreds of masers and lasers, generating frequencies over most of the electromagnetic spectrum, from the radio region far into the ultraviolet. Indeed, it seems that before long the art of stimulating emission will be extended into the X-ray region. Meanwhile the development of visible-light lasers is providing excitement enough. As we go to higher and higher powers, laser light is demonstrating extraordinary nonlinear phenomena in its interactions with matter. Some of the lasers now under development in the laboratory, such as the tunable and picosecond versions, are showing us that lasers so far have been rather simple devices. —Arthur Schawlow”

Schawlow shared the 1981 Nobel Prize in Physics for his work on laser light.

1918

Opposing the Sea

“After nearly 70 years of consideration, the people of the Netherlands are about to begin the partway draining of the Zuyder Zee in order to add quite 523,440 acres to Holland's present area of dry land. The stress of war and the task of harboring hundreds of thousands of refugees has brought Holland to a realization of her shortage of agricultural lands. Nothing less than a massive dike 18 miles long will suffice to shut in the Zuyder Zee and, at the same time, be sturdy enough to hold the North Sea at bay when in its angriest moods. The greatest height known to have been attained by waves along the coast of the Zuyder Zee was in December of 1883, when, owing to an exceptionally severe gale, the surf then mounted embankments fully 17 feet above normal high tide. The height of the dike above sea level will be 17.6 feet near the North Holland end.”

War in the Air

“Speed, climbing ability, and marksmanship are only three factors in aerial combat. It is safe to say that maneuvering skill is by far the most important factor. The aviator who knows every trick of his profession stands the best

chance of winning or escaping. A ‘stunt’ frequently employed at the front is the upward swoop followed by a tail slide. When a machine is being pursued by another which is blazing away at the tail of the first, the usual maneuver for the first pilot is to pull the control stick backwards, heading his machine straight up until it attains a vertical position. Here it ‘hangs’ by its propeller for just an instant, as is strikingly shown in our cover sketch, when it slides back and is finally brought into the level position again. Now it is behind the opponent and possesses the advantage.”

1868

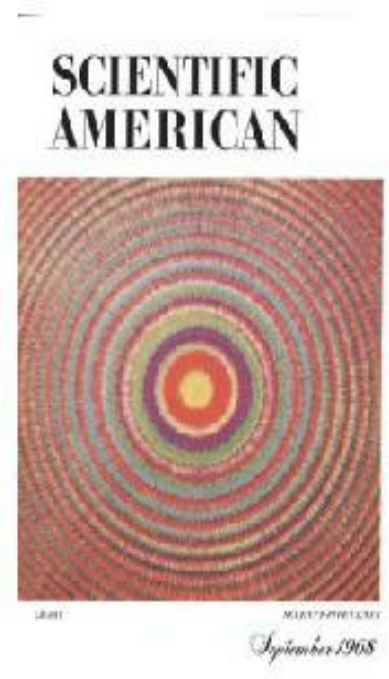
Fashion Victims

“The medical journals are making a feeble crusade against the high-heeled and narrow-toed boots now in vogue. This fashion must be creating a rich harvest for the corn doctors, and it is sure to result in a greater or lesser degree of permanent deformity. When the heel is raised, as is the prevalent custom, the bones of the thigh, pelvis, and leg, as well as the foot, are thrown into abnormal positions; and the effect of such unnatural tension is sure to be perpetuated, in the shape of crooked shins, bandy legs, elephantine toe joints, and cramped ungraceful gait. Let us hope that before these evils shall have become greatly multiplied, fickle fashion may remove the cause, and give us something more sensible and endurable than these toe-screws.”

A Victorian Obsession

“The idea of being buried alive is one that fills the mind with horror, and the accounts which have from time to time appeared in the public prints, describing such occurrences, have always attracted the attention of a sensation-loving public. There are numerous and generally reliable tests for determining whether death has actually occurred previous to the commencement of decay, which are familiar to most people. Granted that in extremely rare cases, it is possible these should fail, it is difficult to perceive how Mr. Vester's patent burial-case is an improvement. It consists of an ordinary burial-case or coffin with a tube at the head, containing a ladder and a cord to enable the resuscitated individual to return to the upper air, provided

he has strength to do it, which we think would in most cases be doubtful. The invention is claimed to be of inestimable service where parties have been interred while in a trance.”



Daniel C. Schlenoff

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Graphic Science

- **Only 150 of Your Facebook Contacts Are Real Friends**
  [周一, 03 9月 06:02]

Computing

Only 150 of Your Facebook Contacts Are Real Friends

Even with social media, we max out at 150 real relationships

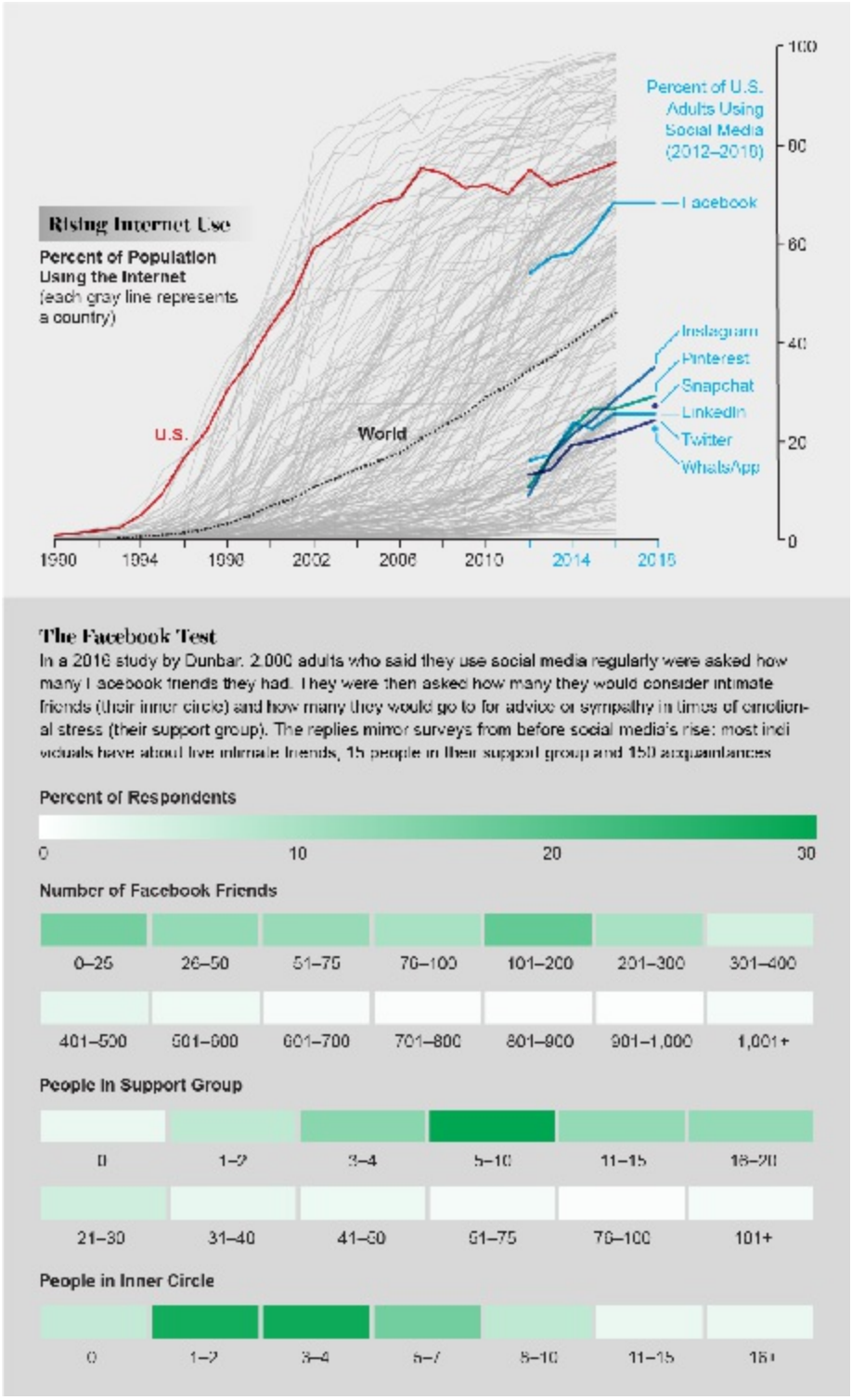
- By Mark Fischetti, Jen Christiansen | Scientific American September 2018 Issue

Credit: Dmitir Otis Getty Images

Humans are extremely social creatures. Anthropologists maintain that our hypersocial nature has helped us become a uniquely dominant species. Now social media allows a large percentage of people to communicate effortlessly worldwide (*large graph*), something no other animal can do.

Yet despite running up hundreds of friends on Facebook and thousands of

followers on Twitter, we are fooling ourselves, scientists say. We can really only maintain about 150 meaningful relationships at any time. Study after study confirms that most people have about five intimate friends, 15 close friends, 50 general friends and 150 acquaintances (*green bars*). Robin Dunbar, an evolutionary psychologist now at the University of Oxford, who had showed this pattern convincingly in the 1990s, revisited his old conclusions in a recent study of several thousand Facebook users. He found that despite social media's explosion, our network of significant contacts still maxes out at around 150. This threshold is imposed by brain size and chemistry, as well as the time it takes to maintain meaningful relationships, Dunbar says. “The time you spend,” he adds, “is crucial.”



Credit: Jen Christiansen; Sources: International Telecommunication Union, World Telecommunication/ICT Development Report and Database (*Internet use data*); Pew Research Center (*social media data*); "Do Online Social Media Cut through the Constraints That Limit the Size of Offline Social

Networks?” by R.I.M. Dunbar, in *Royal Society Open Science*, Vol. 3, Article No. 150292; January 2016 (*Facebook friend survey data*)

Mark Fischetti

Mark Fischetti is a senior editor at *Scientific American*, overseeing coverage of energy and the environment.

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Jen Christiansen

Jen Christiansen is senior graphics editor at *Scientific American*.

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