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ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ DECEMBER 7, 2019

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Feng Zhang discusses the challenges of CRISPR

COVER Scientists can run into trouble when research results clash with government desires. *iStock/Getty Images Plus, adapted by E. Otwell*

FROM TOP: CRANKYT/ISTOCK/GETTY IMAGES PLUS; MATTHIAS WITTLINGER; DAVID LIITTSCHWAGER

When reading *Science News* is the habit of a lifetime

On November 8, we welcomed a visitor to the *Science News* office in Washington, D.C. Kevin W. Parker (shown below with some of our staff) brought with him a faded copy of the Nov. 8, 1969 issue of *Science News* — his first issue in what is now a 50-year-plus habit of reading our magazine to keep up with the latest developments in science, technology and medicine.

I was delighted to meet Parker and eager to hear how this habit began. It turns out that his mom, a librarian, noticed her son's fascination with astronomy and space exploration, and got him his own subscription. He was 11 years old. *Science News* accompanied him through high school and college, and on to work at NASA's Goddard Space Flight Center in Greenbelt, Md., where he's a software engineer.

"In my younger days, I mainly used [the magazine] to keep up with the space program and as an invaluable resource for school papers and reports," Parker said. Now, "I use it to keep me informed on science in general, as well as the accomplishments of missions I've worked on in the past." Those include landmark NASA efforts such as the Hubble Space Telescope.

Since our founding in 1921 by newspaper magnate E.W. Scripps and scientist W.E. Ritter, our mission has been to help the public stay informed of scientific advances. For me, Parker epitomizes our success in that mission. I've met other people — including at least one *Science News* staff member — who say they were introduced to the magazine in their youth by a family member or teacher. Even if our magazine didn't shape your career, I hope it's been an enlightening and enjoyable source of timely, accurate news.

If you're also a longtime subscriber like Parker or Mary Stroh-Twichell, who recently told us she began subscribing as a college student in 1968, we'd love to hear from you! Get in touch with us at feedback@sciencenews.org.

And if getting *Science News* into the hands of more young people sounds like a good idea, please consider sponsoring a school through our *Science News* in High Schools program (www.sciencenews.org/snhs). For $500, a school gets 10 copies of each issue during the academic year, plus teacher resources and full access to our archives. Who knows, you may help inspire the next Kevin Parker. — *Nancy Shute, Editor in Chief*

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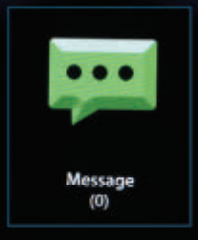

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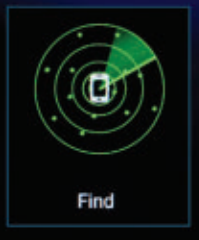

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Excerpt from the December 6, 1969 issue of *Science News*

50 YEARS AGO

Trends in inequality

The share of the total national income going to the poorest 20 percent of the [United States] has increased very little in the past 20 years ... only from 5.1 to 5.4 percent ... between 1947 and 1967. The proportion of the low-earning group that is nonwhite has remained at about 21 percent, which is more than twice the proportion of nonwhite families in the country as a whole. And census figures reveal that a greater proportion of the bottom fifth ... reside in the South.

UPDATE: The gap between the haves and have-nots endures in the United States. In 2018, the lowest-earning fifth of the population made only about 3 percent of the nation's total income, while the top-earning fifth made some 52 percent. Income disparities between racial groups also remain, with white households bringing in more than black and Hispanic households, on average — and a higher percentage of black and Hispanic households falling below the poverty line. America's poorer populations are still mostly in the South.

The world's fastest ant doesn't have the longest legs, but new speed tests in the Sahara show how the ant compensates.

MATTHIAS WITTLINGER

IT'S ALIVE

Saharan silver ants are the world's speediest

The world's newly crowned fastest known ants don't look as if they've got the legs to be champs.

Saharan silver ants (*Cataglyphis bombycina*) have merely runner-up proportions, with legs about 18 percent shorter than those of a related desert ant, *C. fortis*. Yet video shows that, adjusting for body length, silver ants rush along about twice as fast as their leggier cousins.

Sarah Pfeffer of Ulm University in Germany and colleagues took a high-speed video camera to the Tunisian oasis town of Douz to capture footage of the ants in their hot and sandy home. At the edge of the Sahara's great dunes, the team searched for glimpses of silver.

855
millimeters per second
Silver ant's top clocked speed

Tiny silver hairs coat the ants, reflecting some of the sun's glare and shedding heat. When Pfeffer, an applied neuroethologist, digs out a nest to study, several thousand ants seething in her transport box look "like quicksilver," she says. That silvery protection comes in handy because the ants stay in their nests at night and make excursions to scavenge for food in the furnace of midday.

"The sun really burns down," Pfeffer says. Surface sand temps can soar to over 60° Celsius (about 140° Fahrenheit).

Silver ants get two bonuses for foraging in the worst of the heat. It's a great time to find fresh carcasses of creatures that have been fried by the sun but not yet found by heat-averse scavengers. Also, ant-hungry predators often take shelter from the heat, so silver ants are less likely to become lunch themselves.

To see how the ants' shortish legs can run through hell, Pfeffer set up an outdoor, open-topped metal runway dusted with sand. She then offered a free lunch for ants. "They love mealworms," she says. As ants rushed along the runway, Pfeffer recorded their movements with the high-speed camera. The shorter legs compensate by packing more strides into each second, up to 47 for the silver ants running at top speed versus 36 for their taller relatives, Pfeffer and colleagues report online October 16 in the *Journal of Experimental Biology*.

Pfeffer clocked speeds as high as 855 millimeters per second. That's 108 times a silver ant's body length in a second.

The camera picked up six legs moving in two groups of triplets, like alternating tripods. At higher speeds, an ant gets airborne for just an instant with no legs touching the ground. In horses, that's called galloping. Pfeffer describes it as gliding, since the ants zoom forward smoothly instead of galumphing.

That glide is enough to crown the dune dwellers as the fastest known ant so far. Among arthropods in general, the fastest in terms of body lengths per second are *Paratarsotomus macropalpis* mites in Southern California. Young mites can zoom across concrete around three times as fast as the ants (*SN: 6/28/14, p. 4*).

— Susan Milius

TEASER

This sun-tracking material captures lots of energy

Like a sunflower, a new material follows the sun across the sky to soak up more light.

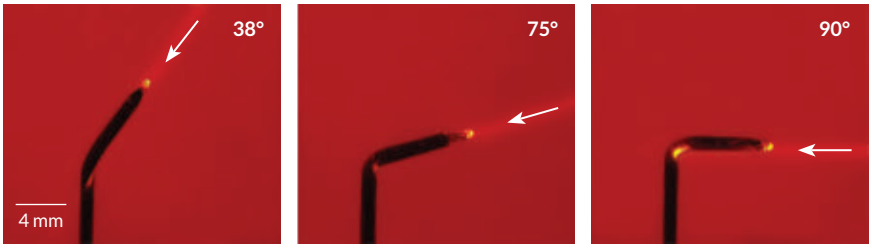
Stemlike cylinders of the material, dubbed SunBOTs, could help to solve a key challenge in solar energy: keeping up as the angle of sunlight changes throughout the day.

SunBOTs maneuver thanks to a light-responsive nanomaterial embedded in the polymer stems. As the nanomaterial converts light into heat, the polymer shrinks in response to increased temperatures, researchers report November 4 in *Nature Nanotechnology*.

SunBOTs captured about 90 percent of available light shining onto a surface at a 75-degree angle in lab tests, says coauthor Ximin He, a materials scientist at UCLA. By comparison, solar panels capture some 22 percent of available solar energy.

The researchers built the SunBOTs using gold nanoparticles and a hydrogel. Tests with other materials revealed the components could be mixed and matched.

Other scientists have made materials that bend toward light but can't self-regulate to stop at the best spot to absorb the sun's rays. SunBOTs can make small adjustments as the sun shifts — and one day could be used to upgrade solar panels. — *Sofie Bates*

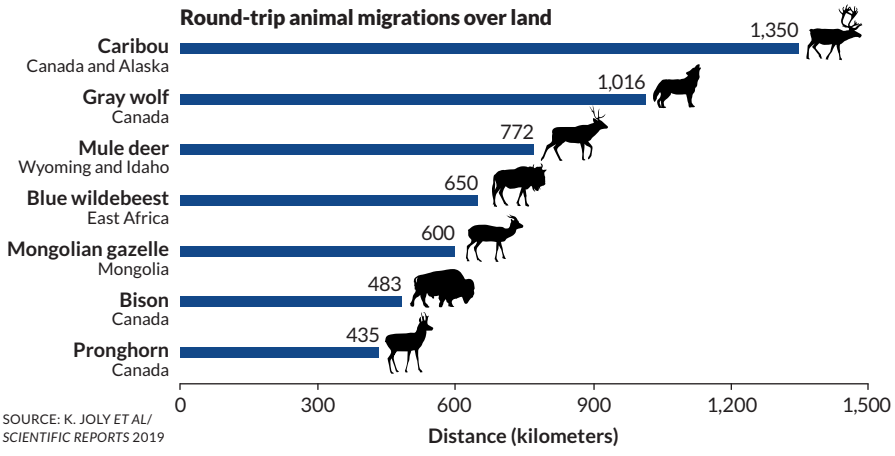


SunBOTs are designed to bend to meet different angles of a beam of light (arrows indicate the direction of incoming light). By shifting position as the light moves, the material captures far more available solar energy than stationary devices capture.

SCIENCE STATS

Caribou near the Arctic migrate farthest by land

Some species journey far for food or a place to raise young. Observations over decades revealed that caribou travel farthest, up to 1,350 kilometers per year, scientists report October 25 in *Scientific Reports*. Round-trip distances for several animals (some listed below) were calculated as double the straight distance between end points. But future infrastructure and climate change could affect migration routes. — *Sofie Bates*



SOURCE: K. JOLY *ET AL*/ *SCIENTIFIC REPORTS* 2019

FROM TOP: ESO, P. VERNAZZA *ET AL*, MISTRAL ALGORITHM (ONERA AND CNRS); XIAOSHI QIAN, YUSEN ZHAO, YOUSIF ALSAID, X. HE; E. OTWELL

THE –EST

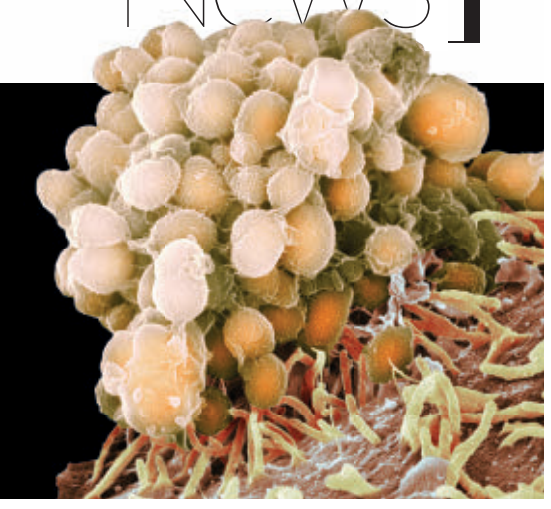
Our newest, smallest dwarf planet: Hygiea

The asteroid belt object known as Hygiea may be the new baby of the dwarf planet family.

Hygiea already met three of four requirements for dwarf planet status: It orbits the sun. It isn't a moon. And it hasn't swept its orbital path clear of other space rocks, the way planets are able to do. Now, telescope images reveal that Hygiea (shown above) is nearly spherical, which checks the last box to qualify it as a dwarf planet.

Once officially classified as a dwarf planet by the International Astronomical Union, Hygiea will join a handful of others in our solar system, including Pluto. And Hygiea, which is roughly 430 kilometers across, would be the smallest, unseating Ceres with its 950-kilometer diameter, scientists report October 28 in *Nature Astronomy*.

Images from the Very Large Telescope in Chile confirmed that Hygiea is about as round as Ceres — and that its surface isn't marred by a huge impact basin. That was a surprise; the researchers had expected to see an enormous crater from a collision billions of years ago thought to have formed Hygiea's entourage of over 6,800 asteroids. Computer simulations offer a possible explanation: More than 2 billion years ago, a space rock about 100 kilometers across shattered Hygiea's parent body completely. When remnants clumped back together, they formed the smooth orb seen today. — *Maria Temming*



Drug-resistant *Neisseria gonorrhoeae* bacteria (shown in this false-color micrograph) are considered an urgent public health threat.

BODY & BRAIN

CDC tallies toll of antibiotic resistance

Hard-to-treat microbes cause over 35,000 U.S. deaths annually

BY AIMEE CUNNINGHAM

Nearly 3 million people in the United States develop difficult-to-treat infections caused by drug-resistant bacteria and fungi each year — and over 35,000 die, according to a new government report.

"The modern medicine available to us today may very well be gone tomorrow if we don't slow the development of antibiotic resistance," Robert Redfield, director of the U.S. Centers for Disease Control and Prevention in Atlanta, said during a news conference on November 13.

In its first report in six years on drug-resistant infections, the CDC revised its 2013 report with newly available data. The number of annual deaths from drug-resistant infections at that time is now estimated to have been about 44,000, up from the 23,000 previously estimated.

The new report also estimates that about 35,000 people now die annually from drug-resistant infections, reflecting an 18 percent decrease from the revised 2013 number. There's been progress in reducing the spread of drug-resistant microbes typically associated with hospitals, a major source of deaths, Michael Craig, a senior adviser on antimicrobial resistance at the CDC, said during the news conference.

"The CDC's new numbers represent excellent progress in assessing the burden of antibiotic resistance, but they still likely underestimate its vast impact," says Greg Frank, director of infectious disease policy for the Biotechnology Innovation Organization, an industry group in Washington, D.C. Deaths due to drug-resistant microbes are often underreported because many patients with these infections also have other health issues that could get recorded as the cause of death, he says.

The latest report adds two organisms to the list of bacteria and fungi that the CDC considers urgent public health threats: the fungus *Candida auris* and *Acinetobacter* bacteria that are resistant to carbapenem antibiotics. Other bacteria on the list are *Clostridioides difficile*, drug-resistant *Neisseria gonorrhoeae* and Enterobacteriaceae bacteria resistant to carbapenem.

Acinetobacter spreads mainly in health care facilities and can cause pneumonia and urinary tract infections. *C. auris*, which causes severe and often fatal infections in hospital patients, is "a pathogen that we didn't even know about when we put out the last report," Craig said. "Since then, it has circumnavigated the globe and has caused a lot of infections and deaths." Its quick rise to becoming a health threat may be aided by climate change, according to one theory (*SN: 9/14/19, p. 4*). ■

EARTH & ENVIRONMENT

Airborne survey sniffs out methane

California landfills emit high levels of the greenhouse gas

BY CAROLYN GRAMLING

The largest sources of methane, a potent greenhouse gas, released into the atmosphere can now be spotted from the sky.

Airborne remote sensing has pinpointed the exact locations of some of California's biggest methane belchers. Of those concentrated superemitters, landfills were the biggest source, followed by dairy farms and the oil and gas industry.

About 34 to 46 percent of the state's emissions comes from 564 point sources, surface features or infrastructure no more than 10 meters across, the team found. Among those point sources, landfills contribute 41 percent of emissions while dairies and the oil and gas sector each contribute 26 percent, Riley Duren, an electrical engineer at the Jet Propulsion Laboratory in Pasadena, Calif., and colleagues report in the Nov. 7 *Nature*.

During five research campaigns consisting of flights across California from 2016 to 2018, Duren's team used an airborne imaging spectrometer, which can see visible and infrared light, to scan more than 271,000 facilities and infrastructure units.

Once large point sources, such as leaky pipelines or malfunctioning gas-capture systems, are identified, managers can take steps to fix the problems and reduce emissions, Duren's team says. Although more diffuse sources such as rice fields or emissions from cow herds are responsible for more than half of California's methane emissions, addressing the superemitters would make a big dent in the overall total.

Atmospheric scientist Alexander Turner of the University of California, Berkeley says remote sensing flights could become part of a "tiered observing system." Satellites could identify regions of interest and then airborne measurements could zero in on facilities. "Coupling these two technologies — satellite and airborne remote sensing — could allow us to make real strides in curbing methane emissions," he says. ■

SCIENCE PHOTO LIBRARY/SCIENCE SOURCE

EARTH & ENVIRONMENT

Fish nurseries are awash in plastic

Pollution outnumbers larvae 7-to-1 in Hawaiian ocean slicks

BY JONATHAN LAMBERT

A net dragged through an ocean slick off the island of Hawaii caught this scribbled filefish, about 50 days old and five centimeters long, plus all sorts of plastics.

Plastics can enter the food web at an unexpected point: inside larval fish as small as the tip of a pencil.

Larval fish congregate in ocean slicks — ribbons of calm water that form naturally on the ocean's surface — to feast on an abundance of prey. Prey-sized pieces of plastic also accumulate in these fish nurseries, outnumbering the fish 7-to-1 and ending up in many of their stomachs, researchers report online November 11 in the *Proceedings of the National Academy of Sciences*.

"This is perhaps the most vulnerable life stage of pelagic fish," says Anela Choy, a biological oceanographer at the Scripps Institution of Oceanography in La Jolla, Calif., who wasn't involved in the study. She has documented plastic accumulation in the deep sea (*SN: 7/6/19 & 7/20/19, p. 5*) and says this new study raises important questions about the effects of plastic ingestion at such a fragile life stage.

The researchers set out to study larval fish, not plastics, says marine ecologist Jonathan Whitney. After eggs hatch, tiny fish just a few millimeters in length feed and grow at the ocean surface for a few days to weeks before traveling to their natural habitat. But "we know very little about where they go, what they eat and how they find their way back home," says Whitney, of the National Oceanic and Atmospheric Administration's Pacific Islands Fisheries Science Center in Honolulu.

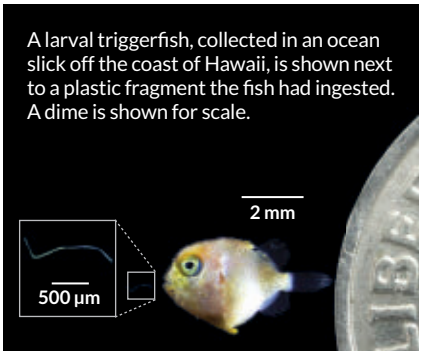
Previous research has suggested that ocean slicks concentrate plankton and other nutrients, and might serve as tranquil nurseries for young fish, Whitney says. He and colleagues decided to investigate ocean slicks just off the west coast of the island of Hawaii, where fish from a variety of ecosystems — open water, deeper sea and coral reefs — converge.

The researchers towed a specialized net inside and outside ocean slicks 100 times from 2016 to 2018 to sample larval fish diversity. But when the researchers inspected their hauls, they quickly realized their study wasn't going to be just about fish.

After manually picking through the catches, the team counted more than 11,000 larval fish, including blennies and goatfish from coral reefs, mahimahi and swordfish from open waters, and anglerfish from depths barely touched by light. "It shows how briefly interconnected these vastly different ecosystems are," says coauthor Gareth Williams, a marine biologist at Bangor University in Anglesey, Wales.

The nets snagged eight times as many fish in ocean slicks as in adjacent waters, confirming the slicks' role as an early fish nursery. But inside these slicks, the tiny swimmers were outnumbered by plastic 7-to-1. "We were shocked," Whitney says. "A five-minute tow in what looks like crystal clear water can turn up 10,000 pieces of plastic."

Of fish large enough to be dissected, 8.6 percent had eaten prey-sized microplastics, the researchers found. "The vast majority of larval fish die before reaching adulthood," so the poor diet comes at a time when the fish are already exceedingly vulnerable, Williams says.



A larval triggerfish, collected in an ocean slick off the coast of Hawaii, is shown next to a plastic fragment the fish had ingested. A dime is shown for scale.

Little is known about the consequences of larval fish ingesting plastic. But Jennifer Brandon, a San Diego–based oceanographer at Applied Ocean Sciences, says it can't be good for them. Plastic ingestion by adult fish has been linked to liver toxicity, tumors, malnutrition, behavioral problems and death. Without a fully developed liver that can filter toxins, the effects could be even worse in larval fish, she says.

The study may even have underestimated the abundance of plastics in slicks, Brandon says. "They used a net that may have missed smaller fragments of plastics, so it could be even worse."

Larval fish play a big role in the ocean food web. Seabirds skim them off the water's surface, while larger fish, such as tuna, eat them from below. If larval fish eat plastic, the predators that consume the fish could accumulate potentially harmful levels of plastic themselves, Whitney and colleagues say. People also eat some of those fish when they are fully grown, such as mahimahi, and their predators.

To Whitney, the study underlines how insidious plastics are in the environment. "Finding plastics in these little guys was honestly kind of an emotional hit," he says. "Climate change is a huge punch to ocean fish. Overfishing another punch. And now, at their most vulnerable stages, there's yet another human-induced impact." ■

FROM TOP: DAVID LIITTSCHWAGER; J. WHITNEY/NOAA FISHERIES

EARTH & ENVIRONMENT

Power lines may stress out honeybees

In lab tests, electromagnetic fields affected behavior, learning

BY RACHEL FRITTS

Power lines may mess with honeybees by creating electromagnetic fields that can alter bee behavior and learning ability.

In the lab, honeybees (*Apis mellifera*) were more aggressive toward other bees after exposure to electromagnetic fields, or EMFs, at strengths similar to what bees might experience at ground level under transmission lines, researchers report October 10 in *PLOS ONE*. Exposed bees also were slower to learn to respond to a new threat than unexposed bees were.

"The reductions in learning are pretty concerning," says entomologist Sebastian Shepherd. He worked on the study at the University of Southampton in England before moving to Purdue University in West Lafayette, Ind. "These were bees that were very happy and healthy" before exposure.

The findings may be one clue to help explain recent declines in managed U.S. honeybee colonies. The insects provide an estimated $15 billion in annual agricultural value by pollinating U.S. crops. But beekeepers reported that colonies in 2018–2019 experienced their worst winter die-off in more than a decade. And in preceding years, some colonies' worker bees simply vanished (*SN: 2/3/18, p. 14*).

Researchers think the problem is the result of multiple stressors, including bees getting jostled during cross-country moves to new farms or flying through fields laced with pesticides. Power lines, it turns out, might also be stressing bees out. All together, stressors could be making bees less capable of surviving disease or extreme weather, Shepherd says.

The new study builds on research published by the same group in *Scientific Reports* in 2018 that found that bees were less successful foragers and fed less when they had to fly through EMF levels of 100 microteslas, μT, to get to a food source. That's the maximum EMF level experienced at ground level beneath a power line. The 2018 study also found that EMF levels as low as 20 μT affected some bees' ability to learn.

In the latest study, bees were subjected for 17 hours — the amount of time some bees would spend overnight in a hive — to either 100 μT or 1,000 μT, a typical EMF level within a meter of a transmission line. The bees were then given behavioral and learning tests.

In one test, bees were familiarized with a floral smell and then put through five trials in which they were exposed to the smell for several seconds before experiencing an electric shock. The team measured how many trials it took the bees to learn to defensively extend their stingers in response to the smell instead of the stimulus. "It's basically Pavlov's dogs with bees," Shepherd says.

Exposed honeybees were slower than unexposed bees in learning to associate the smell with the shock. At both EMF levels, only about a third of the exposed bees learned to do it after the five trials, compared with half of the unexposed bees. Exposed bees also were more likely to exhibit aggressive behavior, such as biting or attempting to sting other bees.

Ecologist Kimberly Russell of Rutgers University in New Brunswick, N.J., notes that it's unclear whether the impacts measured in the lab translate to what's going on in the field. She studies wild honeybee abundance within power line corridors and points out that power companies maintain millions of hectares of open fields beneath transmission lines to keep vegetation from interfering with power flow. These corridors provide sunny fields of wildflowers that attract bees, studies have shown. A healthy habitat full of diverse floral food could make up for any ill effects caused by power line EMFs by reducing the bees' overall amount of stress, Russell says.

Shepherd says he plans to go into the field to study whether EMFs are indeed affecting honeybees. ■

ATOM & COSMOS

Galaxy has clues to reionization

Study suggests source of early universe's hydrogen makeover

BY CHRISTOPHER CROCKETT

A leaky galaxy might be offering up clues about a vast cosmic makeover foisted on the universe during its youth.

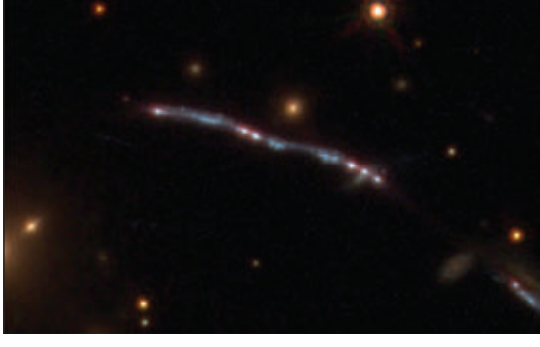
Within about a billion years after the Big Bang, some source of high-energy light stripped nearly all of the hydrogen atoms in the universe of their electrons. This "reionization" puzzles astronomers, who can't account for all of the energy needed to make such a sweeping change (*SN: 3/4/17, p. 10*).

A galaxy dubbed the Sunburst Arc might help. It appears to be blasting ionizing ultraviolet radiation through a small hole (or holes) carved out of the gas that permeates the galaxy, researchers report in the Nov. 8 *Science*. Similar channels in the earliest generation of galaxies could have provided an escape hatch for harsh light to zap intergalactic hydrogen.

While massive youthful stars can produce ionizing radiation, the light has trouble navigating the thickets of gas and dust within the host galaxy. "Not all of it can get outside the galaxy, let alone reionize the intergalactic medium," says Brant Robertson, an astronomer at the University of California, Santa Cruz who was not involved with the research. And

Visible and infrared light shine from a single star-forming region in the Sunburst Arc galaxy (center). The spot of light is duplicated six times in the arc in this image, thanks to the gravity of a separate galaxy cluster (not shown).

T.E. RIVERA-THORSEN, HUBBLE SPACE TELESCOPE



yet, get out it must, given what happened to the cosmic inventory of hydrogen.

Directly looking for ionizing radiation from the first galaxies is out of the question. Intervening gas clouds absorb that faint light before it reaches Earth. Instead, astronomers look for closer analogs, says Joanna Bridge, an astronomer at the University of Louisville in Kentucky who was not part of the study. "We look for galaxies that are similar ... and gain an understanding of the physical processes that might have occurred."

Meet the Sunburst Arc, a galaxy in the constellation Apus whose light takes nearly 11 billion years to reach Earth — far, but not quite as far as the galaxies around at reionization. The Sunburst Arc hides behind a closer cluster of galaxies. That cluster's gravity amplifies the Sunburst Arc's light into an arc — hence the nickname — creating 12 distorted images of the galaxy smeared across the sky.

In 2017, astronomer Thøger Emil Rivera-Thorsen of Stockholm University and colleagues noticed that a particular wavelength of ultraviolet light from the galaxy appeared to sneak out through small gaps in its hydrogen gas, like water through a sieve. This light is not energetic enough to ionize hydrogen. But through those gaps, the team hypothesized, more-energetic ionizing light might slip out too.

To test that idea, the team pointed the Hubble Space Telescope at the Sunburst Arc. In all 12 of the gravitationally distorted images, the researchers saw UV light capable of ionizing hydrogen blasting out of a small region within the galaxy. The light's source coincides with a splotch of bright light seen in previous Hubble images, light that the team suspects radiates from a pocket of intense star formation no more than about 520 light-years across. The ionizing radiation from these young stars may use one or a few holes in the surrounding gas to escape into intergalactic space.

Whether this is a piece in the reionization puzzle is unclear. Of hundreds of thousands of galaxies the team looked at, no other galaxy appears to behave this way. Whether pathways in gas were more common in earlier galaxies is unknown. ■

ATOM & COSMOS

Trapped atoms can measure gravity

Tabletop technique could help map terrain or study dark matter

BY MARIA TEMMING

By watching how atoms behave when they're suspended in midair, rather than in free fall, physicists have come up with a new way to measure Earth's gravity.

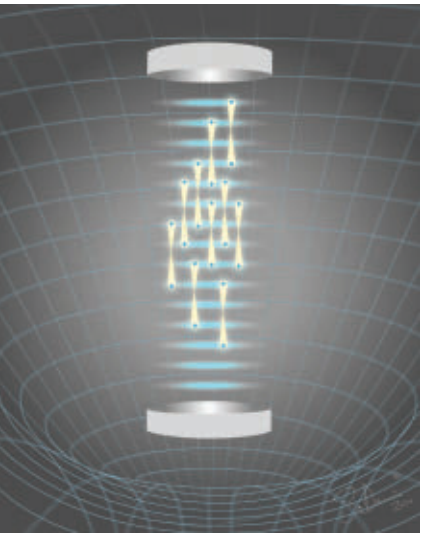
Traditionally, scientists have measured gravity's influence on atoms by tracking how fast atoms tumble down tall chutes. Such experiments help test Einstein's theory of gravity and precisely measure fundamental constants (*SN: 4/28/18 & 5/12/18, p. 24*). But the meterslong tubes used in these experiments can be unwieldy and difficult to shield from environmental interference such as stray magnetic fields. With a new tabletop setup, physicists can gauge the strength of Earth's gravity by monitoring atoms suspended a couple millimeters or so in the air by laser light.

This design, described in the Nov. 8 *Science*, could better probe the gravitational forces exerted by small objects. The technique also could be used to measure slight gravitational variations at different places in the world, which may help in mapping the seafloor or finding oil and minerals underground.

Physicist Victoria Xu and colleagues at the University of California, Berkeley began by launching a cloud of cesium atoms into the air and using flashes of light to split each atom into a superposition of states. In this weird quantum limbo, each atom exists in two places at once: one version of the atom hovering a few micrometers higher than the other. Xu's team then trapped these split cesium atoms in midair with light from a laser.

Measuring the strength of gravity with atoms that are held in place, rather than being tugged downward by a gravitational field, requires tapping into the atoms' wave-particle duality. That quantum effect means that, much as light waves can act like particles, atoms can act like waves. And for each cesium atom caught in superposition, the higher version of the atom wave undulates a little faster than its lower counterpart, due to the atoms' slightly different positions in Earth's gravitational field. By tracking how fast the waviness of the two versions of an atom gets out of sync, physicists can calculate the strength of gravity at that spot.

Physicist Kai Bongs of the University of Birmingham in England imagines using the new technique to investigate the nature of dark matter or test a fundamental facet of Einstein's theory of gravity called the equivalence principle (*SN: 5/27/17, p. 8*). Many unified theories of physics proposed to reconcile quantum mechanics and Einstein's theory of gravity — which are incompatible — violate the equivalence principle in some way, Bongs says. So looking for violations might lead to a unified theory that bridges the divide between quantum mechanics and relativity. "That's one of the Holy Grails in physics," he says. ■



A device gauges gravity by measuring differences between atoms split into superposition, in which one version of the atom is slightly higher than the other (blue dots in yellow bands). Laser light (blue bands) traps the atoms in midair.

SARAH DAVIS

HUMANS & SOCIETY

How the church shaped Western ways

Early Catholic marriage bans may have sparked individualism

BY SUJATA GUPTA

During the Middle Ages, decrees from the early Roman Catholic Church triggered a massive transformation in family structure. That shift explains, at least in part, why Western societies today tend to be more individualistic, nonconformist and trusting of strangers compared with other societies, a new study suggests.

The roots of that Western mind-set go back roughly 1,500 years to when a branch of Christianity that later evolved into the Catholic Church swept across Europe and beyond, report human evolutionary biologist Joseph Henrich and colleagues in the Nov. 8 *Science*.

Leaders of that branch became obsessed with what they saw as incest, the researchers say, and launched a "marriage and family program" that eventually banned marriages between even distant cousins, step-relatives and in-laws. Church policies also encouraged marriage by choice, instead of arranged marriages, and small, nuclear households, with couples living separately from extended family members.

Using historical, anthropological and psychological data, Henrich and colleagues argue that the church's policies helped unravel the tight, cohesive kin networks that had existed. In places under church influence, a Western mind-set has come to dominate, the team says.

"Human psychology and human brains are shaped by the institutions that we experience and the most fundamental of human institutions are our kinships [and] the organization of our families," says Henrich, of Harvard University. "One particular strand of Christianity ... got obsessed with this and altered the direction of European history."

But David Huffman, a behavioral economist at the University of Pittsburgh, urges caution in interpreting the results. "I'm pretty convinced that they're finding these correlations," he says. "I'm just not fully convinced about the causal story from kinship ties to all these other [psychological] variables."

A church ban on marriage between cousins in the Middle Ages transformed Western society, scientists argue. Shown here is Henry V, king of England, marrying Catherine of France in 1420.

Across the globe, much variation exists among different societies' beliefs and behaviors. But in general, individuals in European countries and in other countries of British descent tend to be more individualistic and independent and less conforming and obedient. These societies are often described today as Western, educated, industrialized, rich and democratic, or WEIRD for short.

To understand how that Western mind-set might have emerged, Henrich's team mapped the worldwide spread of the branch of Christianity known as the Western Church when the marriage program reached its height, in the years before 1500. The team then zoomed in on the spread of bishoprics, or church administrative centers, across 440 regions in 36 European countries from 550 to 1500. That spread was mapped alongside exposure to the Eastern Church, which evolved into the Orthodox Church and did not adopt such strong incest taboos.

Next, the researchers assessed how varying levels of exposure to the church and its family policies influenced the strength of community- and family-based institutions. For a qualitative approach, the authors used an existing anthropological and historical database of 1,291 populations observed before industrialization. By honing in on elements of family structure, such as marriages between cousins, habitation patterns and presence or absence of polygamy, the team showed that "kinship" — close ties with an extended clan beyond just immediate family — decreased in areas exposed to the Western Church.

Looking at the rates of marriage between cousins, the team found that for each 500 years a country spent under the influence of the Western Church, this type of marriage dropped by 91 percent.

Lastly, the scientists evaluated that transformation in family structure alongside changes in beliefs and behaviors. Drawing on existing data sources on 24 psychological metrics, such as individualism, creativity, conformity, honesty and trust, the researchers found that the longer a population was exposed to the Western Church, the higher its individualism, nonconformity and trust of strangers.

This interplay between history, family structure and psychology has modern consequences, the authors say. In Italy, for example, the church's influence was limited to the northern and central portions of the country until well into the Middle Ages. Data based on Vatican records show that, consequently, marriages between first cousins were almost nonexistent in the north, but accounted for up to 5 percent of all unions in the south from 1910 to 1964.

What's more, the country's average blood donation rate, which the authors use as a proxy for trust of strangers, equaled about 28 bags of blood for every 1,000 people, according to data from 1995. But the team found that a doubling of the rate of first cousin marriages in a given region was linked to a decline in blood donations by about eight bags per 1,000 people, suggesting more distrust of strangers. Similarly, Italians from areas with higher rates of cousin marriages were more likely than other Italians to distrust banking institutions, preferring instead to take loans from family and friends and keep money in cash. ■

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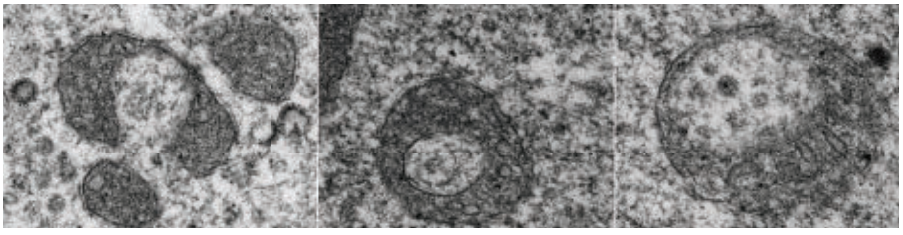
GENES & CELLS

Mitochondria may play a role in ALS

In mice, self-eating organelles preceded nerve damage



Scientists say they think mitochondrial self-destruction occurs when the cellular power plants bend into a U shape (left, one shown in an electron microscopy image) and the ends fuse to form a ring (center). The organelles then dismantle themselves from the inside out (right).

BY TINA HESMAN SAEY

A newfound type of mitochondrial self-destruction may make some brain cells vulnerable to Lou Gehrig's disease.

In mice genetically engineered to develop forms of a degenerative nerve disease similar to amyotrophic lateral sclerosis, or ALS, energy-generating organelles called mitochondria appear to dismantle themselves without help from the usual cell demolition crews.

This self-destruction was spotted in upper motor neurons, brain nerve cells that help initiate and control movements, but not in neighboring cells, researchers report November 7 in *Frontiers in Cellular Neuroscience*. Death of upper motor neurons is a hallmark of ALS. The self-destructing mitochondria may be an early step that sets those cells up to die later.

Pembe Hande Özdinler, a neuroscientist at Northwestern University Feinberg School of Medicine in Chicago, and her colleagues say the destruction, which they call "mitoautophagy," is a distinct process from mitophagy, the usual way that cellular structures remove damaged mitochondria from a cell. Clearing out damaged mitochondria is important for cell health. When mitochondria sustain too much damage, they may trigger the death of the entire cell.

Özdinler's team spotted unusual mitochondria in electron microscope images of upper motor neurons from 15-day-old mice. These mice are the age equivalent of teenage humans, Özdinler says. ALS typically doesn't strike until people are 40 to 70 years old. But by the time symptoms appear, motor neurons are already harmed, so the scientists looked at young mice to capture early signs of disease.

The researchers propose that self-destructing mitochondria progress through several phases of degeneration. First, a mitochondrion stretches out. "Some of them are extremely long, like we have never seen before," Özdinler says. Then, it bends into a U shape. The tips of the U meet and fuse the organelle into a ring. The inner part of the ring disintegrates, followed by the outer part.

"It's self-eating itself," Özdinler says. Such mitochondria may somehow make

BODY & BRAIN

Missing olfactory bulbs baffle scientists

Women apparently lacking the brain structures can still smell

BY SOFIE BATES

Some women may be able to smell even without key structures that relay odor information from the nose to the brain.

Brain scans revealed two women who appear to lack olfactory bulbs, the only parts of the brain known to receive signals about smell sensations from the nose and to send them to other parts of the brain for processing. Both individuals performed similarly to other women with olfactory bulbs on several tests to identify and differentiate odors, scientists report online November 6 in *Neuron*. The findings challenge conventional views of the olfactory system.

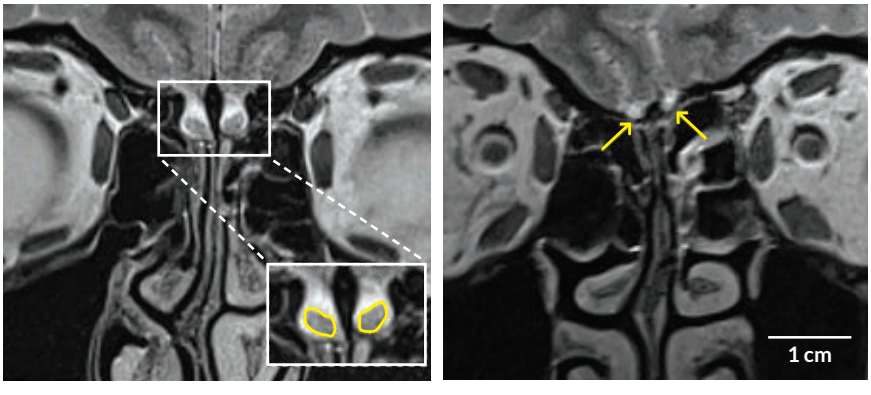
"I'm not sure that our textbook view of how the [olfactory] system works is right," says study coauthor Noam Sobel, a neuroscientist at the Weizmann Institute of Science in Rehovot, Israel.

MRI scans showed that where most people have two olfactory bulbs, these women appear to have cerebrospinal fluid. To the researchers, this implied the women don't have olfactory bulbs.

But neuroscientist Jay Gottfried of the University of Pennsylvania says, "I am not convinced that the women are indeed missing their bulbs." The bulbs may be undetectable with MRI, but there might be microscopic evidence, he says.

A typical olfactory bulb has about 5,500 nerve clusters called glomeruli. With the

A person's brain typically has two olfactory bulbs (left, outlined in yellow in the inset of the MRI image). Two women who appear to be missing the structures but can still smell have only fluid in that area (right, arrows indicate the area of the apparently missing bulbs in one woman).



FROM TOP: MUKESH GAUTAM; T. WEISS *ET AL*/*NEURON* 2019

upper motor neurons more vulnerable to ALS later in life, the researchers speculate.

Other researchers who study mitochondria aren't yet convinced that Özdinler's team has discovered a new type of mitochondrial death. Evandro Fang, a molecular gerontologist at the University of Oslo, says the study's static, 2-D microscope images may give a false impression of what's going on. Watching what happens to single mitochondria over time and examining the organelles in 3-D would provide a fuller picture, he says. And Özdinler's group didn't explain the molecular mechanism that would cause mitochondria to dissolve, he says.

Mitochondria contain some enzymes that can break down proteins, but cell biologist Wen-Xing Ding of the University of Kansas Medical Center in Kansas City doesn't think those enzymes could digest the entire organelle without help from other cellular machinery. Still, something odd may be going on. Ding says that he believes the team has found "a novel way to get rid of mitochondria ... but we don't have clear evidence at the moment." ■

MRI resolution used, the team calculated that it would be able to see olfactory bulbs with at least about 10 glomeruli. But it's possible the women could have even smaller olfactory bulbs, Sobel says.

The women performed about average on two sniff tests — detecting strong or faint smells and identifying 40 scratch-and-sniff odors — compared with women with olfactory bulbs from unrelated experiments. Sobel and colleagues had the two women and 140 others with olfactory bulbs rate the similarity of how roses, peanuts, motor oil and other scents smell. Results suggest that lacking bulbs didn't prevent the women from smelling the world like others do, though it did influence their sense of smell.

The brain is adaptable, so the two women's brains could have compensated for a lack of bulbs early in development. Or the findings could imply that the current understanding of how people smell is wrong, Sobel says. ■

LIFE & EVOLUTION

Tree-living ape was made for walking

Ancient European species had upright gait before hominids did

BY BRUCE BOWER

Tree-dwelling apes in Europe strode upright about 5 million years before members of the human evolutionary family hit the ground walking in Africa.

That's the implication of fossils from a previously unknown ape that lived in what's now Germany about 11.6 million years ago, say paleontologist Madelaine Böhme of the University of Tübingen in Germany and colleagues. But the relation, if any, of these finds to the evolution of a two-legged stride in hominids is hazy.

Excavations produced 37 fossils from the ape, named *Danuvius guggenmosi*. Bones from the most complete of four individuals represented by the finds cover about 15 percent of the skeleton, including nearly complete bones from the forearm and lower leg, Böhme's team reports online November 6 in *Nature*.

Danuvius' limbs, spine and body proportions indicate the ape could hang from branches, like orangutans and gibbons, and walk slowly on two legs, somewhat like hominids that arose in Africa some 7 million to 6 million years ago, the researchers say. The last common ancestor of great apes and hominids was probably built like *Danuvius*, Böhme contends.

If true, *Danuvius*' body design would upend the long-standing idea that hominids evolved an upright stance after splitting from a knuckle-walking, chimp-like ancestor.

A *Danuvius* link to hominids would fit with evidence that a 4.4-million-year-old hominid called *Ardipithecus ramidus* combined an upright gait with adept tree climbing. But *A. ramidus* weighed about three times as much as *Danuvius*, which ranged from an estimated 17 to 31 kilograms. Based on available fossils, the smaller, older *Danuvius* had less efficient walking and better climbing skills than *A. ramidus*, says paleoanthropologist Scott Williams of New York University, who was not involved in the study.

If further finds confirm that *Danuvius* and perhaps other ancient tree-dwelling apes stood upright, "it would show that our lineage never did go through a hunched-over stage of walking because we were always upright," says paleoanthropologist Jeremy DeSilva of Dartmouth College, who was not part of Böhme's team. It's possible, though, that *Danuvius* independently evolved a form of upright walking that had nothing to do with a two-legged gait in hominids, DeSilva says. ■

A partial skeleton of an 11.6-million-year-old European ape consists of 21 bones, including one from the lower leg (far right) and another from the forearm (second from right).

CHRISTOPH JÄCKLE

ATOM & COSMOS

Corona may catch heat from solar jets

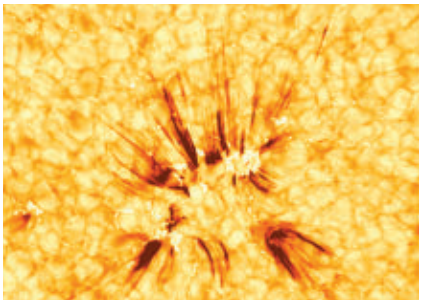
Spicules could explain why the sun's outer atmosphere sizzles

BY CHRISTOPHER CROCKETT

Tendrils of plasma near the sun's surface emerge from realignments of magnetic fields and may pump heat into the corona, the sun's outer atmosphere.

That observation, described in the Nov. 15 *Science*, could help crack the mysteries of how these plasma whiskers, called spicules, form and what role — if any — they play in heating the corona to millions of degrees Celsius.

Spicules undulate like a wind-whipped field of wheat in the chromosphere, the layer of hot gas atop the sun's surface. The filaments stretch for thousands of kilometers and last for just minutes, shuttling ionized gas to the corona. Scientists have long debated how spicules form — with the sun's turbulent magnetic field a prime suspect — and whether spicules can help explain why the corona is a few hundred times as hot as the sun's surface.



Whiskery plasma jets on the sun known as spicules appear as dark, threadlike structures in this Goode Solar Telescope image.

To look for links between spicules and magnetic activity, solar physicist Tanmoy Samanta of Peking University in Beijing and colleagues turned to the Goode Solar Telescope in California. They snapped images of spicules forming, while also measuring the surrounding magnetic field. Thickets of spicules frequently emerged within minutes after pockets of the local magnetic field reversed course to point in the opposite direction from the area's prevailing field.

Opposing magnetic fields create a tension that resolves when the fields break and realign. The team postulates that the energy released in this "magnetic reconnection" creates spicules. "The magnetic field energy is converted to kinetic and thermal energy," says team member Hui Tian, a Peking University solar physicist. "The kinetic energy is in the form of fast plasma motion — jets, or spicules."

The team then pored through images acquired at the same time by NASA's orbiting Solar Dynamics Observatory. Those data revealed a glow from charged iron atoms directly over the spicules. That glow, Tian says, means the plasma reached about 1 million degrees Celsius. Whether that's enough to sustain the scorching temperature throughout the corona, however, remains to be seen.

Solar physicist Juan Martínez-Sykora of the Lockheed Martin Solar and Astrophysics Laboratory in Palo Alto, Calif., calls the observations "amazing," but says the magnetic reconnection story needs to be checked with computer simulations or more observations. ■

NEWS IN BRIEF

BODY & BRAIN

Human liver-on-a chip catches drug reactions other testing can't

A lab-grown liver stand-in may better predict bad responses to drugs than testing in lab animals does.

A human "liver chip" — liver cells grown on a membrane along with supporting cells — formed structures reminiscent of bile ducts and reacted to drugs like intact livers do, researchers report in the Nov. 6 *Science Translational Medicine*.

The chip is designed to detect bad drug reactions that animal tests might miss. For instance, bosentan, a high blood pressure drug, doesn't harm rat livers, but it can cause bile salts to build up in human livers, damaging the organ. The chip mimicked those effects, researchers at Boston-based Emulate Inc., which makes the chip, and their colleagues found.

Some drugs that were toxic to dogs and rats might not harm people, the liver chip tests suggest. Development of one experimental compound called JNJ-2 was discontinued because it caused liver scarring in rats. But the human liver chip didn't show any bad reactions, suggesting the compound might be safe for people. — *Tina Hesman Saey*

BODY & BRAIN

New dengue vaccine passes test

A dengue vaccine reduced the occurrence of the mosquito-borne disease by about 80 percent in vaccinated versus unvaccinated children, researchers report.

The vaccine, under development by Takeda Vaccines, is called TAK-003. Among 12,700 children in Asia and Latin America ages 4 to 16 who were given two doses three months apart, 61 infections occurred. That's compared with 149 cases among 6,316 children not given the vaccine, scientists report online November 6 in the *New England Journal of Medicine*.

Creating a dengue vaccine is difficult because there are four different dengue viruses. A person infected by one type develops antibodies to that version, but those antibodies can make an infection with a different dengue virus severe (*SN Online: 11/8/17*). If a vaccine doesn't produce a strong immune response to all four viruses, it could mean a later infection not only isn't protected against, but also is made worse. That's what happened with the first widely used vaccine candidate, developed by Sanofi Pasteur.

Takeda tested whether kids in its study had been exposed to dengue before vaccination. Initial results didn't find a large difference: The vaccine reduced disease occurrence by close to 75 percent in those not previously infected with dengue and by about 82 percent in those who had been. The extent of the vaccine's protection won't be clear until long-term results are available. — *Aimee Cunningham*

T. SAMANTA, GST, SDO

STOLEN FROM THE U.S. MINT!

The Secret of the U.S. Dollar Valued at $250 Explained

In 2009, the United States Mint made history (but not in the way they wanted) when they released the nation's first Native American Golden Dollar, featuring Sacagawea on the obverse and one-year-only Native American reverse designs.

Over the course of several years, a corrupt U.S. officer stole and smuggled out an entire hoard's worth of coins, each taken before a crucial step in the minting process could be completed—the addition of edge lettering.

Why Steal Unfinished Coins?

In the coin world, rarity means value. Not only were the stolen coins highly coveted first-year issues but, more importantly, their missing edge lettering made them "error coins," increasing their scarcity even more. The thief knew this would drive their value up even further.

Edge Lettering


Missing Edge Lettering

Just how rare are these coins? Only 1,118 of the 39,000,000 coins struck as part of the 2009 Golden Dollar mintage are error dollars that bear the grade, designation and signature of the coin we're offering today. That's ***less than 0.0029% of the entire 2009 Golden Dollar mintage***!

Officially Authenticated Error Dollars

Not only are these 2009 Golden Dollar error coins now legal to own, but they've also been professionally authenticated as error coins by Professional Coin Grading Service (PCGS) and certified as being in collector-grade Mint State-66 (MS66) condition. In addition, each coin comes sealed in a protective holder bearing the autograph of Edmund C. Moy, the former Director of the U.S. Mint who held the office when the coins were stolen.

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SCIENTISTS UNDER FIRE

Human rights take a back seat when governments attempt to control the narrative

By Sujata Gupta

On a sunny day in March 2016, Turkish forensic physician Şebnem Korur Fincanci drove into Cizre, a town in southeastern Turkey. The government had just lifted a 79-day curfew meant to help the Turkish military rout out members of the separatist PKK, or Kurdistan Workers' Party. Turkey has long fought to keep insurgents from creating a separate Kurdish country, and has designated the PKK as a terrorist organization.

Like most people outside of Cizre, Fincanci had no idea what had transpired during the lockdown. She arrived to a devastated city.

The air, she says, smelled of burnt flesh. Houses were riddled with bullet holes, the furniture inside burned or bashed with sledgehammers. Residents led her to three bombed-out buildings. Fincanci entered one and saw within the basement rubble a jawbone and a pair of eyeglasses. She could immediately tell that the jawbone was a child's.

Fincanci had not brought her forensic tools. She had assumed that this visit was preliminary, a time to talk with Cizre residents about their medical needs. So, she snapped pictures of the bone, the glasses and the surrounding debris with her cell phone. Residents later confirmed that the building had been home to a young family.

A few days later, Fincanci wrote a report and posted it on the website of the Human Rights Foundation of Turkey, a volunteer organization she helped found in 1990. She also sent the report to Turkey's internal affairs office. Fincanci wrote that the military had committed atrocities against innocent

After a 79-day curfew was lifted in Cizre, Turkey, in March 2016, forensic physician Şebnem Korur Fincanci found demolished buildings (left) and walls filled with bullet holes (center). In one residential building's basement, she found a burnt jaw (right) from a child thought to have died there.

ALL: Ş. FINCANCI

civilians. She demanded a full investigation. Instead, in June 2016, the government charged her with spreading terrorist propaganda. "I was arrested and sent to prison," Fincanci says.

Weak regimes

Across the ages, scientists have come under fire for all manner of offense, often tied to the work they do. Chinese astronomers Hi and Ho were executed over 4,000 years ago, according to lore, for failing to predict a solar eclipse. In 1633, the Roman Catholic Church convicted astronomer Galileo Galilei of heresy for stating that the Earth revolves around the sun — a concept antithetical to the church doctrine that put the Earth at the center of the universe. He spent the remaining nine years of his life under house arrest.

In the United States, during the Red Scare of the 1940s and 1950s, government officials monitored and interrogated academics seen as Communist sympathizers. Princeton University physicist J. Robert Oppenheimer, a leader of the Manhattan Project, was accused of being a national security risk and lost his security clearance.

In the aftermath of World War II, on December 10, 1948, the United Nations adopted the Universal Declaration of Human Rights so that atrocities of the Holocaust would never be replayed. The document stated that every person everywhere has the right to life and liberty, freedom from slavery and torture, the right to work and education, and the freedom of opinion and expression.

The declaration provided a blueprint for how people around the world ought to be treated, yet human rights abuses, against scientists and others, have continued.

The Cold War's end in 1991 led to a shift from clearly totalitarian regimes where citizens had few personal and political freedoms to countries that appear democratic but exhibit varying levels of authoritarian control, says Andrew Anderson, executive director of Front Line Defenders, a human rights organization based in Dublin.

The blurred line between authoritarianism and democracy in Turkey under President Recep Tayyip Erdoğan is a case in point, Anderson says. Scientists almost anywhere can find themselves under fire as even staunch democracies, including Greece and the United States, struggle to balance state interests and academic freedoms. Some scientists are attacked for sharing their research and others stumble into dangerous situations while doing their jobs, such as doctors accused of providing medical care to protesters or rebels. Others feel compelled to use their standing as public figures to resist and expose wrongdoing.

Quantifying the number of scientists whose human rights are under threat is challenging, but a November 19 report from Scholars at Risk, a nonprofit organization that helps persecuted academics, provides some context. From September 1, 2018, to August 31, 2019, the organization documented 324 attacks on students and academics, including scientists, from 56 countries, says Scholars at Risk advocacy director Clare Robinson. The report also points to countries with increasing restrictions on academics, including India, China, Sudan, Brazil and for the fourth year in a row, Turkey, where thousands of academics have been charged with disloyalty, treason and terrorism.

Forensic physician Şebnem Korur Fincanci faces 2.5 years in prison for calling for an end to violence in Turkey.

ANDREW TOTH/GETTY IMAGES FOR PHYSICIANS FOR HUMAN RIGHTS

> "Thanks to international solidarity and support, they couldn't hold us for a long time. They had to release us."
>
> **ŞEBNEM KORUR FINCANCI**

Scientists, professional organizations and human rights groups have been mounting international campaigns to help persecuted colleagues. Numerous groups agitated on Fincanci's behalf, circulating petitions, sending letters and holding demonstrations. But even when advocacy helps free scientists from detention, the accused can find their professional and personal lives upended. Some must live in exile, cut off from their support systems and their work. Others wind up unemployed.

After 10 days in jail, Fincanci and two detained journalists were released to await trial. "Thanks to international solidarity and support, they couldn't hold us for a long time," she says. "They had to release us." The propaganda charges were dropped in July. Fincanci now faces 2.5 years in prison for signing a petition along with more than 1,000 scholars to demand an end to the fighting between Turkish forces and the PKK.

Persecuted for doing a job

In April 2016, disaster medicine researcher Ahmadreza Djalali was in Tehran to help develop a training program for Iranian hospitals on emergency responses to disasters. The invitation, from the University of Tehran and Shiraz

University, was not unusual. Djalali, an Iranian-born scientist living in Sweden and affiliated with research centers in Sweden, Belgium and Italy, visited research centers and universities in Iran a few times a year. But this time, officials from the country's Ministry of Intelligence detained Djalali and placed him in Tehran's Evin Prison, where political opponents of the Iranian government are often held. In October 2017, under charges that he was a spy for Israel, Djalali was sentenced to death.

Djalali was targeted for refusing to help with Iran's espionage efforts, says his wife, Vida Mehrannia. Iran's Ministry of Intelligence contacted Djalali twice, she says. In 2012, officials asked him to work for Iranian military and intelligence centers, and in 2014, they asked him to cooperate with Iran's intelligence service to spy on European counterterrorism operations. Djalali, she says, refused both requests.

Mehrannia says Djalali was tortured and placed in solitary confinement in the early part of his detainment. Under duress, he signed multiple false confessions, which were later used in his conviction. His lawyer was forbidden from attending the proceedings, and the judge did not review any of Djalali's documents.

Mehrannia, who is in Sweden with the couple's two children, says her husband's health is failing. He has lost 20 kilograms, and blood tests indicate that he may have leukemia. Numerous organizations and scientists have come out in support of Djalali, including through a 2018 letter signed by 124 Nobel laureates sent to Iran's supreme leader, Ayatollah Ali Khamenei.

"He [is] just a researcher," Mehrannia says of her husband. "He is innocent and didn't do anything against his country."

> "He [is] just a researcher. He is innocent and didn't do anything against his country."
>
> **VIDA MEHRANNIA, WIFE OF AHMADREZA DJALALI**

Ahmadreza Djalali went to Tehran to teach disaster preparedness and was sentenced to death as a spy.

While Djalali's case is extreme, scientists can face peril when their work appears to contradict or impede government efforts. As president of Greece's independent statistics office, ELSTAT, from 2010 to 2015, economist and statistician Andreas Georgiou confirmed that the country had been underreporting the size of its deficit to avoid economic sanctions by the European Union. In particular, he determined that the 2009 deficit was 15.4 percent of GDP, not 13.6 percent as previously reported.

Although EU officials have repeatedly validated Georgiou's numbers, in January 2013, he was charged with making false statements about the 2009 government deficit — a felony in Greece that carries a possible life sentence. While he was ultimately cleared of that charge in March 2019, other charges are ongoing. "They're using statistics as a political weapon," says Georgiou, now a lecturer in statistical ethics at Amherst College in Massachusetts.

The list goes on. In August, Ricardo Galvão was fired as director of Brazil's National Institute for Space Research. Brazil's President Jair Bolsonaro, who had begun to open more Amazon rainforest to mining and other commercial activities, disagreed with an institute report showing that deforestation from April to June 2019 was almost 25 percent higher than during the same period the year before. And on November 7, the *New York Times* reported that Russian security forces, masked and carrying automatic weapons, raided the country's prestigious Lebedev Physical Institute in Moscow and interrogated the director for six hours about a purported plot to export glass with military applications. The institute's governing council derided the raid, saying in a statement that such actions "are impossible to imagine in a civilized country in which law enforcement agencies concern themselves with real, not invented, problems."

Medical personnel face risks just by providing medical care to people who are seen as hostile to a governing party. During the ongoing crisis in Syria, the government and its Russian allies have launched 583 attacks on medical facilities, with 912 medical professionals killed, between March 2011 and August 2019, according to the New York City–based advocacy group Physicians for Human Rights. Those numbers do not account for medical staff who sustained injuries but survived or fled the country, says Susannah Sirkin, the organization's director of policy.

In Sudan last December, when protestors demonstrated against the government of then-President Omar al-Bashir, the military responded with force against both the protestors and those rushing to their aid. Physicians for Human Rights reported in April that it found support for allegations that police and security forces intentionally attacked at least seven Sudanese medical facilities. The group's independent assessment of postmortem records supports claims that police shot physician Babiker Abdul Hamid in the chest in January as he tried to explain that doctors were simply treating the injured. "He said he was a doctor, and he was shot point blank," reported one eyewitness. Sudan has claimed that he was shot by "infiltrators."

How a government treats people who offer medical care can serve as a litmus test for academic freedom, Sirkin says. "It's never a crime for a doctor to treat a sick person."

Scrutiny of Chinese scientists

Sharing findings with colleagues around the world is central to science. For years, U.S. funding agencies and research universities have encouraged collaboration between Chinese and

COURTESY OF V. MEHRANNIA

U.S. scientists, says Xiaoxing Xi, a physicist at Temple University in Philadelphia. But collaborating has become riskier.

Xi, who earned his doctorate in China before emigrating to the United States in 1989, has traveled frequently to China and worked with partners at Peking University, Tsinghua University and Shanghai Jiaotong University. His research involves fabricating pure materials for studying their intrinsic properties. Those materials eventually could wind up in devices such as cell phones. "I do fundamental research," Xi says. "I do not do research which is classified or restricted."

In May 2015, Xi was named chair of Temple's physics department. Two days later, FBI agents burst into his home, pulling Xi, his wife and two daughters from their bedrooms at gunpoint. Xi describes it as a scene out of a movie.

Xi says FBI agents interrogated him for two hours. The agents thought he had shared sensitive information with China, particularly about a device called a pocket heater. Xi quickly realized that the agents had gotten the science wrong. The information he had shared was not sensitive; it was about a different device, not a pocket heater. But clearing his name took months, by which point his reputation was in tatters.

On the same day that Xi was arrested, the Committee of 100, a nonprofit organization based in New York City that supports Chinese Americans in U.S. society, held a news conference to discuss a similar case. Sherry Chen, a hydrologist at the National Weather Service, had been arrested in October 2014 on espionage charges related to allegedly sharing information about the nation's dams with China. Her case was dropped one week before trial. In December 2014, charges against two Chinese biologists working at Eli Lilly and Company in Indiana were dismissed.

"So you have ... four individuals accused of very serious crimes and yet all have their cases dropped. That's just very unusual," says Jeremy Wu, a retired U.S. Census Bureau statistician who is on the Committee of 100 board.

To find out what was going on, Wu contacted Andrew Chongseh Kim, a lawyer at Greenberg Traurig LLP in Houston with some statistics expertise. Kim looked at a random sample of 136 cases involving 187 individuals charged under the Economic Espionage Act between 1997 and 2015. Kim recognized that focusing on that one act would not cover all the cases — Xi was charged under a separate statute, for instance — but it was the most straightforward means of quantifying the problem.

Charges against people with Chinese names grew from 17 percent of more than 100 defendants from 1997 to 2008, an 11-year span, to 52 percent of the 80 or so who were charged over the next six years, Kim reported December 2018 in *Cardozo Law Review*. Concerns about economic espionage have been growing in recent years and seem to be centered on Chinese Americans suspected of sharing trade secrets with businesses in China, Kim says.

Some espionage cases against Chinese-American scientists are legitimate. Boeing engineer Dongfan "Greg" Chung was sentenced to 15 years in prison in 2010 for stealing trade secrets for China regarding the U.S. space shuttle program. And Walter Lian-Heen Liew was sentenced to 15 years in 2014 for selling trade secrets to state-owned Chinese companies about a white pigment created by DuPont.

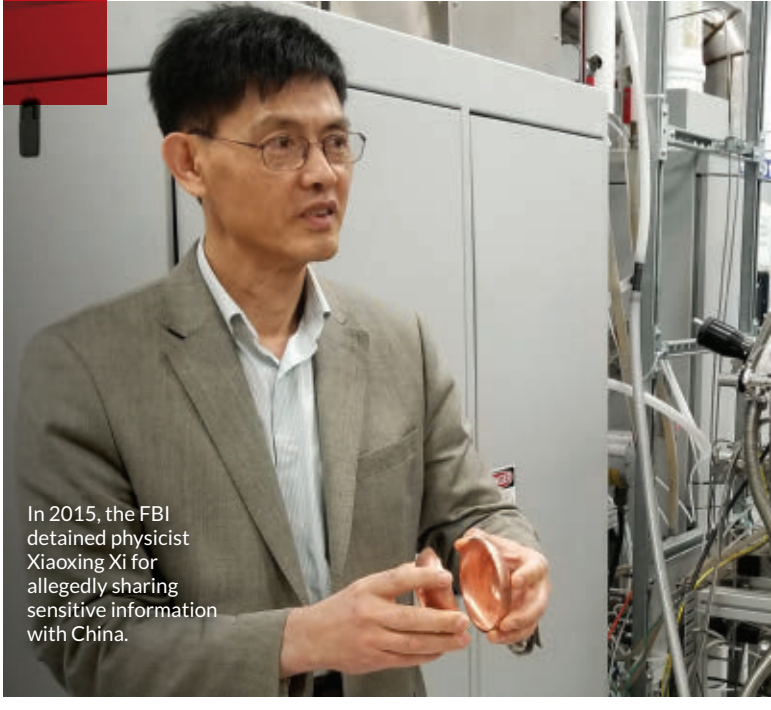
In Xi's case, the charges were dropped in September 2015, and he returned to work. But his professional career has not recovered. He never did get to serve as chair of his department, his federal grants and contracts have dwindled from nine before his arrest to two today and his lab has shrunk from 15 members to three. Xi says his family remains in a state of perpetual vigilance. "We have to be sure that everything we say cannot be twisted by the government to charge us," he says.

Rising up in Turkey

While some scientists unwittingly stumble into bad situations, others act as whistle-blowers. A decade ago, hope was mounting that Turkey could emerge as a democratic stronghold in the troubled Middle East. And Erdoğan, who served as prime minister for over a decade before he became president in 2014, appeared moderate. As president, though, Erdoğan has turned toward authoritarianism.

Turkey's academics have been pushing back. In January 2016, 1,128 Turkish scholars, including Fincanci, signed the

> "We have to be sure that everything we say cannot be twisted by the government to charge us."
>
> **XIAOXING XI**



In 2015, the FBI detained physicist Xiaoxing Xi for allegedly sharing sensitive information with China.

COURTESY OF X. XI

Peace Petition. Accusing Erdoğan's government of the "deliberate massacre and deportation" of civilians, the petitioners demanded an end to the fighting. Turkey responded by suing over 800 signatories and pressuring universities to retaliate against those employees. Almost 500 scholars lost their jobs.

Fincanci was forced to retire from her job at Istanbul University and is appealing the 2.5-year prison sentence she received for signing the document. "I have been banned from public service," she says.

Food engineer Bülent Şik was already caught up in the country's criminal justice system when he signed the petition and subsequently lost his job. In 2011, Turkey's Ministry of Health sought to find out why cancer rates were so high in the country's northwestern industrial cities. Şik, who served as a team leader for one of the 16 resulting projects, was tasked with looking for contaminants in water and produce in four industrial provinces. His home city of Antalya, where industries are rare, served as a control. Şik 's team studied 1,440 locations encompassing about 7 million people, including 1.3 million children.

Food engineer Bülent Şik found dangerously high contaminant levels in produce and drinking water in parts of Turkey. He faces up to 15 months in prison for publishing the findings.

> "I felt that this was my scientific responsibility to explain those results and share [them] with the public."
>
> **BÜLENT ŞIK**

Between 2013 and 2015, the team found that in 52 locations, people's drinking water was dangerously high in lead, aluminum and arsenic, which have been linked to cancer. Almost a fifth of the food sampled contained pesticides above the legal limit. Şik's team identified 66 types of pesticide residues, 26 of which are known to disrupt the endocrine systems of infants and children.

The cumulative effect of ingesting those pesticides throughout childhood could be catastrophic, says Şik, speaking through a translator. "I felt that this was my scientific responsibility to explain those results and share [them] with the public."

In 2015, representatives from all 16 projects and the health ministry pledged to make the findings public. But the Ministry of Health never released the information. So, in April 2018, Şik published a four-part series about his findings in the national newspaper *Cumhuriyet*. Government officials sued Şik for distributing confidential information. At one of several trials, he defiantly spent an hour and a half describing his findings.

"It is our freedom to say whatever we want during our defense. I used this freedom to explain the rest of the findings," Şik says. At his latest hearing on September 26, he was sentenced to 15 months in prison, a decision he is appealing.

While the Universal Declaration of Human Rights lays out the fundamental rights of all people, it lacks enforcement teeth. More people need to come to the aid of persecuted scientists, Anderson says. "If we want to secure democracy and human rights, we need to mobilize. We need to support the people that are willing to stick their necks out."

More than four decades ago, the U.S. National Academies of Sciences, Engineering and Medicine established an advocacy arm for scientists experiencing persecution worldwide. The National Academies' Committee on Human Rights works behind the scenes to research allegations of persecution against scientists and to advocate on their behalf.

Other organizations have also been lending their support. In 2018, six professional statistical societies commended Georgiou for his work in Greece, noting his "upholding of the highest professional standards in his public service in the pursuit of integrity of statistical systems." That same year, more than 40 organizations signed a petition calling for Greek officials to halt proceedings against Georgiou.

In October, the American Physical Society awarded Xi a 2020 Andrei Sakharov Prize for his "articulate and steadfast advocacy in support of the U.S. scientific community and open scientific exchange, and especially his efforts to clarify the nature of international scientific collaboration in cases involving allegations of scientific espionage." And in September, members of 60 scientific societies wrote a letter calling on the U.S. government to find "the appropriate balance between our nation's security and an open, collaborative scientific environment."

In Turkey, where most universities are state-run, sustained international pressure has yielded limited success, says Robinson, of Scholars at Risk. "A lot of academics are now being acquitted in Turkey but then they're being reassigned to [remote] universities or regions where they will be forgotten." ■

Explore more

- Scholars at Risk Network. "Free to Think 2019." Posted November 19, 2019. bit.ly/freetothink2019

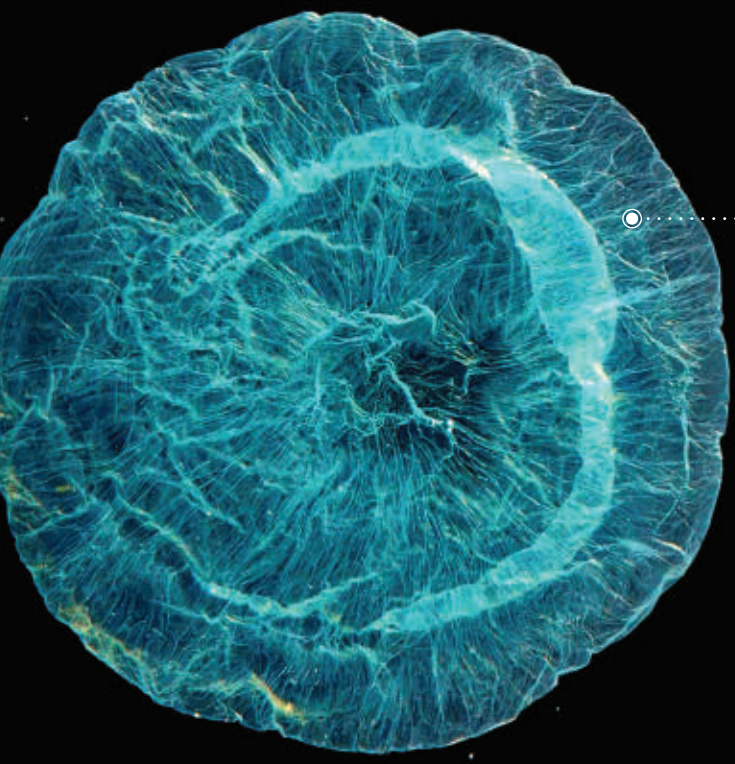
Editor's note: Nobel laureate Martin Chalfie of Columbia University is chair of the National Academies' Committee on Human Rights. He is also a member of the Board of Trustees of Society for Science & the Public, which publishes Science News.

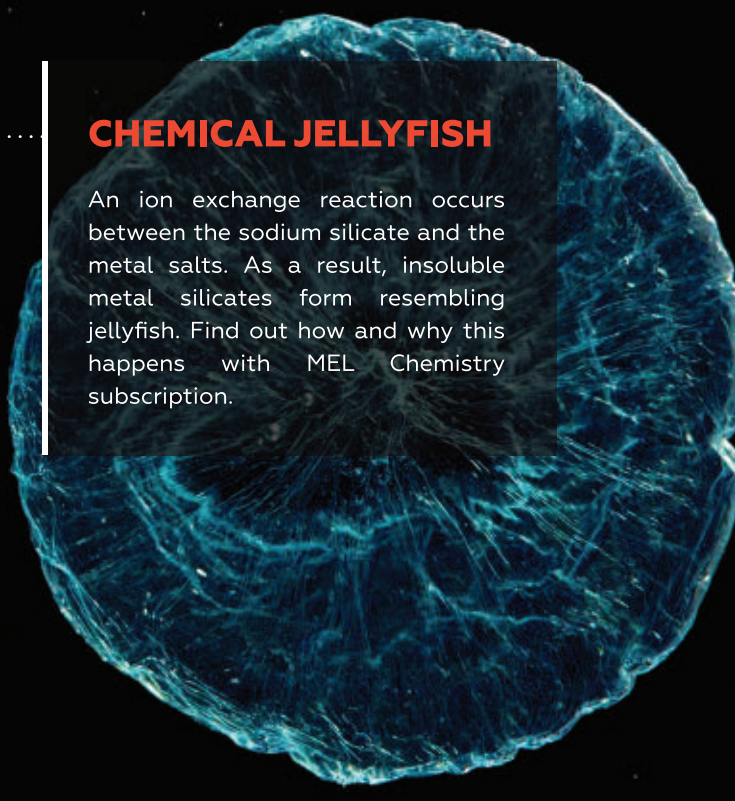
BARIŞ ILGAZ ŞIK

MEL Science

AGES 10+

VR-POWERED NEXT GENERATION CHEMISTRY SET





CHEMICAL JELLYFISH

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Hormonal birth control pills give women control over their lives. But whether the pill has any effect on teenage brains is not settled.

TEEN BRAINS ON BIRTH CONTROL

Studies that link the pill with depression raise questions

By Laura Sanders

"Does the pill cause depression?" the news headline asked. Prompted by a recent study that described a link between taking birth control pills as a teenager and depression in adulthood, the news got some doctors hopping mad.

Early research hints that there are reasons to look more closely at hormonal birth control's side effects. But so far, the link is less than certain. "This is a premature connection," says pediatrician Cora Breuner of Seattle Children's Hospital.

Putting too much stock in preliminary evidence may lead to fewer teenagers getting birth control and, in turn, more unwanted pregnancies among teens — a situation that can upend young lives, Breuner says. Headlines that frighten teens, their families and doctors are "yet another barrier in place for accessing a completely effective way to prevent unplanned pregnancies."

Ob-gyn and contraception researcher Katharine O'Connell White agrees. "Birth control gets all of the worry and concern," says White, of Boston University School of Medicine. "But we know that other things are much more dangerous." Teen pregnancy, for instance. Access to effective birth control is vital for sexually active teenagers, the doctors say.

"I don't think the evidence is there right now to say that this is a threat," adds epidemiologist and public health researcher Sarah McKetta of Columbia University, who has studied birth control use in teens. Still, she sees value in more research on the issue. "Women deserve good medication ... that's not giving them problems." If there are risks that come with the pill, then scientists ought to get a handle on them.

Easier said than done. Existing studies can't quite answer the question at hand, so their results can be interpreted in different ways. Getting an answer is important. In the United States, 42 percent of teenage girls — 4 million in total — have had sexual intercourse, estimates suggest. And an estimated 56 percent of sexually active girls ages 15 to 19 have taken hormonal birth control pills. In the search for clarity, research may illuminate scientific mysteries, including how biology and personal experience combine to shape a teenage girl's brain in ways that scientists don't yet understand.

The link

The advent of hormonal contraceptive pills was revolutionary. Starting in the 1960s, women began controlling their fertility — and their lives — in ways that were previously impossible. The daily dose of hormones, cleverly engineered to dupe the body into thinking it's already pregnant so that a real pregnancy won't happen, is so iconic that even today, it's the one medicine known simply as "the pill."

And it prevents pregnancy remarkably well. With the exception of rare risks, such as blood clots, the pill doesn't seem to cause much trouble for most people. Its uses have expanded beyond its primary job of suppressing ovulation. About a third of teen pill prescriptions are for noncontraceptive reasons: to ease painful or irregular periods, endometriosis, acne and other conditions.

But every so often, a study crops up that raises a potential red flag. That happened this summer with a report that women who had taken the pill as teenagers were more likely to develop depression as adults. The study, published online August 28 in the *Journal of Child Psychology and Psychiatry*, asked 1,236 U.S. women, ages 20 to 39, to remember when they began taking hormonal birth control pills. Researchers also asked about the participants' current depressive symptoms.

CRANKYT/ISTOCK/GETTY IMAGES PLUS

A potentially worrisome trend emerged: Use of the pill in the teenage years was linked to higher rates of depression later. At the time of the study, 16 percent of the women who had taken hormonal birth control as teenagers met the criteria for clinical depression. Only 9 percent of women who began taking the pill as adults met the same criteria for depression. For women who never had used birth control, the number was 6 percent.

Those differences among the groups were "really quite substantial," says study coauthor Christine Anderl, a psychologist at the University of British Columbia in Vancouver. "There might be a long-lasting relationship between birth control use and depression later on," she says.

Take note of that "might." Anderl is careful and up-front about the study's limitations. The results turned up a correlation, not a causal relationship, she emphasizes. The researchers used a statistical approach to make the comparison groups more similar, evening out the differences in education, for instance, that might affect depression rates. That method, called propensity weight scoring, "isn't perfect — nothing in statistics can make the comparison between groups crystal clear — but it's a skillful way of dealing with the problem," says Regina Nuzzo, a statistician at Gallaudet University in Washington, D.C.

Anderl and colleagues used the method to control for other explanations for depression, including smoking, age of first sexual behavior, education, body mass index and so on. But it's possible that another factor, unknown or just not considered in this study, could be to blame. "We tried to control for everything else that we thought would be an alternative explanation for the link, but that doesn't mean we didn't unintentionally miss [something]," Anderl says.

Other limitations further cloud these results (as well as the results of many other studies that assess people's behaviors and health). The women were asked to remember when they started taking the pill — and memories can be hazy. What's more, the authors didn't have information about what kinds of hormonal pills the women used, how consistently they used the pills or for how long — all crucial information, Breuner says.

Hormonal birth control pills come in two main types: the older type, which contains a mixture of estrogen and progestin (a synthetic form of progesterone), and the "mini pills," which contain only progestin in small amounts. To understand what these pills might do to the developing brain, the type and amount of hormones matter, Breuner says. These caveats, along with others, make her skeptical that there is a true association between birth control pills and depression later in life, she says. "I'm not ready to stop prescribing."

Two other studies have linked oral contraceptives with depression during the teen years, as opposed to later in life. A study published online October 2 in *JAMA Psychiatry* found a link between the pill and depressive symptoms in 16-year-olds in the Netherlands. Girls on the pill reported crying more, sleeping more and having more eating problems than girls not taking oral contraceptives.

The second study, of over 1 million Danish teenagers and women, found that teenagers ages 15 to 19 taking birth control pills were more likely to also have prescriptions for antidepressants at the same time. The effect was strongest for teens taking progestin-only pills. That study's size gave it a "powerful enough lens to spot even a small effect," Nuzzo says. It was published in 2016 in *JAMA Psychiatry*.

Now consider a dissenting report. McKetta and Columbia epidemiologist Katherine Keyes studied 4,765 U.S. adolescents and found no evidence that birth control pills influence depression, neither at the time of taking the pill or afterward.

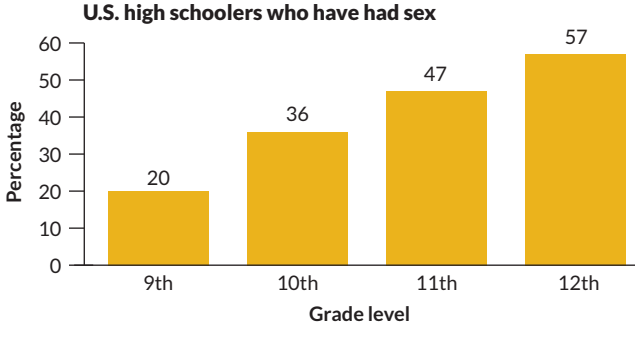
That study, published in January in *Annals of Epidemiology*, looked at teenagers' current or prior use of birth control pills, and used interviews to gather information about depression. "Any way we looked at it, we found no effect," McKetta says.

Like every other study on people, this one comes with limitations. As with Anderl's study, researchers asked teenagers to think back and remember information, which isn't foolproof. Parents were also interviewed about their children's depression, and wishful thinking might have tempted them to fudge answers, particularly to sensitive questions. Those caveats could have hidden an effect, Nuzzo says.

Malleable brains

As a whole, these studies — all imperfect, all beset by their own limitations — offer little clarity on whether and how these birth control hormones are changing the brains of teenagers.

Action More than half of U.S. teens, boys and girls, have had sexual intercourse by their last year in high school, a situation that highlights the need for access to reliable birth control. SOURCE: GUTTMACHER INST.



C. CHANG

Thinking back
In one study, women who recalled taking the pill as teens reported more depression as adults, but caveats make this study worthy of follow-up rather than changes in practice.

16
percent
Of women who had taken the pill as teens were clinically depressed

9
percent
Of women who had taken the pill as adults were clinically depressed

6
percent
Of women who had never taken the pill were clinically depressed

SOURCE: C. ANDERL, G. LI AND F.S. CHEN/*J. CHILD PSYCHOLOGY AND PSYCHIATRY* 2019

Yet, the idea is plausible. The teen years are important for brain development. Hormones such as testosterone, estrogen and progesterone during adolescence can change the brain's development. "It is a fact," says Cheryl Sisk, a neuroscientist at Michigan State University in East Lansing.

Her certainty comes from a large collection of research on lab animals, and a slimmer set of human brain studies. In experiments on lab animals, scientists can exquisitely control the timing and levels of hormones and then see what happens to the brain as the animals grow. Female mice, for instance, with ovaries removed before the mice reach adolescence, had differences in learning abilities during adulthood.

Human studies hint that estrogen affects adolescent girls' brains, too. A genetic disorder called Turner syndrome can leave girls with very low levels of estrogen. Girls with the disorder have differences in the volume of certain brain regions, small studies show. (Testosterone during adolescence can also sculpt boys' brains.)

It's possible that hormones delivered in the pill would affect the brain differently than hormones delivered from a teenager's own ovaries. The timing or the type of hormones would be off, and that mismatch could affect a girl's brain development, Sisk says.

Derived from cholesterol, hormones like progesterone and estradiol, one of the body's naturally occurring estrogens, can slip past the blood-brain barrier. "You can almost think about the brain as being bathed in testosterone and estradiol and progesterone," says neuroscientist Russell Romeo of Barnard College in New York City. These hormones "can get there, and they can affect these cells very intimately," he says. The hormones can change the behavior of large collections of genes, many of which shape how the brain operates.

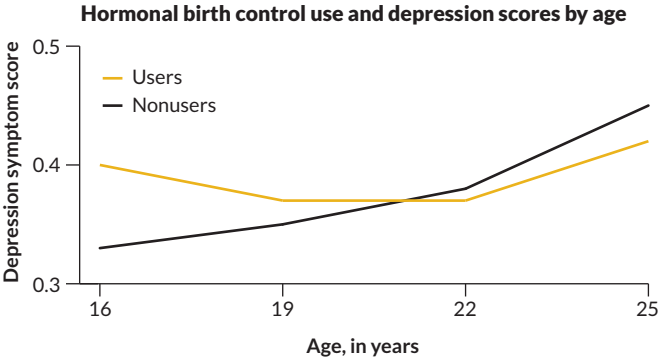
But some brain regions are more susceptible than others to the effects of hormones. The hippocampus, the amygdala and select stretches of the prefrontal cortex are still developing during puberty, and all have been linked to depression. Those regions are loaded with molecules that sense estrogen and progesterone, and respond by kicking off a host of cellular changes when the hormones reach the brain.

Next steps

Set against this backdrop of research mainly in lab animals, the idea that hormones during adolescence could change the brain, particularly in a way that could influence depression, makes sense. But just because something makes sense doesn't mean it's true.

To really answer the question well, what's needed are large head-to-head comparisons of teenage girls randomly assigned to take either hormonal birth control or a placebo, and then monitored for depression years later. But that study will never happen. Research ethics would prevent teenagers who need birth control pills from being given a sugar pill substitute.

Clues might come from other places. McKetta mentions Colorado, where changes to public health policies since 2009 have made birth control options widely available — "any kind you want, wherever, whenever," she says. In areas near the Colorado clinics that provide birth control, teen birth rates are down 20 percent, according to recent data from the nonprofit National Bureau of Economic Research. The girls who take advantage of access to the pill may be a valuable source of long-term mental health data. "We may be able to completely put this to bed, or we'll find longer-term differences," McKetta says.



Sensitive age In a large study of young women, oral birth control use was linked to more signs of depression in 16-year-olds than in their peers who didn't take the pill. The relationship was not evident at ages 19, 22 and 25. SOURCE: A.E. DE WIT *ET AL/JAMA PSYCHIATRY* 2019

Meanwhile, Anderl and her colleagues have begun enrolling young teen girls for a study that will span three to five years. The researchers will measure the girls' hormone levels, monitor their birth control use, assess their emotional health and look for signs of depression. This forward-looking study gets around some of the problems that dogged earlier reports. For one thing, objectively measuring symptoms as they unfold over time means that researchers won't have to rely on participants' memories.

"Access to birth control is a universal human right," says Anderl, who doesn't want her results to be used to limit access to birth control by politicians, doctors, parents or even young women themselves. The data are too preliminary to be used to make the case against the pill's use by teenagers, she says.

For a sexually active teen, the hypothetical risk of depression is dwarfed by the known and potentially severe risks of pregnancy, says White, of Boston University. The comparison of risks here is everything: The alternative to reliable contraception is pregnancy, she says. "When you're looking at media coverage, that is not a point that gets made very often."

A teenager having unprotected sex has an 85 percent chance of getting pregnant within a year, a condition that comes with many known risks, including depression. "Pregnancy is so much more dangerous than birth control, across the board, full stop, for everyone," White says. ■

Explore more

■ American Academy of Pediatrics. "Contraception for adolescents." *Pediatrics*. October 2014. bit.ly/AAPcontraception

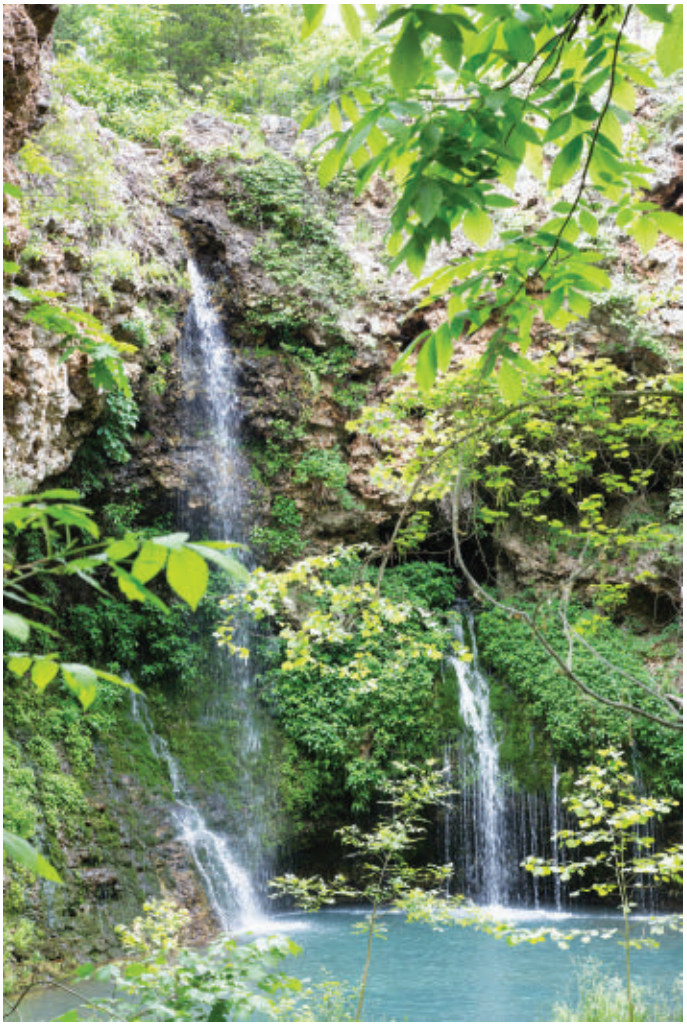
C. CHANG

GEOLOGIC ROAD TRIP OF THE MONTH

KARST AQUIFER AT NATURAL FALLS STATE PARK

Natural Falls State Park, just south of US 412 about 6 miles west of the Oklahoma–Arkansas state line, features an 80-foot waterfall along Dripping Springs Branch, a tributary of the Illinois River. At the falls, a large number of springs and seeps flow into a deep plunge pool. These springs are perhaps the most spectacular of the numerous springs throughout this part of the Ozark Plateau.

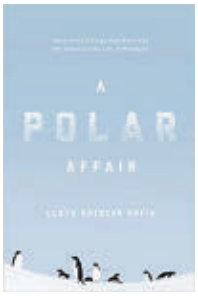
The springs issue from the Springfield Plateau Aquifer, part of the larger Ozark Plateau Aquifer, a karst aquifer in which groundwater flows through extensive dissolution features. The Springfield Plateau Aquifer is the youngest bedrock aquifer in the Ozarks and includes the Keokuk Limestone, Reeds Spring Formation, and the Saint Joe Group, although most of the springs are found along bedding planes in the Reeds Spring. The abundant limestone in the formations easily dissolves, forming caves and sinkholes that, in turn, result in springs and disappearing streams, all common characteristics of karst aquifers.



Springs and seeps emanate from the aquifer in the Keokuk Limestone–Reeds Spring Formation at Natural Falls State Park. —Photograph courtesy of Lori Duckworth, Oklahoma Tourism and Recreation Department

Precipitation, about 42 inches per year here, percolates through the relatively thin soil and quickly reaches fresh limestone bedrock. Because the limestone is fractured and jointed and the water slightly acidic, over time vertical pathways for the water are gradually enlarged. Slight differences in the permeability of the different beds also cause the water to flow laterally, gradually opening up horizontal paths that eventually become caves. Some of the more permeable beds form along unconformities. For example, a Mississippian-age karst system, which may have formed when a Mississippian formation was exposed at the surface and eroding, was utilized and enhanced in more recent times by groundwater. Springs and seeps emerge when these horizontal flow paths encounter the ground surface in stream valleys.

Because the flow paths for the water are well-connected and can be large, the groundwater flow rate is high and the residence time of the water in the aquifer is short. With 25 percent of the precipitation reaching the aquifer, it is quickly and efficiently recharged, resulting in high spring flow rates during the seasonal spring recharge seasons. One problem with this kind of aquifer is that surface pollutants can quickly contaminate the groundwater, but this is partly alleviated by the relatively rapid flushing of the system.



A Polar Affair
Lloyd Spencer Davis
PEGASUS BOOKS, $29.95

BOOKSHELF

The sex lives of penguins shocked early explorer

On March 29, 1912, British explorer Robert Falcon Scott wrote the final diary entry of his ill-fated quest to reach the South Pole. That same day, more than 350 kilometers away, naval surgeon and zoologist George Murray Levick was hunkered down within a snowbank at Cape Adare, observing Adélie penguins.

Levick had accompanied Scott to Antarctica, but was not one of the five expedition members on the final trek to the pole. The return journey claimed the lives of all five. Levick survived the expedition, however, and in 1914, published a manuscript summarizing his observations — the first scientific descriptions of Antarctic penguins.

But he left something out.

During his months observing Adélie penguins, which included an entire breeding cycle, Levick witnessed the birds engaging in same-sex mating rituals. He also saw the birds engage in a variety of other sexual behaviors that in humans we might call promiscuity, infidelity, even prostitution. Levick recorded these scandalous details in a second manuscript, "The sexual habits of the Adélie penguin," in 1915. But the manuscript was stamped "Not for Publication" and remained unpublished for nearly a century.

In 2012, the manuscript resurfaced in a scientific journal. Penguin biologist and author Lloyd Spencer Davis, who had thought he was the first to record same-sex behavior in Antarctic penguins in 1996, was dismayed and intrigued. So Davis embarked on a personal quest to understand how and why Levick's observations had been buried in the first place — seemingly by his own wishes.

The result of that quest is Davis' book *A Polar Affair*, an entertaining, chatty and sometimes salacious romp through polar exploration history, penguin biology and Victorian mores.

Each of the book's five sections opens with a brief essay — Homosexuality, Divorce, Infidelity, Rape, Prostitution — that highlights how tempting it can be, whether in Victorian or modern times, to view penguin sexual behaviors through an anthropomorphic lens.

But the driving force of *A Polar Affair* isn't really to understand these sexual behaviors, Davis writes. Instead, what he really wants to understand is "why Murray Levick would discover the dirty side of penguins and then try to cover it up."

Davis delves into Levick's personal history, hunting down his field notes and retracing his long, frostbitten months studying Cape Adare's penguin colony.

Davis' investigations are interspersed with a sweeping history of polar exploration that is by turns fascinating and frustrating. He also includes stories from his own penguin studies. The narrative meanders through the exploits of a wide-ranging cast of explorers who have since lent their names to bits of Antarctica's geography, from James Clark Ross to Fabian Gottlieb von Bellingshausen.

The social and mating behaviors of Antarctica's Adélie penguins have intrigued researchers for more than a century.

Early expeditions led to key innovations to manage challenges such as the bitter cold and ever-present nutrient deprivation. And many of those innovations, we learn, came to bear in the 1911–1912 race to the South Pole between Robert Falcon Scott and Norwegian Roald Amundsen. (Amundsen got there first, beating Scott by about one month.) This rich and often intimate history can be riveting stuff. But much of it is also well-trodden ground, and at times, I found myself flipping ahead, wanting to get back to Levick and his penguins.

Other digressions, though, particularly Davis' discussions of whether there are evolutionary benefits to penguins' same-sex mating or nonmonogamous behaviors, are fascinating. Is same-sex mating a case of mistaken identity, in that male and female penguins are monomorphic, looking much alike? Is promiscuity among penguins related to the female's inclination to build a stronger nest, one that is shored up by stones earned through offering sex?

These are questions with which Davis and other penguin biologists still wrestle. And *A Polar Affair* doesn't come to a tidy answer for why Levick suppressed his most startling findings. But the book's unique approach to polar exploration history makes for an engaging read. And by the end, Davis does come to terms with his need to understand his predecessor and with his own dismay at being scooped a century ago. The journey in discovery, he suggests, was satisfying.

"It doesn't really matter who was the first to see a bit of male-on-male action in penguins," he writes, "any more than it probably matters who was first to stand on an arbitrary piece of ice and drive a flagpole into it."

— *Carolyn Gramling*

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CONVERSATIONS WITH MAYA

FENG ZHANG
CORE INSTITUTE MEMBER AT THE BROAD INSTITUTE AND PROFESSOR AT MIT

Maya Ajmera, President & CEO of Society for Science & the Public and Publisher of *Science News*, chatted with Feng Zhang, a Core Institute Member of the Broad Institute, a Professor at MIT and a Howard Hughes Medical Institute Investigator. He is best known for his central role in developing CRISPR-mediated molecular technologies. Zhang is an alumnus of the 2000 Science Talent Search (STS) and the 1998 and 1999 International Science and Engineering Fair (ISEF), both competitions of the Society. He is also a member of the Society's Board of Trustees. We are thrilled to share an edited summary of the conversation.

You are an alumnus of STS and ISEF. How did these competitions impact your life?

Both ISEF and STS were very important experiences for me as I was going through high school. I grew up in Iowa, and even though I had a few friends in high school who shared my interest in science, it wasn't like everybody shared my interests. Participating in ISEF opened up my view of the world, helping me to realize that there are a lot more people interested in science and technology. Meeting students from around the world, making new friends and instantly connecting with them gave me more confidence about pursuing science.

Participating in science fairs also gave me exposure to a larger breadth of science. It gave me an amazing glimpse of scientific areas that I wasn't previously aware of, which reinforced my interest in science.

So you found your people, as they say?

Yes. A lot of the students I met through STS and ISEF became really good friends. By the time I started college at Harvard University, I already knew more than 50 other students who were going to be there because of my experience in these programs. And that was very special.

Let's jump forward. You're one of the pioneers of CRISPR gene-editing technology. Can you describe that journey?

One of the really exciting advances in biology over the past decade or two has been the completion of the human genome. As scientists started to understand more about how each part of the genome contributes to human health, the idea of being able to treat disease by going into our DNA and fixing it has become more and more tantalizing and urgent.

I was first exposed to genetics in high school when I was lucky enough to work in a gene therapy lab. Back then it was more rudimentary gene therapy, simply using viruses to deliver a gene that would kill cancer cells.

Later, I was excited to develop ways to modify DNA in our genome and started by working on systems that were new at the time, like zinc finger nucleases. Then I began to learn about the real challenges facing gene editing: our inability to correct different genes. When I first learned about CRISPR at a seminar, I got excited because I realized that it was something that could be customized to target a new gene.

So that's how I got started. Since then it's been really exciting to develop gene editing into a technology and see all the ways that scientists have creatively applied it, from understanding disease and biology to using it in agriculture to improve crops to turning it into a therapeutic. We're continuing to develop the technology so that we can make people's lives better and make the world a more sustainable place.

You and other researchers have called for a moratorium on human germline editing, which would create genetic changes

CHRIS AYERS PHOTOGRAPHY

that would be passed down to future generations. What are your concerns?

CRISPR is a very broadly applicable technology. You can use it in animal cells, human cells and plant cells to make changes to DNA and the potential for correcting DNA in somatic cells has really captured scientists' imagination. These are cells in our body that don't give rise to germ cells, meaning that people who receive gene-editing treatments in their somatic cells will not pass those changes on to their children.

The ethically challenging aspect has been the application of gene editing to germ cells, which are cells that give rise to eggs or sperm, or to directly modify newly fertilized embryos to change the DNA in the embryo. Those kinds of changes will lead to transmission of genetic changes to subsequent generations, which could have very large consequences for society.

CRISPR gene editing is still a new technology, and there are open questions about the efficacy or the specificity of the various CRISPR-based tools that are currently available. So technically there are a lot of challenges that prevent me from feeling comfortable using the technology in a human germ line.

Scientifically and morally there are challenges too. Scientifically, because the genome is so complicated, when you make one change it can directly impact other processes in the cell. That complexity makes it challenging to feel comfortable about the results being predictable when it occurs in the context of the developing embryo. And then ethically it is also very challenging because DNA changes could be passed on to future generations. This could have consequences on society or the human race as a whole, one of which could be exacerbated inequality.

I think because of all three challenges — technically, scientifically and ethically — it really is important to have a strong moratorium against the use of human germline editing until society forms a consensus regarding how and whether to move forward with the technology. Consensus doesn't mean that every single person has to agree, but it does mean that society as a whole will have to have had a thorough and productive discussion around this topic.

You have an important role in academia, but you're also an entrepreneur with multiple business ventures. Why do you think it is important to be a part of both worlds?

My parents instilled in me this idea that it's important to do something useful for the world, and that's the motivation that I bring to the things that I work on. Academic science is great for taking on high-risk projects and using outside-the-box approaches. So, within an academic setting, we can really explore new ways to solve a given problem.

But academic labs are not optimized for developing real-world products that can be directly used to benefit patients' lives. That stage is much more suited for industry. It's very expensive to hire experts, run clinical trials and set up large manufacturing processes, and there are more financial resources that are available in industry. Being able to take laboratory research and then expand that into an industrial-scale R&D process is really important for turning laboratory discoveries into useful solutions.

Feng Zhang, Viviana Risca and Jayce Getz (shown here) were the top three winners of the Science Talent Search 2000 competition.

What advice do you have for young people just starting college?

When I was finishing high school and getting ready to go to college, one of my high school teachers gave me a piece of advice that I want to pass on. He said, "When you get to college, figure out who the best teachers are. It doesn't matter what the teacher teaches. Go and take a class with him or her, and you will open up your mind to thinking about many more interesting problems." I took that advice to heart, and it was really the best advice that I could have received. When you encounter a good teacher who can share their passion and excitement for a given area, they can infect you with the same passion.

And what about people who are starting their professional careers? Any advice around that?

As one starts on a professional career, I think it is equally important to find good mentors; someone you can learn from and who will take an interest in helping you develop your own abilities. It also means that you have to be willing to be mentored and keep an open mind.

What books are you reading right now? And what books inspired you when you were young?

This week, I'm reading *Blink* by Malcolm Gladwell. When I was young, I read a lot of science fiction, but I think the one that probably was most inspiring for me was actually *Jurassic Park*. That really got me excited about the potential of molecular biology.

There are so many challenges in the world today. What keeps you up at night?

I think one of the biggest challenges that we face today is climate change, and I think there are a lot of things that we should be and need to be doing to mitigate the potential negative consequences of climate change. That is something that I hope more and more people will start to realize and act on. CRISPR is actually one of the tools that I think can help a bit, particularly in agriculture and the global food supply. Scientists are working on creating more drought-resistant crops, as well as crops that need less water or require fewer pesticides. This could both create a more resilient food supply as our climate changes, while reducing some of the pressure that modern agriculture places on our environment. ◆

OCTOBER 12, 2019 & OCTOBER 26, 2019

Scientist Q&A

In late October, *Science News* earth and climate writer **Carolyn Gramling** hosted a live webinar with marine ecologist Malin Pinsky (below), one of this year's SN 10: Scientists to Watch (*SN: 10/12/19 & 10/26/19, p. 36*). They discussed how climate change is affecting marine life and what society can do about it — and answered viewers' questions. Watch a recording at bit.ly/SN_OceanofChanges

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Pushing limits

Stanford physicist Monika Schleier-Smith's atom experiments could be a boon to quantum computing and possibly offer insights into black holes, ***Elizabeth Quill*** *reported in "Atom master drives quantum chatter" (*SN: 10/12/19 & 10/26/19, p. 37*).*

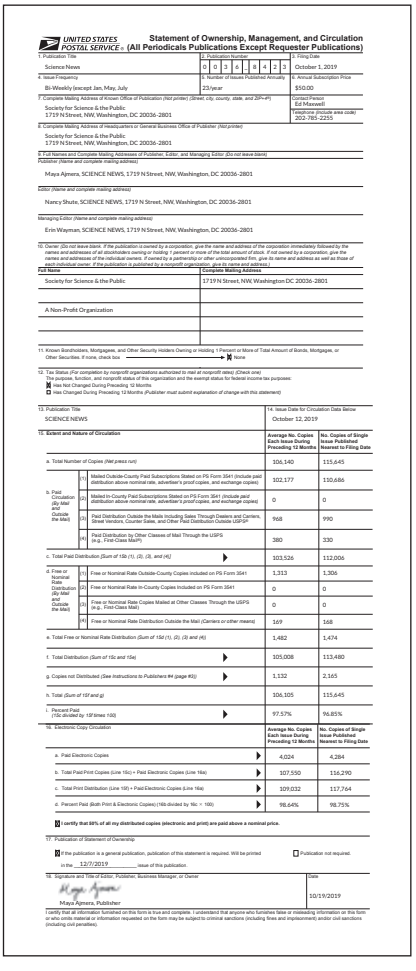
Reader **Ray Bryan** asked if these experiments could shed light on how to unite quantum mechanics and gravity.

The answer right now is "maybe," **Quill** says. "Some theoretical physicists are excited about Schleier-Smith's quantum systems because of the parallels between the behavior of these systems and the behavior of black holes," **Quill** says. Black holes are a great place to probe the limits of general relativity, Einstein's theory of gravity. "Studying parallels between black holes and quantum systems, as well as any emergent phenomena from Schleier-Smith's systems, might lead to new insights or new directions to explore. But what those insights or directions might be is still hazy," **Quill** says.

Schleier-Smith told **Quill** that she is not the right person to directly tackle the problem of uniting general relativity with quantum mechanics. "For now at least, she is more interested in whether existing theories make any predictions that could be useful for controlling qubits for quantum metrology or quantum computation," **Quill** says. "If the benefits go both ways, all the better."

Clarification

"Predicting premature birth" explored efforts to use systems immunology to find indicators of early labor in a pregnant woman's blood (*SN: 11/9/19, p. 14*). For the line graph labeled "Signs of inflammation appear with early delivery," the x-axis could have been labeled more clearly as "Gestational age at amniocentesis." The graph shows that among women with a short cervix, those who delivered their baby at or before 32 weeks were more likely to have higher levels of a cytokine called macrophage inflammatory protein-1 beta, or MIP-1B, in their amniotic fluid than did women who delivered after 32 weeks.



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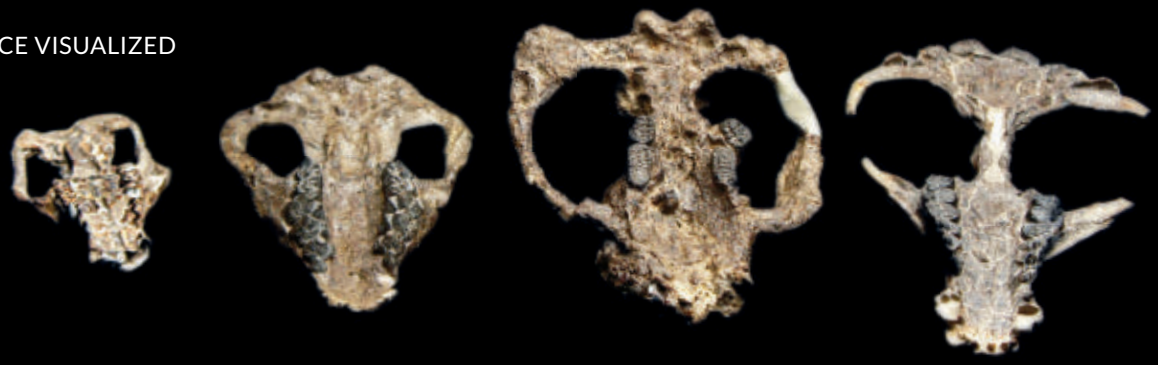

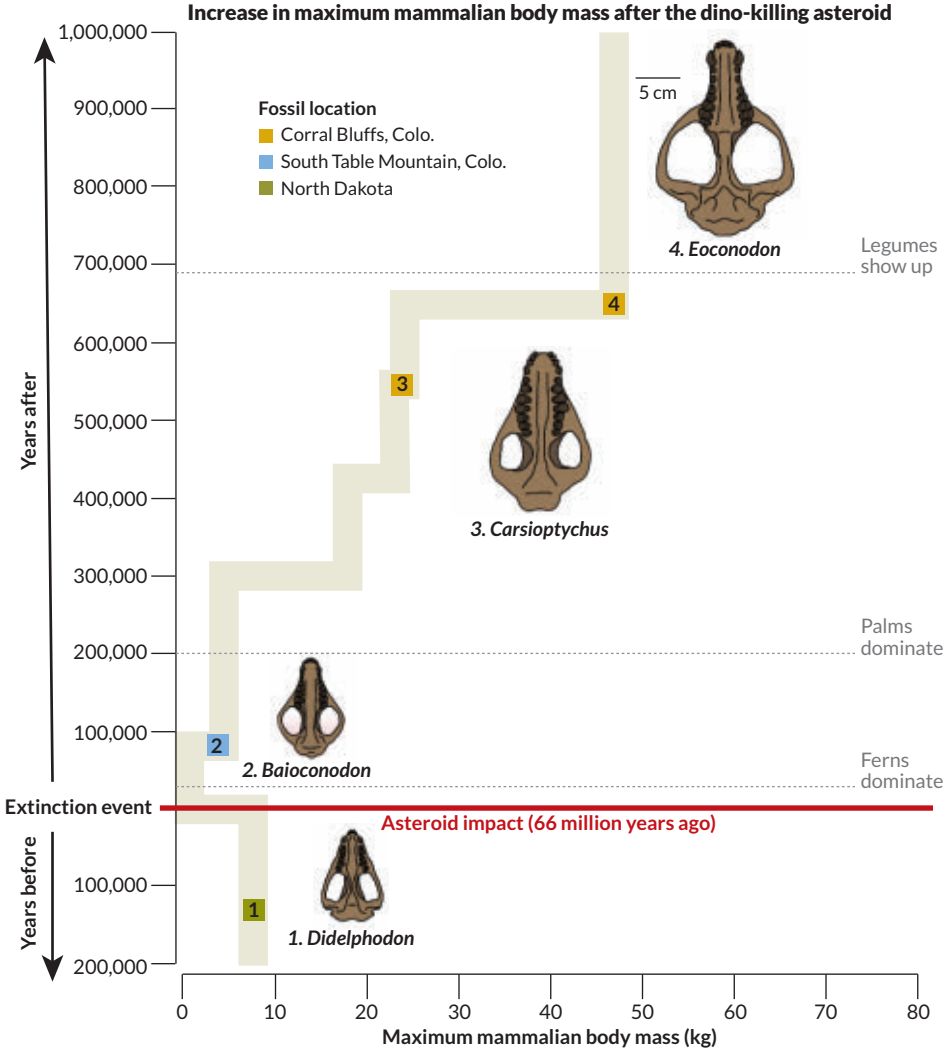

Here come the (bigger) mammals

Understanding how life rebounded after an asteroid strike 66 million years ago, which is believed to have devastated the dinosaurs, has been hard. But newfound fossils from Corral Bluffs, Colo., along with other outcrops in the region, are offering a look at how mammals and plants recovered and flourished. The fossils (some mammal skulls from Corral Bluffs above) are helping paleontologists piece together a timeline (at left) of how mammals grew in size once non-avian dinosaurs were gone.

The biggest initial mammal survivors were rat-sized creatures. But in rock dated to roughly 100,000 years later, raccoon-sized mammals, such as *Baioconodon* (No. 2 at left), appear. That's not far off from mammals' maximum body mass (represented by *Didelphodon*, No. 1) before the strike.

A lack of large predators and an explosion in plant diversity may have helped some mammals reach about 25 kilograms, such as beaver-sized *Carsioptychus* (No. 3), roughly 500,000 years after the impact. By almost 700,000 years after, wolf-sized mammals, such as *Eoconodon* (No. 4), appear, researchers report online October 24 in *Science*.

—John Pickrell

An ancient *Carsioptychus* mammal may have looked like this CGI rendering (far left). Most of the fossils found so far at Corral Bluffs were hidden inside roughly spherical rocks called concretions (example at left).

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The primary symbol of the snowflake is uniqueness. No two natural snowflakes are alike. Thus, the snowflake can be a symbol of one's individuality.

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