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SCIENCE NEWS MAGAZINE
SOCIETY FOR SCIENCE & THE PUBLIC
APRIL 14, 2018

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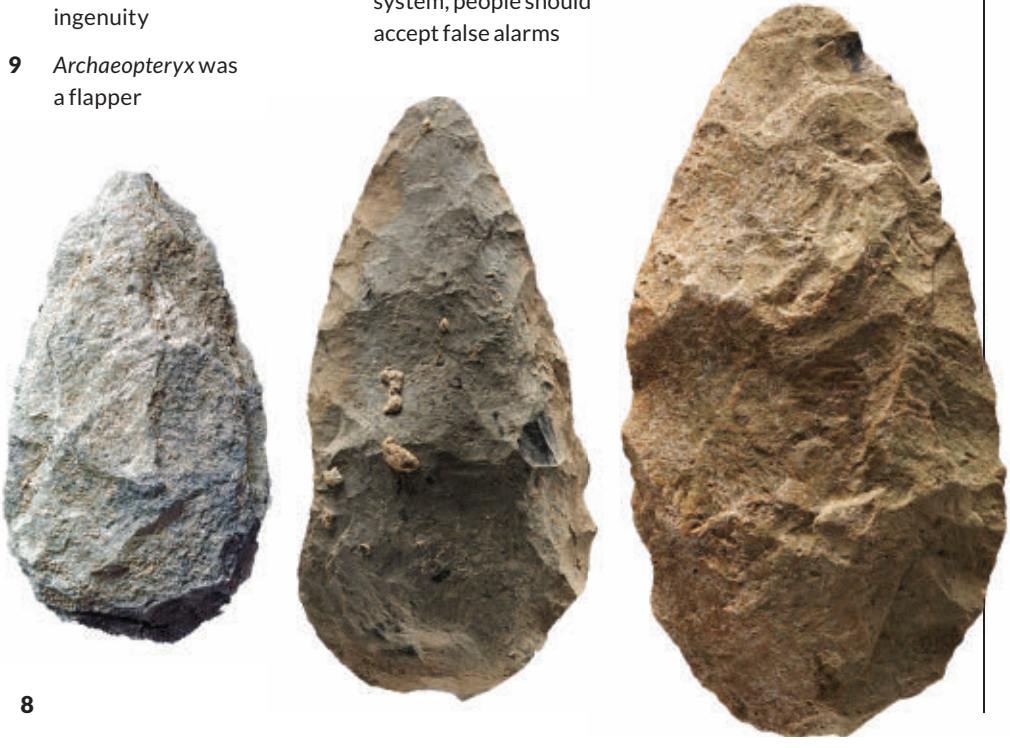

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SOCIETY UPDATE
Meet the top winners of this year's Regeneron STS

COVER Cities that are low on trees and high on nonreflective surfaces are in the hot seat as the planet warms. *PPAMPicture/iStockphoto*

How many scientists do you know in real life?

The death of physicist Stephen Hawking on March 14 at age 76 sparked a global outpouring of admiration. In our appreciation, *Science News* physics writer Emily Conover calls him "a black hole whisperer who divined the secrets of the universe's most inscrutable objects" (see Page 12). He was also among the very few cosmologists (hello, Carl Sagan) to have written an international best seller; Hawking was also the subject of an Academy Award–winning biopic (*SN: 11/1/14, p. 28*).

Hawking's status as superstar scientist led us to ponder what other contemporary scientists people would immediately recall. Primatologist Jane Goodall came to mind, as did astrophysicist Neil deGrasse Tyson. Also Bill Nye (who worked as a mechanical engineer for Boeing before heading off to TV-land) and string theorist Brian Greene.

After that, our water cooler discussion of scientists who excel both at science and at explaining it branched off in many directions. We named Lisa Randall (yet another articulate physicist); Dava Newman, a former deputy administrator of NASA; Anthony Fauci, an AIDS researcher and director of the National Institute of Allergy and Infectious Diseases; neuroscientist Christof Koch; economist Raj Chetty; geneticist George Church; physician and *New Yorker* contributor Atul Gawande; "inner fish" paleontologist Neil Shubin; and climate science defender James Hansen. We could have gone on for hours; we talk with more than a thousand scientists each year in the course of researching stories, each one fascinating in her or his own way.

But most people don't have the chance to talk with scientists as we do, and their vision of "who's a scientist" remains tragically underpopulated. A survey last year by Research!America found that 81 percent of Americans couldn't name a single living scientist. The most well-known then living? Hawking.

But the news isn't all bad. A new analysis of schoolchildren's drawings of scientists that reaches back decades shows that children today are less likely to draw the stereotypically nerdy guy with glasses (see Page 5). The number of women pictured has grown from close to zero in the 1960s to about one-third in 2016. One particularly charming drawing shows a casually attired scientist happily collecting data amidst a field of flowers, her red braids peeping out from a safari hat. That looks like science, and it looks delightful.

But clearly scientists and we science journalists have more work to do in making it easier for people to connect with scientists and their work. We rise to that challenge in this issue, in the next — a double issue that you'll receive on or around May 12 — and in every issue we offer up. In the months to come, look for more profiles and Q&As with scientists, so you can look behind the scenes and see them at work. We love science and the people who do it, and we know you do, too. — *Nancy Shute, Editor in Chief*

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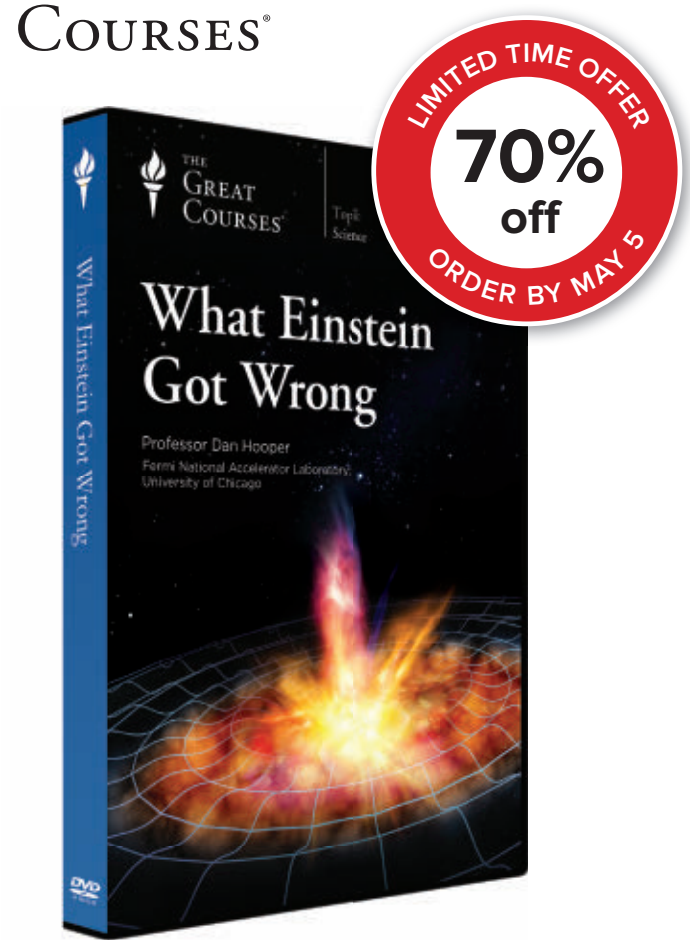

Trace Einstein's Path to Greatness—Missteps and All

Who has not heard of Einstein's theory of relativity, which revolutionized our understanding of space, time, and matter? He was *Time* magazine's Person of the Century, but even geniuses are not infallible. He rejected the possibility of black holes, and he was reluctant to accept the concept of an expanding universe or that gravity waves might exist. In other words, what Einstein got wrong includes some of the most exciting science of our time.

Physicist Dan Hooper of the Fermi National Accelerator Laboratory and the University of Chicago focuses on Einstein's major achievements, then covers his false starts, blind alleys, and outright blunders, which are fascinating for what they reveal about how science is done. More than just a biography of Einstein's life, this course provides you with an inside look at how this brilliant thinker arrived at his various revolutionary breakthroughs.

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Excerpt from the April 13, 1968 issue of *Science News*

50 YEARS AGO

Mexico takes vaccine to hinterland

The campaign to eradicate measles in Mexico is going into the hinterland areas. Mobile brigades will use live virus vaccine produced in laboratories of the Republic's Department of Health. Measles kills 10,000 Mexican children a year.

UPDATE: The last measles case to originate in Mexico occurred in 1995. In 2016, the Pan American Health Organization declared that the Americas were measles-free, largely because of far-reaching vaccination campaigns. That year, 98 percent of Mexicans and 92 percent of Americans received at least one dose of vaccine, the World Health Organization and UNICEF estimate. Eliminating infections doesn't mean a virus can't be reintroduced. International travelers can bring measles in from other places. A 2017 outbreak in Minnesota saw 79 cases confirmed, many in a community with low vaccination rates, though the outbreak's source was never identified.

Humpback whales are looking thinner and bumpier than they used to.

THE SCIENCE LIFE

Mystery of the bumpy humpbacks

Off the Kohala coast on the Big Island of Hawaii, Christine Gabriele spots whale 875. The familiar propeller scar on its left side and the shape of its dorsal fin are like a telltale fingerprint. Gabriele, a marine biologist at the Hawaii Marine Mammal Consortium, confirms the whale's identity against her extensive photo catalog. Both Gabriele and this male humpback have migrated to Hawaii's waters from southeastern Alaska.

In the Alaska summer feeding grounds, Gabriele sees the same 300 or so whales "again and again." But winter brings more than 10,000 whales to the waters of Hawaii from all over the North Pacific. Spotting 875 is like finding a needle in a haystack.

Gabriele is here today to focus on the slew of worrisome bumps on the familiar traveler's flank. The bumps are separate from the usual ones bulging from the head of a humpback (*Megaptera novaeangliae*). Those iconic oversize hair follicles are thought to be part of the whale's sensory system. The smaller body bumps look more like bad acne or an allergic reaction. Noted on rare occasions in the 1970s, the condition called nodular dermatitis has become more prevalent. These days, Gabriele and colleagues see these skin lesions on over 75 percent of Hawaii's humpback visitors.

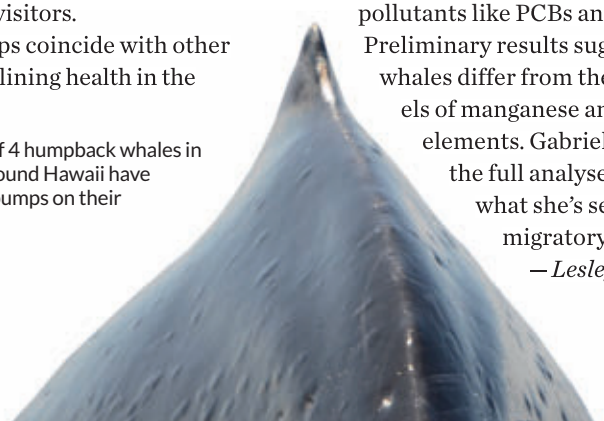
The bumps coincide with other signs of declining health in the whales. During most of the nearly three decades she's been studying whales, Gabriele would not have described the animals as skinny. Now, often "you can see their shoulder blades," she says. "They look angular rather than round."

Gabriele's team is trying to figure out the cause of the bumps, comparing tissue samples from bumpy and nonbumpy whales. Several times per week, a small team sets out on the water, research permits in hand. Once a whale pod is spotted, Gabriele's colleague Suzanne Yin zooms in with a camera and volunteer Kim New enlarges the image on her iPad, examining skin on the whale's flanks and behind the blowhole to confirm if bumpy or not. Gabriele carefully steers the boat so that Yin can shoot a biopsy dart from a crossbow.

The dart "takes a little plug of skin and blubber ... about the size of a pencil eraser," Gabriele says. The dart bounces off the whale and floats until the researchers can grab it. When darted, some whales dive; others show no reaction at all.

Collaborators at the National Institute of Standards and Technology's Hollings Marine Laboratory in Charleston, S.C., are analyzing the skin for trace elements. National Marine Fisheries Service lab staff are studying the blubber for organic pollutants like PCBs and flame retardants. Preliminary results suggest that bumpy whales differ from the nonbumpy in levels of manganese and a few other trace elements. Gabriele eagerly awaits the full analyses to make sense of what she's seeing among the migratory creatures.

— Lesley Evans Ogden



About 3 out of 4 humpback whales in the waters around Hawaii have unexplained bumps on their flanks.

FROM TOP: NOAA; COURTESY OF HAWAII MARINE MAMMAL CONSORTIUM NMFS PERMIT 31127-1921

TEASER

The tattoo keepers

Tattoos may have staying power because of handoffs between immune cells known as macrophages, a group of French researchers says.

If true, this would overturn notions that the ink persists in connective tissue or in long-lasting macrophages. Immunologist Sandrine Henri of the Immunology Center of Marseille-Luminy and colleagues tattooed mice's tails with green ink to see how waste-disposing macrophages in the skin would respond.

"Macrophages will scavenge everything. That's their job," Henri says. "If they could do their job properly, tattoo ink would be removed rapidly." In the experiment, described online March 6 in the *Journal of Experimental Medicine*, macrophages gobbled up the ink but did not digest and remove it. Instead, the cells held on to the ink until the researchers killed the cells. About 90 days later, new macrophages moved in and reabsorbed the ink, which had been floating in the area. This capture-release-recapture cycle was key to preserving the tattoos, the researchers say.

Tattoos on a mouse's tail appear the same before (left) and after (right) certain immune cells were killed, because new cells recaptured the ink.

But a mouse study doesn't settle the science of tattoos in humans, says Desmond Tobin, a dermatology expert at the University of Bradford in England. Macrophages may live longer in people than in mice, and the persistence of those cells might be responsible for preserving tattoos in human skin, Tobin says. The findings may still help improve tattoo removal, the authors say. Combining laser therapy with a treatment to get rid of skin macrophages could oust the ink. — *Dan Garisto*

RETHINK

Kids have evolving notions of 'scientist'

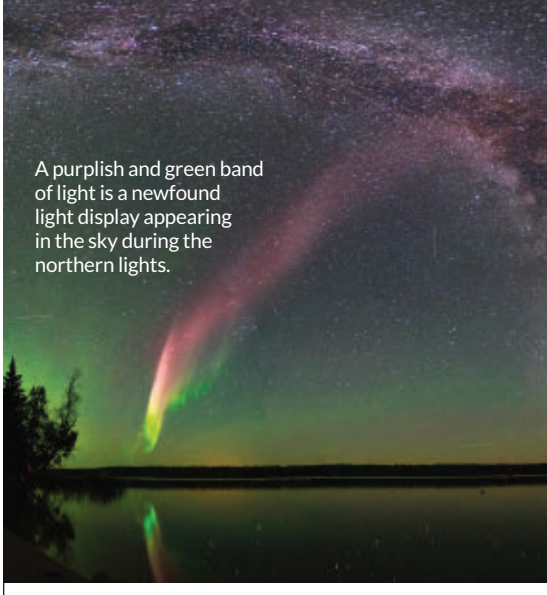
Ask a classroom of children to draw a scientist, and you'll see plenty of Crayola-colored lab coats, goggles and bubbling beakers. That image hasn't changed much since the 1960s. But the person wearing the lab coat is shifting, says David Miller, a Ph.D. candidate in psychology at Northwestern University in Evanston, Ill.

From 1966 through 1977, the first of many "draw-a-scientist" studies asked nearly 5,000 children to draw a scientist. "Of those 5,000 drawings, only 28 ... depicted a female scientist," Miller says. That's 0.6 percent. To look for changes in children's perceptions over time, Miller and colleagues combined data from 78 more recent studies that included a total of more than 20,000 U.S. children in kindergarten through 12th grade.

On average, 28 percent of children drew female scientists in studies conducted from 1985 to 2016, the researchers report online March 20 in *Child Development*.

What hasn't changed much: Kids pick up gender stereotypes as they grow up. At age 6, girls in the more recent studies drew female scientists about 70 percent of the time. By age 16, only 25 percent did so. — *Erika Engelhaupt*

In a recent study, an 8-year-old Hispanic girl from San Antonio drew a female scientist with a banner reading "best job ever."



A purplish and green band of light is a newfound light display appearing in the sky during the northern lights.

INTRODUCING

STEVE the light show makes debut

Meet STEVE, a nontraditional aurora that drapes the sky with a mauve ribbon and bedazzling green bling.

This feature of the northern lights, first photographed and named by citizen scientists in Canada, now has a scientific explanation. The streak of color, which appears to the south of the main aurora, may be a visible version of a typically invisible process involving drifting charged particles, or ions, physicist Elizabeth MacDonald and colleagues report March 14 in *Science Advances*.

Measurements from ground-based cameras and a satellite that passed when STEVE was in full swing show that the luminous band is associated with a strong flow of ions in the upper atmosphere, MacDonald, of NASA's Goddard Space Flight Center in Greenbelt, Md., and colleagues conclude. But the researchers can't yet say how the glow arises from this flow.

Volunteers with a citizen science project called Aurorasaurus (*SN Online: 4/3/15*) gave the phenomenon its moniker before STEVE's association with ion drift was known.

MacDonald and colleagues kept the name, but gave the colorful display a backronym: "Strong Thermal Emission Velocity Enhancement."

We'll stick with STEVE. — *Emily Conover*

FROM TOP: KRISTA TRINDER; A. BARANSKA *ET AL/J. EXP. MED.* 2018; COURTESY OF LEON WALLS/UNIV. OF VERMONT

The final data taken by the Cassini spacecraft before it plunged into Saturn reveal new details about the planet's clouds, rings and moons.

ATOM & COSMOS

Saturn surprises keep coming

Scientists begin to analyze data from Cassini's last hurrah

BY LISA GROSSMAN

It's been more than six months since NASA's Cassini spacecraft plunged to its doom in the atmosphere of Saturn, but scientists didn't spend much time mourning. They got busy analyzing the final data.

The Cassini mission ended September 15, after more than 13 years orbiting Saturn (*SN Online: 9/15/17*). The probe's final 22 orbits, dubbed the Grand Finale, sent Cassini into the potentially dangerous region between the gas giant and its rings; the final orbit sent the spacecraft directly into Saturn's atmosphere.

That mission-ending ride helped solve mysteries about the planet's atmosphere, rings and moons that could not be tackled any other way, scientists reported March 19.

"The Grand Finale orbits provided information that was totally unexpected," said Cassini project scientist Linda Spilker of NASA's Jet Propulsion Laboratory in Pasadena, Calif.

One surprise came from new measurements of Saturn's gravity. Cassini's final daredevil orbits allowed the spacecraft to measure the gravity of Saturn and its rings independent of one another. Looking at the planet's gravity field alone revealed that Saturn's swirling bands of clouds penetrate much deeper into the planet than expected.

Last month, astronomers announced a similar discovery for an even larger gas giant, reporting that Jupiter's cloud belts reach about 3,000 kilometers below the top of the atmosphere (*SN: 3/31/18, p. 10*).

Saturn's clouds reach a few times deeper than that. "People used to think that maybe Saturn was just a slightly smaller version of Jupiter, but it's evident that that's not the case," says planetary scientist Paul Schenk of the Lunar and Planetary Institute in Houston, who was not involved in the gravity measurements. The difference speaks to how diverse planets are, he says. "Every place you look, everywhere we've been to, it's just been so dramatically different and unique."

Cassini also confirmed that bits of ice from Saturn's rings rain into the planet's atmosphere, an idea first suggested in the 1980s. In its last five full orbits before diving into Saturn, Cassini found a zoo of organic molecules in and just above the planet's atmosphere, said planetary scientist Kelly Miller of the Southwest Research Institute in San Antonio. Cassini found a lot of water, as expected. But there were also lots of hydrocarbons similar to propane, plus some methane and sulfur-bearing molecules.

The types of molecules became less well-mixed as the spacecraft looked deeper into Saturn's atmosphere, which is what would happen if the particles came from the rings and sank at different speeds. The researchers think this material is raining especially from Saturn's thin innermost ring. Other Cassini data suggest this ring is losing mass.

The organics in the ring rain seem to resolve a debate about why Saturn's rings appear reddish in some spots.

"We've had this debate going on for a couple of years now — are they red because of good old-fashioned rust like Mars, or because of the same kinds of organic materials ... that make carrots and tomatoes and watermelon red?" asked planetary scientist Jeff Cuzzi of NASA's Ames Research Center at Moffett Field, Calif. "To me, this answers the question of what makes the rings red: It's organics."

Where the organics come from is still not clear. They could be created within the rings, or they could come from cosmic dust from the tails of comets. Miller and her colleagues are comparing the ring rain molecules with data from comet 67P, which the Rosetta spacecraft observed, to see how well the molecules match up (*SN: 11/11/17, p. 32*).

With the last of Cassini's data in hand, researchers also have a new understanding of one of the forces nudging plumes on Saturn's tiny moon Enceladus.

The spurts of liquid water were discovered in 2006. Over the next six years, scientists noticed that the plumes varied in brightness (a proxy for how much material is gushing from the moon) on a daily cycle, probably driven by changes in gravitational strength as Saturn and Enceladus moved with respect to each other.

Then, in 2015, some researchers noted that the plumes' overall brightness had

Disappearing islands on Saturn's moon Titan may actually be tall waves reflecting sunlight. Such a reflection (yellow spot at upper left) is shown in the sea Kraken Mare in this infrared image.

FROM TOP: JPL-CALTECH/NASA, SSI, CORNELL UNIV.; JPL-CALTECH/NASA, UNIV. OF ARIZONA, UNIV. OF IDAHO

been decreasing since the beginning of the Cassini mission.

One possible explanation: The plumes change with Saturn's seasons. Another: Ice built up and clogged the vents, decreasing the flow. But looking at the full 13-year Cassini dataset, planetary scientist Francis Nimmo found that the plumes grow brighter in a regular cycle every four and 11 years. The pattern is too coherent to be explained by clogged vents, said Nimmo, of the University of California, Santa Cruz. And the plumes grew brighter in 2017 — the wrong time if plumes changed with the seasons.

The variations may be explained by a neighboring moon, Dione. When Dione and Enceladus line up, their gravitational stress on each other may force Enceladus' vents to open a bit more, causing the plumes to grow brighter, Nimmo said.

Shutting off the fire hose of new data from Cassini also gave scientists time to look back at older observations, which revealed something new about Saturn's moon Titan. Disappearing features in its lakes are caused by sunlight reflecting off giant waves, said planetary scientist Alexander Hayes of Cornell University.

When spotted in 2014, these features were named "magic islands." Just last year, researchers claimed the islands were caused by champagnelike bubbles of nitrogen burbling through the moon's hydrocarbon seas (*SN Online: 4/18/17*).

But Hayes presented newly analyzed data from 2014, when Cassini looked at one of Titan's seas, Kraken Mare, in radar and infrared wavelengths within two hours of each other. The radar revealed a magic island; the infrared images showed a peak in brightness at the same spot.

Because the observations were taken within two hours, the island probably couldn't have been due to bubbles, which would pop or disperse too quickly, Hayes said. Instead, he thinks the brightening could be the glint of sunlight reflecting directly off of giant waves, like how Earth's oceans ripple with gold at sunset.

As the Titan research demonstrates, although Cassini is gone, the spacecraft left decades' worth of data to sift through in search of answers. ■

P. BYRNE, NASA

ATOM & COSMOS

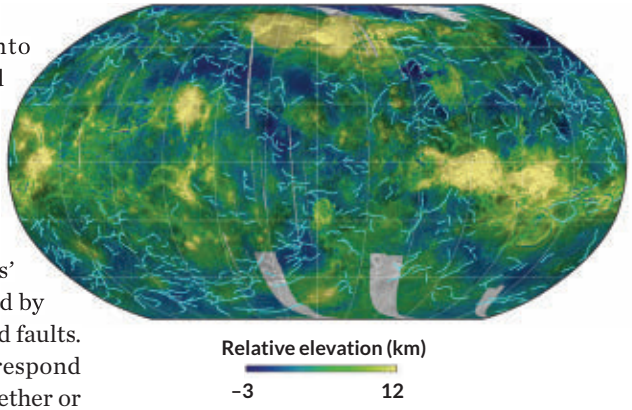
Venus shows off new kind of tectonics

Jostling blocks of crust defy notions about planetary surfaces

BY LISA GROSSMAN

Venus' crust is broken up into chunks that shuffle, jostle and rotate on a global scale, scientists proposed March 20.

New maps of the planet's surface, based on images taken by NASA's Magellan spacecraft in the 1990s, show that Venus' low-lying plains are crisscrossed by a complex network of ridges and faults. Similar features on Earth correspond to tectonic plates crunching together or pulling apart. Even more intriguing, the edges of the Venusian plains show signs of rubbing against each other, also suggesting these blocks of crust have moved.



The light blue squiggles on this map of Venus, based on images from the Magellan spacecraft, are boundaries of crustal blocks that have probably moved, new research finds. Gray denotes areas with incomplete data.

"This is a new way of looking at the surface of Venus," reported planetary geologist Paul Byrne of North Carolina State University in Raleigh.

Geologists generally thought rocky planets could have only two forms of crust: a stagnant lid as on Mars, where the whole crust is one continuous piece, or plate tectonics as on Earth, where the surface is split into giant moving blocks that sink beneath or collide with each other. Venus was thought to have one solid lid (*SN: 12/3/11, p. 26*).

Instead, "Venus may be somewhere in between," Byrne said. "It's not plate tectonics, but it ain't not plate tectonics."

While Earth's plates move independently like icebergs, Venus' blocks jangle together like chaotic sea ice, reported planetary scientist Richard Ghail of Imperial College London. Ghail identified similar ridges and faults around two specific regions on Venus that resemble continental interiors on Earth, such as the Tarim and Sichuan basins in China.

Crustal motion may be possible because Venus' surface is scorching hot (*SN: 3/3/18, p. 14*). "Those rocks already have to be kind of gooey" from the high temperatures, Byrne said. So it wouldn't take a lot of force to move the rock. Venus' interior is also probably still hot, like Earth's, so convection in the mantle could help push the blocks around.

"It's a bit of a paradigm shift," says planetary scientist Lori Glaze of NASA's Goddard Space Flight Center in Greenbelt, Md., who was not involved in the research. "People have always wanted Venus to be active. We believe it to be active, but being able to identify these features gives us more of a sense that it is."

The work may have implications for astronomers trying to figure out which Earth-sized planets in other solar systems are habitable (*SN: 4/30/16, p. 36*). Venus is almost the same size and mass as Earth. But no known life exists on Venus, where the average surface temperature is 462° Celsius and the atmosphere is acidic. Scientists have speculated that an apparent lack of plate tectonics might help make Venus uninhabitable.

What's more, the work raises the possibility that planets go through phases of plate tectonics (*SN: 6/25/16, p. 8*). Venus could have had full-blown plate tectonics 1 billion or 2 billion years ago, according to a simulation presented by geophysicist Matthew Weller of the University of Texas at Austin. "Does that predict where the Earth is going in the relatively near future?" he wondered. ■

HUMANS & SOCIETY

Changing climate drove innovation

Trade networks, small tools arose by 320,000 years ago

By around 320,000 years ago in East Africa, *Homo sapiens* or a closely related species had shifted from making large, handheld chopping implements (left) to fashioning spearpoints and other small tools (above).

BY BRUCE BOWER

Dramatic shifts in East Africa's climate may have driven toolmaking advances and the development of trading networks among *Homo sapiens* or their close relatives by the Middle Stone Age, roughly 320,000 years ago. That's the implication of discoveries reported in three papers published online March 15 in *Science*.

Newly excavated Middle Stone Age tools and red pigment chunks from Kenya's Olorgesailie Basin appear to have been part of a long trend of climate-driven behavior changes in the *Homo* genus that amped up in *H. sapiens*. As locations of food sources became unpredictable on changing landscapes, *H. sapiens* and their precursors responded by foraging over larger areas with increasingly smaller tools, the researchers propose. Obsidian used for the tools came from far away, raising the likelihood of long-distance contacts and trading among hominid populations near the dawn of humankind.

The Middle Stone Age tools, spearpoints and other small implements struck from prepared chunks of stone, are the oldest of their kind, paleoanthropologist Rick Potts and colleagues report in one of the papers. The timing of the tools coincides roughly with the emergence of *H. sapiens* (*SN: 12/23/17, p. 24*). Researchers had previously estimated that such tools date from no earlier than 280,000 to perhaps 300,000 years ago. More primitive, handheld cutting stones made of local rock date from around 1.2 million to 499,000 years ago at Olorgesailie. Gradual downsizing of those tools, including oval hand axes, occurred from 615,000 to 499,000 years ago, a stretch characterized by frequent shifts between wet and dry conditions, the scientists say.

It's not known whether that tool trend continued or if a sudden transition to Middle Stone Age implements happened between 499,000 and 320,000 years ago. Erosion at Olorgesailie has destroyed sediment from that period, leaving the nature of toolmaking during that gap a mystery. It's also unclear who made Olorgesailie's Middle Stone Age tools; no hominid fossils have been found there.

Back-and-forth shifts from dry to wet conditions — many happening over only a few years or decades — continued to regularly reshape the Olorgesailie landscape around 320,000 years ago, conclude Potts, of the Smithsonian Institution in Washington, D.C., and colleagues in the second paper. The team's climate reconstruction is based on microscopic and chemical analyses of the region's soil.

A substantial number of the region's Middle Stone Age tools are made from obsidian that came from at least 25 to 50 kilometers away from the excavation sites. At one site in particular, 42 percent of over 3,400 artifacts were obsidian. Some display signs of having been attached to handles, probably as spearpoints, a group led by archaeologist Alison Brooks of George Washington University in Washington, and including Potts, reports in the third paper. Brooks is also a coauthor on the other studies.

Formation of trading networks among dispersed groups of *H. sapiens*, or possibly among closely related populations, best explains how large amounts of obsidian turned up at Olorgesailie, Potts contends. "Social networking during a long period of climate variability was a key to success for early *Homo sapiens*," he says. "Greater mobility encouraged inventive thinking about how to acquire resources." Potts has long argued that *H. sapiens* and close relatives evolved to deal with constantly changing environments (*SN: 8/20/05, p. 116*).

Still, factors other than climate fluctuations, such as population declines or surges, may also have spurred hominids to develop new tools to acquire more or different types of food, cautions archaeologist Yonatan Sahle of the University of Tübingen in Germany.

In addition to the tools, 88 pigment lumps, including two with grinding marks, came from an undetermined distance outside Olorgesailie, Brooks' group says. Pigment applied to one's body or belongings may have signaled group identity or social status, the researchers say.

The reports fit with genetic evidence that *H. sapiens* arose in Africa between 350,000 and 260,000 years ago, says archaeologist Marlize Lombard of the University of Johannesburg. Smaller, more specialized Middle Stone Age tools appearing along with pigment "provide strong indicators that by about 300,000 years ago we were well on our way to becoming modern humans in Africa," Lombard says.

Ancient toolmaking approaches varied greatly from one part of Africa to another, with hominids employing diverse mixes of old-school chopping tools and newer, sharp points, says archaeologist John Shea of Stony Brook University in New York. At Olorgesailie and elsewhere, he says, "early *Homo sapiens* and their immediate African ancestors were at least as smart as the scientists investigating them." ■

HUMAN ORIGINS PROGRAM/SMITHSONIAN

LIFE & EVOLUTION

Archaeopteryx had wings for flapping

Dino-bird could fly in brief bursts, fossil analysis suggests

BY CAROLYN GRAMLING

Archaeopteryx was a flapper, not just a glider. The shape of the dino-bird's wing bones suggests that the creature was capable of short bursts of active, flapping flight, similar to how pheasants and quails fly to escape predators, scientists report March 13 in *Nature Communications*.

Archaeopteryx lived about 150 million years ago during the Jurassic Period, spanning the evolutionary gap between modern birds and feathered dinosaurs. *Archaeopteryx* fossils have been instrumental in the recognition that birds are dinosaurs. But researchers have long wrangled over whether the primitive fowl was a true bird and how well it could fly.

The dino-bird lacked several features considered essential to flight in modern birds, including a ball-and-socket arrangement that lets the wing flap fully up over the back and down again, and a muscle pulley system linking chest and shoulder muscles that lets birds swiftly alternate between powerful downstrokes and upstrokes. Researchers also have suggested that *Archaeopteryx*'s plumage was too delicate for vigorous flapping (*SN: 6/5/10, p. 12*). Based on these observations, *Archaeopteryx* was thought to merely glide from branch to branch.

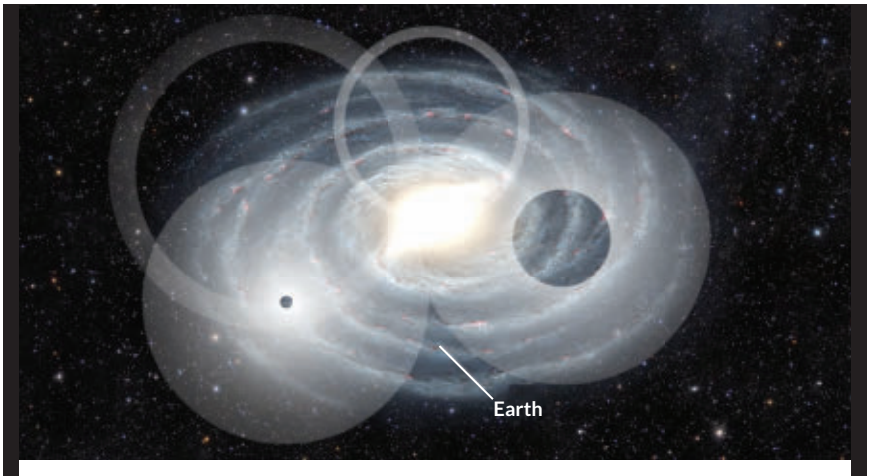
Paleontologist Dennis Voeten of Palacký University Olomouc in the Czech Republic and colleagues decided to look for other features that might indicate whether the dino-birds flapped their wings while flying. The team used X-ray microtomography to examine two different wing bones — the humerus, or upper arm bone, and a lower arm bone called the ulna — in three *Archaeopteryx* fossils.

The team compared the thickness of the bones' walls and their resistance to torsion — a twisting force that birds' wings withstand during flapping flight — with similar bones from several dinosaurs, flying reptiles called pterosaurs and modern birds. *Archaeopteryx* had wing bone structures most similar to pheasants and quails, which are capable of small bursts of active flapping flight.

Gerald Mayr, an ornithologist at the Senckenberg Research Institute Frankfurt, notes that the researchers still haven't answered whether *Archaeopteryx* could launch itself from the ground into the air. "Their results convincingly show that it could do active flight" once it was airborne, Mayr says. "What they do not explain is how it would have been possible to produce strong flapping flight to take off from the ground." Some early birds might have used a combination of wing and leg strength to launch into the air, but this hasn't been shown for *Archaeopteryx* (*SN: 11/26/16, p. 9*).

Without flight adaptations such as the muscle pulley system, *Archaeopteryx* wouldn't have been capable of the full range of flapping motion birds today use, Voeten says. Instead, other parts of its anatomy indicate *Archaeopteryx* may have thrown its wings upward and forward, similar to a swimmer's butterfly stroke, he says. "Dedicated studies would need to show if it would work that way." ■

New examinations of *Archaeopteryx* fossils, including this one, suggest that the ancient dino-bird could fly like a pheasant or quail.



ATOM & COSMOS

Ghostly alien signals may haunt the galaxy

If signals from an alien civilization ever reach Earth, odds are the aliens will already be dead. In an effort to update the 1961 Drake Equation, which estimates the number of detectable, intelligent civilizations in the Milky Way, researchers calculated the area of the galaxy that should be filled with alien signals at a given time.

The team — including astronomer Frank Drake, for whom the equation is named — assumed tech-savvy civilizations are born and die at a constant rate. After a civilization dies, the electromagnetic signals it had sent continue traveling like concentric ripples on a pond (as shown in the simulation above).

If the civilization lasted less than 100,000 years — the time it takes light to cross the galaxy — then the odds of the signals reaching Earth while the civilization is still broadcasting are vanishingly small, the researchers report February 27 at arXiv.org. Humans, for instance, have been transmitting radio waves for only about 80 years, so our signals cover less than 0.001 percent of the Milky Way. — *Lisa Grossman*

FROM TOP: PASCAL GOETGHELUCK/ESRF; GEOFF MARCY

BODY & BRAIN

Weight gain robs mice of taste buds

Inflammation may explain why obesity dulls sense of flavor

BY AIMEE CUNNINGHAM

As mice plumped up on a high-fat diet, some of their taste buds vanished. This disappearing act could explain why some people with obesity seem to have a weakened sense of taste, which may compel them to eat more.

Compared with siblings fed normal chow, mice given high-fat meals lost about 25 percent of the taste buds on a section of their tongues over eight weeks. Buds went missing because mature taste bud cells died off more quickly, and fewer new cells developed to take their place. Chronic, low-level inflammation associated with obesity appears to be behind the loss, researchers report March 20 in *PLOS Biology*.

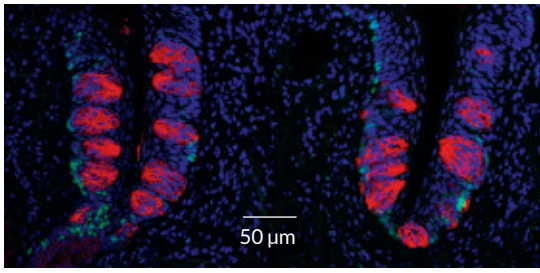
The research "provides a possible link between obesity and taste," says taste physiologist Kathryn Medler of the University at Buffalo in New York, who was not involved with the research.

Taste buds, each a collection of about 50 to 100 cells, help identify safe and nourishing food, and stimulate reward centers in the brain. A taste bud lasts about 10 days. Progenitor cells give rise to new taste bud cells that replace old ones.

If taste becomes less intense, "then maybe you don't get the positive feeling that you should," which could give way to more overeating, says study coauthor Robin Dando, who studies the biology of taste at Cornell University. Nearly 40 percent of U.S. adults have obesity. The condition is linked to health problems, such as heart disease, diabetes and cancer.

Obesity triggers low-level, ongoing inflammation in the body, which can harm cells. Taste tissues of the obese mice had a higher amount of a type of cytokine, a protein that regulates inflammation, than their normal-weight kin.

This cytokine, called tumor necrosis factor alpha, seems to damage taste buds, the researchers found. In a test with mice that couldn't make the cytokine, obese mice didn't have missing taste buds. Another experiment showed that mice engineered not to gain excess weight on a fatty diet — and that therefore didn't have obesity-related inflammation — also had the normal amount of taste buds.



Compared with mice on a regular diet (left), mice that became obese on a high-fat diet (right) lost a quarter of the taste buds (red) on a section of their tongues.

Dando is interested in working toward new treatments for obesity, perhaps by countering the dulled sense of taste. "These mice lose taste buds," he says. "Can we bring them back?" ■

BODY & BRAIN

Male birth control pill passes first test

In a safety trial, men didn't suffer worrisome side effects

BY AIMEE CUNNINGHAM

CHICAGO — In a small study, a once-daily capsule safely suppressed reproductive hormones in men, making it an appealing candidate for a male birth control pill.

After about a month, a prototype pill called dimethandrolone undecanoate, or DMAU, had reduced levels of hormones that are necessary for sperm production. None of the 83 men who completed the treatment suffered troubling symptoms, such as a loss in sexual function, that can arise with a dramatic drop in testosterone, researchers reported March 18 at the Endocrine Society's annual meeting.

"Scientists have been working on a male contraceptive for decades," says Monica Laronda, a reproductive endocrinologist at the Ann & Robert H. Lurie Children's Hospital of Chicago who was not involved in the study. "DMAU shows great promise." Surveys show that many men are interested in forms of contraception besides condoms and vasectomies, she says, and "would prefer a pill."

Hormonal contraception works for men much as it does for women — by manipulating levels of certain hormones so the body backs off on making its own. In men, extra testosterone suppresses the brain's release of luteinizing hormone and follicle-stimulating hormone, which stops testicles from making testosterone and sperm (*SN: 9/2/17, p. 20*). Once treatment ends, fertility returns.

But testosterone doesn't stay in the blood very long, so a single dose is less likely to work for contraception. And an excess of the hormone can damage the liver. DMAU, which becomes an active compound called dimethandrolone in the body that has a similar effect to testosterone, is designed to avoid these issues, the researchers say.

Three different doses of DMAU were tested. Men on the highest dose experienced a precipitous fall in luteinizing hormone, follicle-stimulating hormone and testosterone from taking just one daily pill for 28 days. Those low levels are known to prevent sperm development.

The researchers will soon launch a clinical study to test sperm counts in men taking the drug. If those results are good, the pill will be tested by couples as contraception. Developing such products for men is important in preventing unplanned pregnancies, says study coauthor Arthi Thirumalai, an endocrinologist at the University of Washington Medical Center in Seattle. "It's hard to solve a problem when you essentially exclude half the world's population from doing anything about it." ■

A. KAUFMAN *ET AL*/*PLOS BIOLOGY* 2018

EARTH & ENVIRONMENT

Quake alerts can't avoid false alarms

An early warning would have to go out before a threat is clear

BY CAROLYN GRAMLING

Earthquake warning systems face a tough trade-off: To give enough time to take cover or shut down emergency systems, alerts may need to go out before it's clear how strong the quake will be. And that raises the risk of false alarms, undermining confidence in the system.

A study aims to quantify the best-case scenario for warning time from a hypothetical earthquake early warning system. The result? There's no magic formula for deciding when to issue an alert, researchers say March 21 in *Science Advances*.

"We have a choice when issuing earthquake warnings," says Sarah Minson, a seismologist at the U.S. Geological Survey in Menlo Park, Calif. "You have to think about your relative risk appetite: What is the cost of taking action versus the cost of the damage you're trying to prevent?"

Earthquake early warning systems, called EEWs, don't actually warn that a quake is imminent; they alert people that one has happened or is happening, giving them precious seconds, perhaps a minute or two, to prepare for ground shaking.

For places far from a large quake's origin, waiting for clear signs of risk before sending an alert may mean waiting too long for people to take action. For managers of crucial infrastructure, such as trains or nuclear power plants, an early warning even if false may be preferable to one coming too late (*SN: 4/19/14, p. 16*).

EEWs base alerts on the depth and location of a quake's origin, as well as estimated magnitude and ground properties, such as the type of soil and rock that seismic waves would travel through.

Estimating magnitude is a sticking point. It's impossible to distinguish a powerful quake in its earliest stages from a small, weak one. Estimating magnitude for larger quakes also takes more time because the fault rupture lasts longer. And there's a trade-off in terms of distance: For places farther away, there's less certainty the shaking will reach that far.

In the study, Minson and colleagues used ground-motion prediction equations to calculate the minimum quake magnitude that would produce shaking at any distance. Then, the team calculated how quickly an EEW could estimate whether the quake would exceed that minimum magnitude to qualify for an alert. Finally, the team estimated how long it would take for the shaking to strike a location. Ultimately, an EEW holds the greatest benefit for users who are willing to take action early, even with the risk of false alarms.

EEWs are already in operation around the world. USGS and partners are developing one for the U.S. West Coast called the ShakeAlert system, which is expected to be fully rolled out this year.

Any alert system's value will depend on whether it fulfills its objective — getting people to take cover. "More than half of injuries from past earthquakes are associated with things falling on people," says Richard Allen, a seismologist at the University of California, Berkeley. "A few seconds of warning can more than halve the number of injuries." ■

LIFE & EVOLUTION

Earwigs bend the rules of folding

Springy joints let the insects quickly pack, unfurl their wings

BY LAUREL HAMERS

To quickly unfurl and refold their wings, earwigs stretch the rules of origami.

Yes, those garden pests that scurry out from under overturned flowerpots can also fly. Because earwigs spend most of their time underground and only occasionally take to the air, they use an origami-like series of folds to pack their wings into a surface area less than a tenth as big as when unfurled. Springy wing joints let the insects bypass some of the mathematical constraints that normally limit the way a rigid two-dimensional material can be folded, researchers report in the March 23 *Science*.

Origami theory assumes that a 2-D material being folded is perfectly rigid. But earwig wing joints, where creases form, are rich in a rubbery polymer called resilin. This little bit of stretch lets earwig wings do what a regular origami structure can't: lock into two different conformations — open or folded up — and transition between the two.

It's an example of a bistable structure, like the slap bracelets of the 1980s and '90s that switched from a flat conformation to a curved one when whacked against a wrist, says study coauthor André Studart, a materials scientist at ETH Zurich. When locked open, earwig wings store energy in the springy resilin joints. When that strain is released, the wings rapidly crumple back to a folded position.

Such constructions can inform robotics design. Inspired by the wings, the researchers created a prototype gripper. Its rigid pieces are held together by rubbery, strategically placed joints. The structure can quickly snap from its mostly flat conformation to one that can grip a small object and hold it without constant external force.

Earwigs don't normally reveal their wings, but the folded-up appendages unfurl on demand and lock into place until refolded.

JAKOB FABER/ETH ZURICH

While other materials scientists have pushed the limits of origami by making flat pieces bendable, this design stretches the hinges, says physicist Jesse Silverberg of Harvard University. Such a design has never before been implemented in this way. ■

See an earwig-inspired gripper in action at **bit.ly/SN_earwigs**

During a career that spanned more than half a century, Stephen Hawking deduced new properties of mysterious chasms in spacetime.

SCIENCE & SOCIETY

Stephen Hawking's legacy will live on

Physicists are still pondering puzzles posed by the cosmologist

BY EMILY CONOVER

Stephen Hawking, a black hole whisperer who divined the secrets of the universe's most inscrutable objects, left a legacy of cosmological puzzles sparked by his work, and inspired a generation of scientists who grew up reading his books.

Upon Hawking's death on March 14 at age 76, his most famous discovery — that black holes aren't entirely black, but emit faint radiation — was still fueling debate.

Hawking "really, really cared about the truth, and trying to find it," says physicist Andrew Strominger of Harvard University, who collaborated with the famed scientist. Hawking "was deeply committed, his whole life, to this quest of understanding more about the physical universe around us."

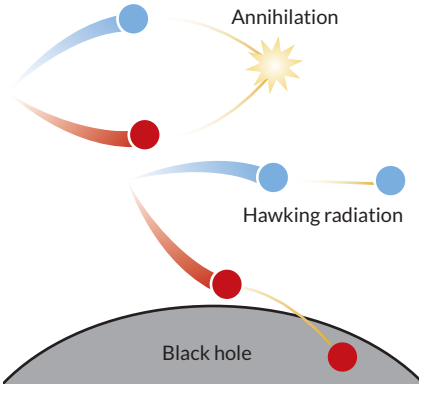
After earning his Ph.D. in 1965 at the University of Cambridge, Hawking continued studying cosmology there for the rest of his life. Due to a degenerative illness, amyotrophic lateral sclerosis, or ALS, Hawking gradually lost control of his body, requiring a wheelchair and eventually a voice synthesizer to speak. Yet his desire to uncover nature's secrets remained boundless.

In one of the most significant realizations of his career, Hawking reported in 1974 that black holes emit a faint glow of particles. This effect arises from quantum mechanics, which states that a sea of transient particles and antiparticles pervades all of space. These "virtual" particles usually annihilate in an instant, but if one of those particles is lost inside a black hole's boundary, or event horizon, its partner can escape, producing what's now known as Hawking radiation (*SN: 5/31/14, p. 16*).

As a result, black holes can gradually evaporate and disappear. This led to a still unresolved paradox: Throw an encyclopedia into a black hole and the information will eventually be lost. But according to quantum mechanics, information can never be destroyed.

Many solutions have been proposed for this problem, but none has stuck. In 2016, Hawking and colleagues proposed a path toward a solution: Black holes might have "soft hair," low-energy particles that would retain information about what fell inside (*SN: 2/16/16, p. 16*). Hawking's collaborators, including Strominger, are still working on the research. Standing at the interface between two seemingly incompatible theories — quantum mechanics, which describes the very small, and the general theory of relativity, which describes gravity — the quandary and its resolution may eventually help reveal a unified theory of quantum gravity.

Great escape Black holes aren't so black after all. Quantum particles constantly appear and annihilate, even in empty space. If one of a pair falls inside a black hole, the other can escape, producing Hawking radiation.



Hawking made many other contributions, including studies of spacetime curvature during the Big Bang and the possibility that mini black holes might have formed in the universe's infancy. Despite their groundbreaking nature, Hawking's ideas remained largely theoretical, says Harvard theoretical astrophysicist Avi Loeb. Hawking radiation, for example, has never been directly detected. "That's, unfortunately, why he didn't get the Nobel Prize," Loeb says.

Yet Hawking achieved a level of fame uncommon among scientists. He excelled at making abstruse science digestible to the public. With his books, most notably the best-selling *A Brief History of Time*, first published in 1988, Hawking inspired countless future scientists and science lovers (including the author of this article). Theoretical cosmologist Katie Mack of North Carolina State University in Raleigh first opened the book when she was about 10 years old. "I found it so fascinating at the time," she says. "I found out that Stephen Hawking was called a cosmologist and so I said I wanted to be a cosmologist." Hawking similarly motivated dozens of her colleagues, Mack says.

Hawking remained active in research even in the last months of his life. A paper on which he is a coauthor, which was updated in the weeks before his death, considered the physics of multiverses, the possibility that a slew of other universes exist in addition to our own.

Hawking's ashes will be interred in Westminster Abbey in London, where they will rest alongside the remains of other famous British scientists, including Isaac Newton and Charles Darwin. ■

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Students run with their hands up following a February 14 shooting at a high school in Parkland, Fla. Little is known about why some individuals become mass killers.

HUMANS & SOCIETY

Science can't yet explain shootings

A lack of research hinders an understanding of mass killers

BY BRUCE BOWER

Immediately after a 19-year-old shot and killed 17 people and wounded 17 others at a high school in Parkland, Fla., on Valentine's Day, people leaped to explain what had caused the latest mass slaughter.

By now, it's a familiar drill: Too many readily available guns. Too much untreated mental illness. Too much warped masculinity. Don't forget those shoot-'em-up video games and movies. Add (or repeat, with voice raised) your own favorite here.

Now the debate has received an invigorated dose of activism. Inspired by students from the targeted Florida high school, hundreds of thousands of people rallied against gun violence and in favor of stricter gun laws on March 24 in Washington, D.C., and in cities across the world. But a big problem haunts the justifiable outrage over massacres of innocents going about their daily affairs: Whatever we think we know about school shootings, or mass public shootings in general, is either sheer speculation or wrong. A science of mass shootings doesn't exist.

"There is little good research on what are probably a host of problems contributing to mass violence," says Grant Duwe, a criminologist at the Minnesota Department of Corrections in St. Paul. Duwe has spent over two decades mining federal crime records and newspaper accounts to track trends in mass killings.

Perhaps this dearth of data is no surprise. Research on any kind of gun violence gets little federal funding (*SN: 5/14/16, p. 16*). Criminologist James Alan Fox of Northeastern University in Boston has argued for over 20 years that crime researchers mostly ignore mass shootings. Some of these researchers assume that whatever causes people to commit any form of murder explains mass shootings. Others regard mass killings as driven by severe mental disorders, thus falling outside the realm of crime studies.

When a research vacuum on a matter of public safety meets a 24-hour news cycle juiced up on national anguish, a thousand speculations bloom. "Everybody's an expert on this issue, but we're relying on anecdotes," says sociologist Michael Rocque of Bates College in Lewiston, Maine.

Rocque and Duwe published a review of what's known about reasons for mass public shootings, sometimes called rampage shootings, in the February *Current Opinion in Psychology*. Their conclusion: not much. Scientific ignorance on this issue is especially concerning given that Rocque and Duwe describe a slight, but not unprecedented, recent uptick in the national rate of rampage shootings.

Shooting stats

Defining mass public shootings to track their frequency is tricky. A consensus is emerging that these events occur in public places, include at least four people killed by gunshots within a 24-hour period and are not part of any other separate crime, Rocque and Duwe say.

Overall, mass public shootings are rare, Duwe says, though intense media coverage may suggest the opposite. Even less obvious is that rampage shootings have been occurring for at least 100 years.

Using FBI homicide reports, Congressional Research Service data on mass shootings and online archives of news accounts about multiple murders, Duwe has tracked U.S. rates of mass shootings from 1915 to 2017.

He has identified 185 such events through 2017, 150 of which have occurred since 1966. (In 2016, he published results up to 2013 in the *Wiley Handbook of the Psychology of Mass Shootings*.) In the earliest-known case, from 1915, a Georgia man shot five people dead in the street, after killing an attorney he blamed for financial losses, and wounded 32 others. Another lawyer, who came to the crime scene upon hearing gunshots and was wounded by a bullet, ended the rampage when he grabbed a pistol from a hardware store and killed the shooter.

What stands out over a century later is that, contrary to popular opinion, mass public shooting rates have not ballooned to record highs. While the average rate of the crimes since 2005 is up, it's currently no greater than rates for some earlier periods. Crime trends are usually calculated as rates per 100,000 people for, say, robberies and assaults. But because of the small number of mass shootings, Duwe calculates annual rates per 100 million people in the United States.

The average annual rate of mass public shootings since 2010 is about 1.44 per 100 million people. That roughly equals the 1990s rate of 1.41, Duwe finds.

The average annual rate from 1988 to 1993 reached 1.52, about the same as the 1.51 rate from 2007 to 2012. After dropping to just below 1 per 100 million people in 2013 and 2014, rates increased to nearly 1.3 the next three years.

From 1994 to 2004, rates mostly

JOHN MCCALL/*SOUTH FLORIDA SUN-SENTINEL*, ASSOCIATED PRESS

hovered around 1 per 100 million people or below, but spiked to over 2.5 in 1999. That's the year two teens killed 13 people at Columbine High School in Colorado.

In contrast, rates were minuscule from 1950 to 1965, when only three mass shootings were recorded. The average annual rate for 1970 to 1979 reached 0.52, based on 13 mass shootings.

Numbers of people killed and wounded per shooting incident have risen in the last decade, though. Two events in 2012 were particularly horrific. Shootings at a movie theater in Aurora, Colo., and an elementary school in Newtown, Conn., resulted in 40 murders, many of children, and 60 gunshot wounds. Whether this trend reflects an increasing use of guns with large-capacity magazines or other factors "is up for grabs," Duwe says.

The unknowns

No good evidence exists that either limiting or loosening gun access would reduce mass shootings, Rocque says. Virtually no research has examined whether a federal ban on assault weapons from 1994 to 2004 contributed to the relatively low rate of mass public shootings during that period. The same questions apply to concealed-carry laws, promoted as a way to deter rampage killers. As a gun owner and hunter, Rocque calls for "an evidence-based movement" to establish links between gun laws and trends in mass shootings.

Mental illness also demands closer scrutiny, Duwe says. Of 160 mass public shooters from 1915 to 2013, about 60 percent had been assigned a psychiatric diagnosis or had shown signs of serious mental illness before the attack, Duwe has found. In general, mental illness is not linked to becoming violent. But, he says, many mass shooters are tormented and paranoid individuals who want to end their painful lives after evening the score with those they feel have wronged them.

Masculinity also regularly gets raised as a contributor to mass public shootings. It's a plausible idea, since males committed all but one of the tragedies in Duwe's review. Michael Kimmel, a sociologist at Stony Brook University in New York, contends that a sense of wounded masculinity as a result of various life failures inspires rage and even violence. But researchers have yet to examine how any facet of masculinity plays into school or workplace shootings, Rocque says.

Although school shooters often report feeling a desperate need to make up for having been inadequate as men, many factors contribute to their actions, argues clinical psychologist Peter Langman. Based in Allentown, Pa., Langman has interviewed and profiled several dozen school shooters.

He divides perpetrators into three psychological categories: psychopathic (lacking empathy and concern for others), psychotic (experiencing paranoid delusions, hearing voices and having poor social skills) and traumatized (coming from families marked by drug addiction, sexual abuse and other severe problems).

But only a few of the millions who qualify for those categories translate their personal demons into killing sprees. Any formula to tag mass shooters in the making will inevitably round up lots of people who would never pose a deadly threat.

"There is no good evidence on what differentiates a bitter, aggrieved man from a bitter, aggrieved and dangerous man," says Benjamin Winegard, a psychologist at Carroll College in Helena, Mont.

Nor does any published evidence support claims that being a bully or a victim of bullying, or watching violent video games and movies, leads to mass public shootings, Winegard contends. Bullying affects a disturbingly high proportion of youngsters and has been linked to later anxiety and depression but not to later violence (*SN: 5/30/15, p. 12*). In lab studies, youngsters who play violent computer games or watch violent videos generally don't become more aggressive or violent in experimental situations. Investigators have found that some school shooters, including the Newtown perpetrator, preferred playing nonviolent video games, Winegard says.

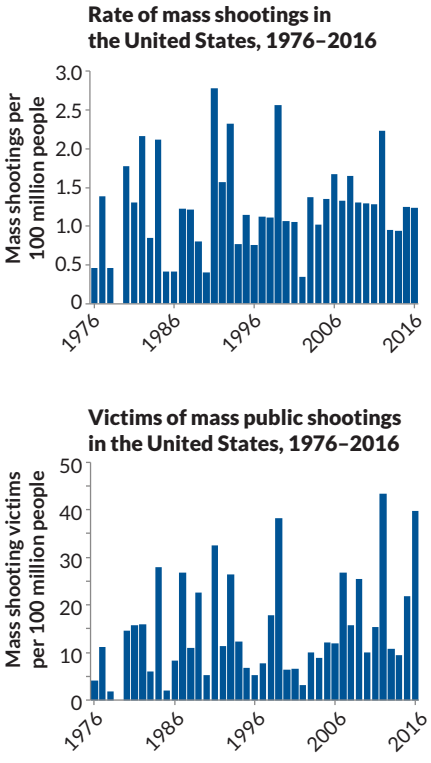
He and a colleague presented this evidence in the *Wiley Handbook of the Psychology of Mass Shootings*.

Still, a small but tragic group of people lead lives that somehow turn them into killers of classmates or strangers (*SN: 5/27/06, p. 328*). If some precise mix of, say, early brain damage, social ineptitude, paranoia and fury over life's unfair twists cooks up mass killers, scientists don't know the toxic recipe. And it won't be easy to come up with one given the small number of mass public shooters to study.

Duwe recommends that researchers first do a better job of documenting the backgrounds of individual mass shooters and any events or experiences that may have precipitated their actions. Then investigators can address broader social influences on mass shootings, including gun legislation and media coverage.

But more than a century after a distraught Georgia man mowed down six of his fellow citizens, research on mass violence still takes a back seat to public fear and outrage. "If we're bemoaning the state of research," Duwe says, "we have no one to blame but ourselves." ■

On a rampage Recent annual rates of mass shootings in the United States have not been unprecedented (top). But rates of victims killed and injured in these incidents have gone up in the last decade (bottom).



G. DUWE

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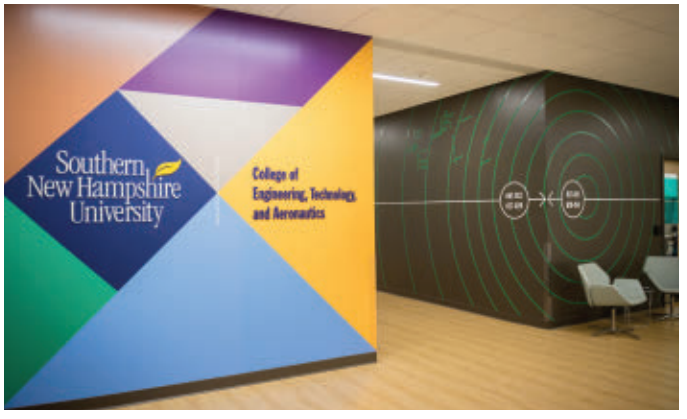


Just over a year ago, we at Southern New Hampshire University proudly announced our intention to expand our program offerings with a massive new STEM initiative. This initiative culminated in the launch of our College of Engineering, Technology, and Aeronautics (CETA).

In the time since then, CETA has opened its doors and begun to thrive. We have always measured our success by our students' success, and CETA has allowed SNHU to better serve our students' needs both now and into the future. As more and more students enter college with the goal of earning high-paying jobs after graduation, we are proud to offer a first-rate education responsive to the needs of a wide range of scientific industries.

"They have an idea of what they want to be, and they want a university that's going to provide them with a learning environment to be able to succeed in that," says James Smith, CETA's executive vice president. "And clearly, they want a pathway to a job."

Guiding students along the path to their career goals has long been a strength at SNHU, and CETA allows us to help students build careers in exciting new industries. With major programs including Computer Science, Mechanical Engineering, Aeronautical Engineering, and more, we're helping students gain knowledge and experience in a wide range of STEM fields. This year, we even added an Aviation Operations and Management degree, New Hampshire's newest flight program.

We empower our students at SNHU. We empower them to shape their own education, but, more than that, we empower them to seek out the experience they need to find success in their field of study. Our Career and Professional Development Center posts over 1,500 internship and job listings each year, a number that is sure to grow as we develop new partnerships with engineering and aeronautical organizations for our CETA students. With career development opportunities built directly into our curriculum, our goal is to ensure that every student who leaves SNHU does so fully prepared to enter the workforce.

Over the next several years, SNHU will invest $50 million in CETA, an investment that includes the construction of a new, state-of-the-art engineering, technology, and aeronautics building slated to open in the fall of 2019. SNHU Online has given us access to resources that outpace many similarly sized institutions, and we will continue to use those resources to make improvements to our campus, expand our academic offerings, and make a high-quality private education accessible to as many students as possible.

If you'd like to learn more about Southern New Hampshire University, feel free to get in touch! You can email us at **admission@snhu.edu** or call us at **603-645-9611**.

Overwhelmed

Heat waves are on the rise, putting city dwellers in danger

By Aimee Cunningham

Some victims were found at home. An 84-year-old woman who'd spent over half her life in the same Sacramento, Calif., apartment died near her front door, gripping her keys. A World War II veteran succumbed in his bedroom. Many died outside, including a hiker who perished on the Pacific Crest Trail, his water bottles empty.

The killer? Heat. Hundreds of others lost their lives when a stifling air mass settled on California in July 2006. And this repeat offender's rap sheet stretches on. In Chicago, a multiday scorcher in July 1995 killed nearly 700. Elderly, black residents and people in homes without air conditioning were hardest hit. Europe's 2003 heat wave left more than 70,000 dead, almost 20,000 of them in France. Many elderly Parisians baked to death in upper-floor apartments while younger residents who might have checked in on their neighbors were on August vacation. In 2010, Russia lost at least 10,000 residents to heat. India, in 2015, reported more than 2,500 heat-related deaths.

Year in and year out, heat claims lives. Since 1986, the first year the National Weather Service reported data on heat-related deaths, more people in the United States have died from heat (3,979) than from any other weather-related disaster — more than floods (2,599), tornadoes (2,116) or hurricanes (1,391). Heat's victim counts would be even higher, but unless the deceased are found with a fatal body temperature or in a hot room, the fact that heat might have been the cause is often left off of the death certificate, says Jonathan Patz, director of the Global Health Institute at the University of Wisconsin–Madison.

As greenhouse gases accumulate in the atmosphere, heat's toll is expected to rise. Temperatures will probably keep smashing records as carbon dioxide, methane and other gases continue warming the planet. Heat waves (unusually hot weather lasting two or more days) will probably be longer, hotter and more frequent in the future.

Beyond deaths, researchers are beginning to document other losses: Heat appears to rob us of sleep, of smarts and of healthy births. "Heat has the ability to affect so many people," says Rupa Basu, an epidemiologist with the California Environmental Protection Agency's Office of Environmental Health Hazard Assessment in Oakland. "Everybody's vulnerable."

In New Delhi, India, during a May 2015 heat wave, a man wipes his brow. That year, heat claimed more than 2,500 lives in the South Asian country.

TSERING TOPGYAL/AP PHOTO

Many people see heat as more of an annoyance than a threat, but climate change, extreme heat and human health are entwined. "There might not be a huge burden of disease from heat-related illness right now in your community," says Jeremy Hess, an emergency medicine physician and public health researcher at the University of Washington in Seattle. "But give it another 20 years, and it might be a more significant issue."

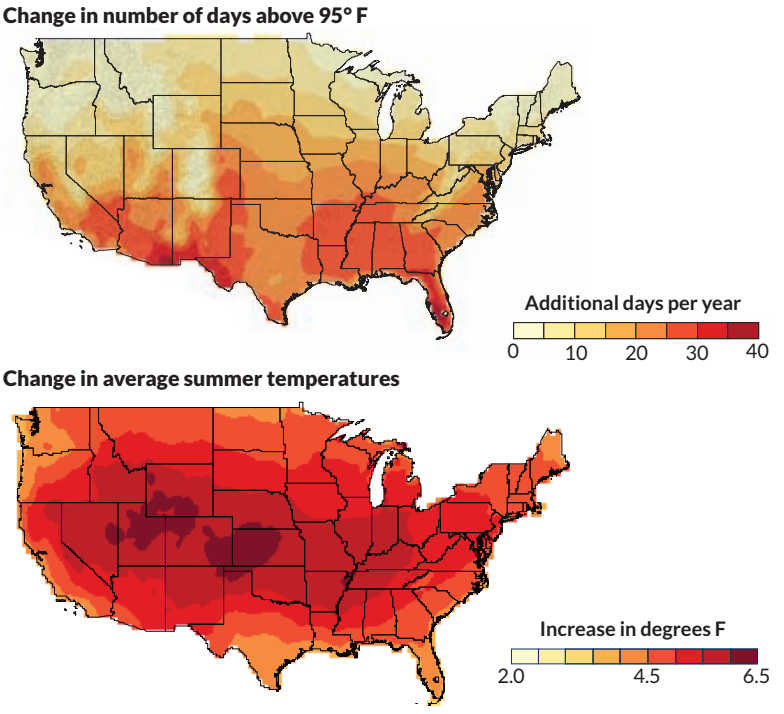
Adaptation has limits

The human body can't tolerate excessive heat. The biological and chemical processes that keep us alive are best carried out at a core temperature of 36° to 37° Celsius (96.8° to 98.6° Fahrenheit), with slight variation from person to person. Beyond that, "the body's primary response to heat is to try and get rid of it," says Jonathan Samet, dean of the Colorado School of Public Health in Aurora. Blood vessels in the skin dilate and heart rate goes up to push blood flow to the skin, where the blood can release heat to cool down. Meanwhile, sweating kicks in to cool the skin.

With repeated exposure to high temperatures, the body can become more efficient at shedding excess heat. That's why a person can move from cold Minneapolis to steamy Miami and get used to the higher heat and humidity. But there is a limit to how much a person can adjust, which depends on the person's underlying health and the ambient temperature and humidity. If the outside is hotter than the body, blood at the skin surface won't release heat. If humidity is high, sweating won't cool the skin. Two scientists proposed in 2008 that humans cannot effectively dissipate heat with extended exposure to a wet-bulb temperature, which combines heat and humidity, that is greater than 35° C.

Forced to regulate heat without a break, the body gets worn out. Heat exhaustion leads to weakness, dizziness and nausea. If a person doesn't cool off, heat stroke is likely — and likely fatal. The ability to regulate heat breaks down and core body temperature reaches or exceeds 40° C. A person suffering heat stroke may have seizures, convulsions or go into a coma.

No one is immune to heat, but it hits some groups harder than others. The elderly, considered the most vulnerable, have fewer sweat glands and their bodies respond more slowly to rising temperatures. Children haven't fully developed the ability to regulate heat, and pregnant women can struggle due to the demands of the fetus. People with chronic diseases like diabetes, cardiovascular disease and obesity can have trouble dissipating heat. And, of course, people living in poverty often lack air conditioning and other resources to withstand sweltering conditions.



Nowhere but up
The number of days each year above 95° Fahrenheit (35° Celsius) is expected to rise across the United States, and average summer temperatures will reach new heights if greenhouse gas emissions remain high. The maps above compare late 20th century temperatures to projections for the mid–21st century.

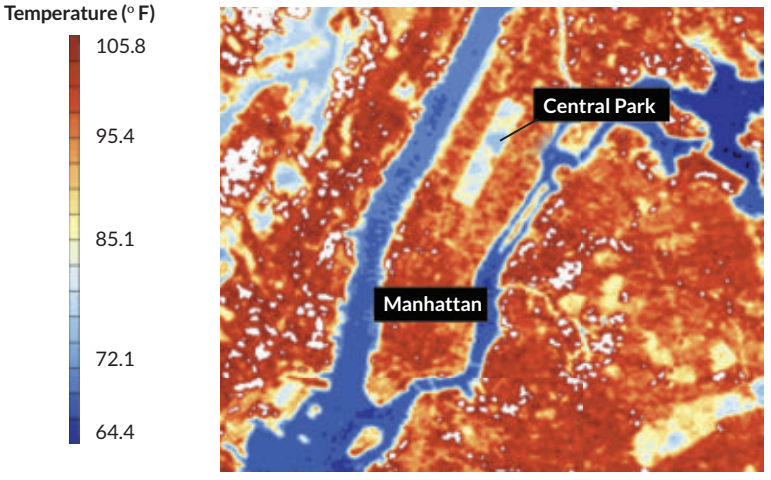
Collateral damage

Researchers are discovering more ways that heat can hurt. Take sleep: The onset and duration of sleep is sensitive to temperature. The body cools down as it prepares to sleep; this decrease in core temperature is a signal to bring on the z's. Body temperature stays low throughout the night, then rises just before awakening. A good night's rest is a cornerstone of health.

Hot nights make for bad sleep, according to a study combining responses to a U.S. Centers for Disease Control and Prevention sleep survey of 765,000 U.S. residents from 2002 to 2011 with data on nighttime temperatures during that period. The higher the nighttime temperatures, the more nights respondents reported getting too little shut-eye. The effect hit low-income respondents and the elderly hardest, the researchers reported last May in *Science Advances*.

The ability to think and calculate may take a beating in the heat, according to a small study presented in January in Austin, Texas, at the American Meteorological Society's annual meeting. Researchers from Harvard University tested undergraduate students for 12 days — the time before, during and after a heat wave. Twenty-four

U.S. GLOBAL CHANGE RESEARCH PROGRAM

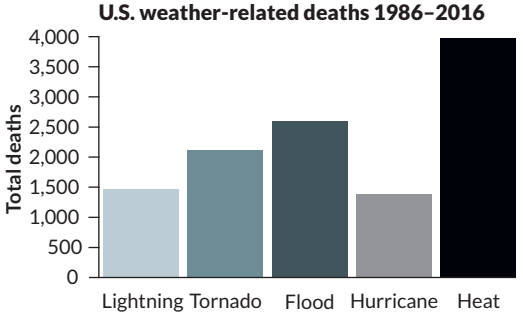


Sun-day in the park The cooler hues of Central Park jump out of this otherwise red-hot map of New York City heat on a summer day. The built areas of the city are around 10 degrees Fahrenheit higher than tree-filled parts of the park.

lived in buildings with air conditioning and 20 in buildings without. The researchers assessed how quickly and accurately students performed an addition and subtraction test and a test that asked for the color of a written word, rather than the word itself. During the heat wave, the students without air conditioning got about 6 percent fewer correct answers on the math problems and 10 percent fewer on the color problems than the students with air conditioning.

Heat may even increase the risk of stillbirth. Researchers with the National Institute of Child Health and Human Development in Bethesda, Md., analyzed weather data and more than 223,000 U.S. births from 2002 to 2008. During the warm months of the year, a 1 degree C increase in temperature during the week before birth was associated with about four additional stillbirths per 10,000 births, the researchers reported last June in *Environmental Health Perspectives*.

As heat gets vicious, it threatens to disrupt the fabric of society. Extreme heat — beyond a wet-bulb temperature of 35° C — could become more regular in South Asia and the Persian Gulf, rendering parts of those areas uninhabitable, according to studies in the August 2017 *Science Advances* (*SN: 9/2/17, p. 10*) and the February 2016 *Nature Climate Change*. It's not hard to imagine that there will be profound societal and political instability "in a world where tens of millions of people have to move and are looking for cooler places to live," says Howard Frumkin, a physician epidemiologist specializing in environmental health at the University of Washington.



Weather dangers
Although tornadoes, floods and hurricanes tend to get more attention, U.S. heat fatalities top the list of weather-related deaths in the 30 years since heat-related data were first reported.
SOURCE: NATIONAL WEATHER SERVICE

Emerald cities

Fifty-four percent of the world's population — and around 80 percent of U.S. residents — live in urban areas. Cities are where some action to combat heat can be taken now, says Brian Stone Jr., an environmental planner and member of the Urban Climate Lab at Georgia Tech in Atlanta. "If we're waiting for the national government to signal it's time to do this, we're going to wait too long," he says. "We are well into a world that's been altered by climate change."

Heat thrives in cities. All of the nonreflective roofs, walls, roads and other surfaces absorb and retain heat during the day. Waste heat, emitted from air conditioners and vehicles, concentrates in cities too. Together, these factors contribute to what's called an urban heat island, an amplification of heat that occurs within cities. On average, a city with at least a million residents can be 1 to 3 degrees C hotter than surrounding areas. At night, the temperature differences widen. Cities may be as much as 12 degrees C hotter than surrounding areas in the evening hours, because cities release built-up heat back out among buildings and avenues.

City planners can rid their locales of some of this heat with several strategies. One is to plant more trees to create shade for residents and structures. Trees also lower the air temperature by transferring water from the soil through the tree to the air. The surrounding air is cooled as the water changes from a liquid to a vapor. The process is "much like the way sweating works for our bodies," says George Ban-Weiss, an environmental engineer at the University of Southern California in Los Angeles.

Another strategy is to reduce the amount of sunlight that city surfaces absorb by using "cool" materials on exposed surfaces. The best known are cool roofs, which "reflect more sunlight than usual," says Ronnen Levinson of Lawrence Berkeley National Laboratory in Berkeley, Calif., who studies cool surfaces and urban heat islands. In

FROM TOP: DANIEL BADER/COLUMBIA UNIV.; T. TIBBITTS

general, to make a surface cool, you make it lighter, with coatings or other light-colored materials. For example, a white roof that reflects 80 percent of the sun's light on a typical summer afternoon will stay about 31 degrees C cooler than a gray roof that reflects only 20 percent.

Giving buildings cool-surface makeovers counters the urban heat island effect and reduces the temperature inside a building. "In disadvantaged communities, people simply may not have air conditioning to help them ride out hot summers," Levinson says. Cooling off the insides of buildings is "where I think the greatest potential benefits are for improving human comfort and health," he says.

Stone has estimated how many heat-related deaths could be avoided by reducing urban heat island effects. In 2016, he and colleagues produced a report for the city of Louisville, Ky., that analyzed the impact of adding 450,000 trees, converting 168 square kilometers of surfaces to cool materials and more. The researchers estimated that areas of the city could reduce average summertime temperatures by as much as 1.7 degrees C or more. And based on the 53 deaths Stone attributed to the city's unusually warm summer of 2012, there could be 11 fewer deaths from heat, a reduction of 21 percent. "When we get a big heat wave," Stone says, "that could really translate into hundreds of lives."

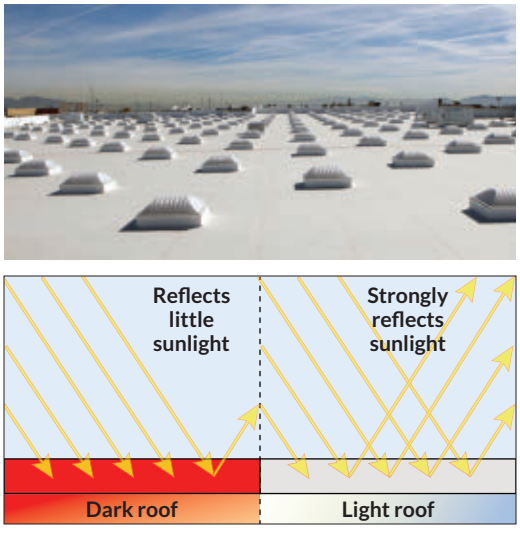
Many cities in the United States and abroad are working on tempering their urban heat islands with a variety of strategies, including programs to install cool roofs or plant more trees. The city of Los Angeles now requires that new or replaced roofs for homes and other residential buildings meet a solar reflectance index value — a measure of a materials' ability to stay cool in the sun between zero (black surface) and 100 (white) — of at least 75 for flatter roofs and 16 for steeper ones. Through a provision in California's building energy efficiency code, cities throughout the state have been converting flat, commercial roofs, like those on big-box stores, to light-colored cool roofs when a new topper is needed.

New York City has planted a million new trees since 2007 and committed additional funds to adding even more to streets and parks. The city also has coated 0.62 square kilometers of roof surfaces white since 2009. The city of Ahmedabad, India, where about 25 percent of the residents live in slum communities, announced a heat action plan in 2017 that includes a cool roofs initiative to paint or otherwise convert at least 500 slum household roofs and to improve the reflectivity of roofs on government buildings and schools.

> Cities are working on tempering their urban heat islands with programs to install cool roofs or plant more trees.

Measures that tackle the urban heat island effect also make cities more energy efficient (by reducing the cooling needs inside buildings) and more comfortable (by shading city residents). Individual cities need to implement strategies that make sense for their landscapes, their water resources, their usual climate and their populations, Ban-Weiss says.

But ameliorating urban heat can only do so much. There will still need to be a worldwide push to reduce emissions of greenhouse gases. Ban-Weiss and colleagues estimated how much cool roofs could counter warming from climate change in Southern California. Assuming that greenhouse gas emissions continue to increase, the widespread adoption of cool roofs in the Los Angeles metropolitan area would offset some of the warming expected by midcentury, the team reported in 2016 in *Environmental Research Letters*. But by the end of the century, Ban-Weiss says, the cool roof benefits "become mostly dwarfed by climate change." ■



A light roof (top) reflects more sunlight and can thus be dozens of degrees cooler than a dark roof.

In July 2014, a worker in Las Vegas cools off with a wet cloth during a break from her outdoor advertising job. Hot days are expected to become more common.

FROM TOP: AP PHOTO/JOHN LOCHER; WALMART/FLICKR (CC BY 2.0); T. TIBBITTS

Explore more

- Lawrence Berkeley National Lab Heat Island Group: heatisland.lbl.gov
- Climate change and extreme heat: What you can do to prepare. bit.ly/CDCclimatehealth

MASS MIGRATIONS

Researchers are asking big questions about animal movements by tracking tiny insects in flight

By Alexandra Witze

This hawk moth (*Hyles gallii*) is one of millions of insects that migrate through a Swiss Alpine pass each year.

WILL HAWKES, @HAWKES_WILL

Every autumn, a quiet mountain pass in the Swiss Alps turns into an insect superhighway. For a couple of months, the air thickens as millions of migrating flies, moths and butterflies make their way through a narrow opening in the mountains. For Myles Menz, it's a front-row seat to one of the greatest movements in the animal kingdom.

Menz, an ecologist at the University of Bern in Switzerland, leads an international team of scientists who descend on the pass for a few months each year. By day, they switch on radar instruments and raise webbed nets to track and capture some of the insects buzzing south. At sunset, they break out drinks and snacks and wait for nocturnal life to arrive. That's when they lure enormous furry moths from the sky into sampling nets, snagging them like salmon from a stream. "I love it up there," Menz says.

He loves the scenery and the science. This pass, known as the Col de Bretolet, is an iconic field site among European ecologists. For decades, ornithologists have tracked birds migrating through. Menz is doing the same kind of tracking, but this time, he's after the insects on which the birds feast.

Migrating insects, like those that zip through the Swiss mountain pass, provide crucial ecosystem services. They pollinate crops and wild plants and gobble agricultural pests.

"Trillions of insects around the world migrate every year, and we're just beginning to understand their connections to ecosystems and human life," says Dara Satterfield, an ecologist

at the Smithsonian Institution in Washington, D.C.

Scientists like Menz are fanning out across the globe to track butterflies, moths, hoverflies and other insects on their great journeys. Among the new discoveries: Painted lady butterflies time their round trips between Africa and Europe to coincide within days of their favorite flowers' first blossoms. Hoverflies navigate unerringly across Europe for more than 100 kilometers per day, chowing down on aphids that suck the juice out of greening shoots. What's more, some agricultural pests that ravage crops in Texas and other U.S. farmlands are now visible using ordinary weather radar, giving farmers a better chance of fighting off the pests.

Until now, most studies of animal migration have focused on large, easy-to-study birds and mammals. But entomologists say that insects can also illuminate the phenomenon of mass movement. "How are these animals finding their way across such large scales? Why do they do it?" asks Menz. "It's really quite fantastic."

To warmer worlds

Animals migrate for many reasons, but the aim is usually to eat, breed or otherwise survive year-round. One of the most famous insect migrations, of North America's monarch butterflies (*Danaus plexippus*), happens when the animals fly south from eastern North America to overwinter in Mexico's warmer setting. (A second population from western North America overwinters in California.) In Taiwan, the purple crow butterfly (*Euploea tulliolus*) migrates south from northern and central parts of the island to the warmer Maolin scenic area every winter, where the butterfly masses draw crowds of lepidopteran-loving tourists. In Australia, the bogong moth (*Agrotis infusa*) escapes the hot and dry summer of the country's eastern parts by traveling in the billions to cool mountain caves in the southeast.

The migrations can be arduous. Each spring, the painted lady butterfly (*Vanessa cardui*) moves out of northern Africa into Europe, crossing the harsh Sahara and then the Mediterranean Sea before retracing the route in the autumn (*SN Online: 10/12/16*). Because adult life spans are only about a month, the journey is a family affair: Up to six generations are needed to make the round trip. It's like running a relay race, with successive generations of butterflies passing the baton across thousands of kilometers.

Constantí Stefanescu, a butterfly expert at the Museum of Natural Sciences in Granollers, Spain, has been tracking the painted lady migrations. He relies on citizen scientists who alert him when the orange-and-black-winged painted ladies arrive in people's backyards each year, as well as field studies by groups of scientists. In 2014, 2015 and 2016, Stefanescu led autumn expeditions to Morocco and Algeria to try to catch the return of the painted ladies to their wintering grounds.

By surveying swaths of North Africa, Stefanescu's team confirmed that the painted ladies virtually disappeared from the area during the hot summer months and returned in huge numbers in October. The fliers arrived back in Africa just in time to feed on the daisylike false yellowhead (*Dittrichia viscosa*) and other flowers. The findings make clear how well the butterflies are able to time their migrations to take advantage of resources, Stefanescu reported in December in *Ecological Entomology*.

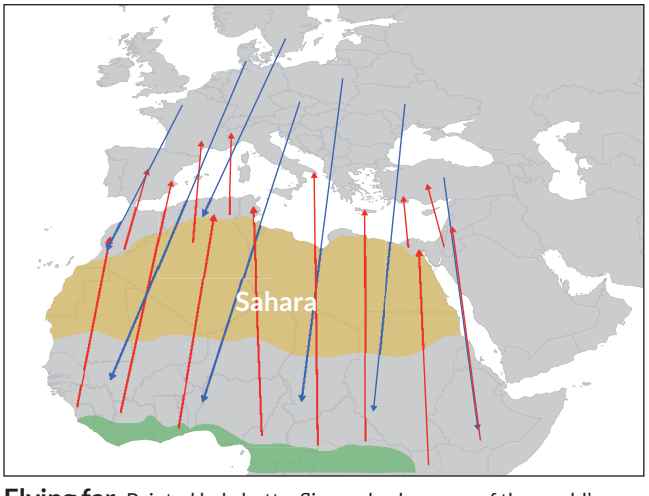
Naturalists track the distinctive painted lady butterfly (*Vanessa cardui*) during its annual migrations.

Other insect species are less visibly stunning than the painted lady, but just as important to the study of migrations. One emerging model species is the marmalade hoverfly (*Episyrphus balteatus*), which migrates from northern to southern Europe and back each year.

Marmalade hoverflies have translucent wings and an orange-and-black striped body. As larvae, they eat aphids that would otherwise damage crops. As adults, the traveling hoverflies help pollinate plants. "They're useful for so many things," says Karl Wotton, a geneticist at the University of Exeter in England.

Wotton started thinking about the importance of insect migration after 2011, when windblown midges carried an exotic virus into the southern United Kingdom that caused birth defects in cattle on his family's farm. Intrigued, Wotton set up camp at a spot in the Pyrenees at the border of Spain and France to study migrating hoverflies. Then he heard that Menz was doing almost exactly the same kind of research at the Col de Bretolet and a neighboring pass. The two connected, hit it off and now collaborate in both the Pyrenees and the Alps.

Funneled by the high mountain topography, hoverflies whiz through the passes like rush hour commuters through a railway station. "We're talking about an immense number of insects," Menz says. Millions of flies traverse the Swiss



Flying far Painted lady butterflies embark on one of the world's most distinctive migrations, traveling thousands of kilometers from Africa into Europe each spring, and back again in the fall. It can take six generations of butterflies to make the round trip journey.

FROM TOP: JOHN SERRAO/SCIENCE SOURCE; GERARD TALAVERA, BASED ON G. TALAVERA AND R. VILA, *BIOLOGICAL JOURNAL OF THE LINNEAN SOCIETY* 2017

The marmalade hoverfly (*Episyrphus balteatus*) eats aphids and pollinates plants as it travels.

passes each year. Extrapolating to all of Europe, Wootton estimates that many billions of hoverflies are probably migrating. The insects consume billions of aphids that otherwise would have feasted on agricultural crops.

As astonishing as this migration is, most people never notice it. Only at the passes do the hoverflies become noticeable, a never-ending stream of tiny bodies glinting in the mountain light. They ride high on tailwinds and scoot low when the wind is against them. "They fly fast and low and they don't stop," Wotton says. "The butterflies are getting turned around like in a tumble dryer, but the hoverflies just shoot straight over."

Wotton, Menz and colleagues use specialized upward-looking radar to track signals reflecting off of insects passing overhead. The researchers also use traps to catch individual flies to identify the species passing through.

And they study navigation in a sort of hoverfly flight simulator. The researchers glue the backs of flies to the heads of pins and watch how the flies navigate when held between two magnets. The aim is to see if the insects are using cues from Earth's magnetic field to find their way. Suspended between the magnets, the insects can move freely left or right, choosing their direction of travel. The whole contraption is enclosed in an opaque plastic barrel so the flies cannot see the visual cues of the surrounding mountains. Preliminary findings suggest the flies do indeed find their way using some kind of compass, Wotton reported in Denver last November at a meeting of the Entomological Society of America.

Season after season, the researchers are building up a hoverfly census. By comparing that information with a 1960s survey done at the Col de Bretolet, the team hopes to determine whether species' numbers have changed over time. Menz says: "I wouldn't be surprised if they've declined."

Other entomologists have documented sharp drops in the numbers of insects across Europe. Last October, a Dutch-German-British research team reported in *PLOS ONE* that the total insect biomass collected at 63 nature-protection areas in Germany over 27 years had dropped by more than 76 percent.

The paper garnered media headlines around the world as heralding an "insect Armageddon." That may be overly dramatic. The work covered just one small part of Europe, and the authors could not explain what might be causing the drop, whether climate change, habitat destruction or something else.

But if hoverfly numbers are dropping, that would mean fewer are around to eat destructive aphids and to spread beneficial pollen. Hoverflies, which pollinate a wide range of plants, are the second most important group of pollinators in Europe after bees, Wotton says.

76
percent
Drop in insect biomass collected in protected areas of Germany from 1989 to 2016

Hoverflies also migrate in North America, in ways that are far less understood than in Europe. This month, Menz and Wotton are visiting Montaña de Oro State Park on California's Central Coast, where last year an entomologist reported spotting a rare hoverfly migration. The researchers hope to see whether the American hoverflies, probably a different species, are moving in the same ways their European cousins do.

Swoop in the destroyers

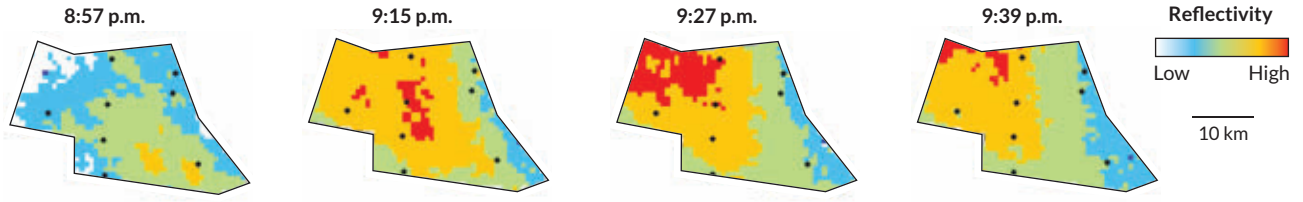
Not all migrating insects are beneficial. Some are troublemakers that chase ripening crops with the season. Farmers can spray pesticides once insects arrive in the fields, but knowing more about when and where to expect the critters can help growers better prepare for the onslaught.

Weather radar — Doppler data that meteorologists use to follow rain, hail and snow in near real time — is beginning to help. The radar signals reflect off of birds and other animals flying through the air. And although many insect species are too small to be detected in Doppler radar data, researchers are finding new ways to extract the signals of insects and track their migrations as they happen.

John Westbrook, a research meteorologist at the U.S. Department of Agriculture's Agricultural Research Service in College Station, Texas, has been using weather radar to follow insect

Scientists rigged a moth trap at this Swiss pass so they could capture, identify and release migrating moth species.

BOTH: WILL HAWKES, @HAWKES_WILL



Tracking pests Weather radar data from southern Texas reveal the higher reflectivity of flying crop-eating moths (red). During an outbreak in 1995 that destroyed cotton crops, the moths flew northwest across much of Willacy County (shown) in under an hour. Farmers could use similar radar data to track pests approaching fields.

flyways in the south-central United States. A 1995 outbreak of two migratory moth species — beet armyworm (*Spodoptera exigua*) and cabbage looper (*Trichoplusia ni*) — devastated cotton crops in Texas' Lower Rio Grande Valley. Westbrook recently dug through the Doppler data from 1995 and was able to pick out the signals of these two species moving during the outbreak, Westbrook and USDA colleague Ritchie Eyster wrote last November in *Remote Sensing Applications: Society and Environment*.

"Outbreaks are unpredictable," Westbrook says. "But the weather radar can show where they are occurring." Modern weather radar contains even more information than 1995 systems did, he notes — and farmers can use that data to their advantage. They may decide to spray heavily where most of the insects are gathering before they spread. Or farmers might stock up on pesticides if a particularly dangerous outbreak is headed in their direction.

Another way to track destructive insects is to grind them up and test the chemistry of their tissues. As caterpillars grow, they take on a characteristic chemical signature of the environment, with hydrogen, oxygen and other elements fixed in tissues in varying amounts. Analyzing those ratios can reveal the geographic region of a caterpillar's origin.

Larvae of the migratory cabbage looper (top) destroy cabbage and other crops.

Keith Hobson of Western University in London, Canada, and colleagues have been studying the insect pest known as the true armyworm moth (*Mythimna unipuncta*). It travels between Canada and the southern United States every year, damaging crops along the way. But scientists weren't sure exactly where the insects originated each year, making it harder to figure out how to manage the problem with pesticides.

In new experiments, Hobson's team captured true armyworm moths in Ontario throughout the year and analyzed the hydrogen retained within the moths' wings. Moths captured early in the season had values similar to those seen in Texas waters, while those captured in the summer showed values closer to Canadian waters. The reverse was also true: Adult moths captured in autumn in Texas had Canadian-type values.

It is the first direct evidence that individual moths are making these long-distance round trips, the scientists wrote in January in *Ecological Entomology*. Further studies could reveal how to better control the pests throughout the growing season, by showing precisely where the insects are coming from and how far they will travel.

The migrating masses

For Menz, Wotton, Satterfield and the rest, the ultimate goal is to go from studying individual species to investigating broader questions of how and why animals move around. That includes exploring how insects alter food webs during migrations across the landscape.

For instance, Mexican free-tailed bats (*Tadarida brasiliensis*) in Texas and Mexico forage for nocturnal moths, which migrate in very narrow layers in the atmosphere based on how the wind is blowing. "These are like food webs in the sky," says Jason Chapman, an ecologist at the University of Exeter. "Can bats read the weather patterns and predict where the insects are going to be?"

Similarly, many dragonflies attempt to migrate 3,500 kilometers or more across the Indian Ocean from India to east Africa and back each year, breeding in temporary ponds created by monsoon rains. The dragonfly-eating Amur falcon (*Falco amurensis*) makes a similar journey, in one of the longest-known migrations for any raptor. If the dragonflies are the reason for the falcon migration, then tiny insects are a major player in this important bird movement.

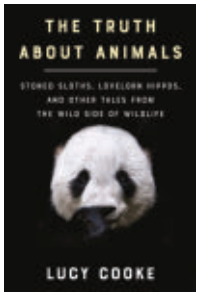
Insects rule the migratory world by virtue of their sheer numbers. Compared with birds, mammals and other migratory animals, insects are by far the most numerous. Roughly 3.5 trillion migrate each year over just the southern United Kingdom, a 2016 radar study suggested (*SN: 2/4/17, p. 12*). That means that the majority of land migrations are made by insects.

To Aislinn Pearson, an entomologist at Rothamsted Research in Harpenden, England, studying insects will boost scientific understanding of how animals flow around the planet. "In the next 10 years," she says, "a lot of the key findings of migration are going to come from these tiny little animals." ■

Explore more

- Insect Migration and Ecology Lab, University of Bern: insectmigration.wordpress.com

FROM TOP: J.K. WESTBROOK AND R.S. EYSTER/*REMOTE SENSING APPLICATIONS: SOCIETY AND ENVIRONMENT* 2017; ALTON N. SPARKS, JR., UNIV. OF GEORGIA, UNITED STATES/WIKIMEDIA COMMONS (CC BY 3.0); UNIV. OF MINNESOTA.



The Truth About Animals
Lucy Cooke
BASIC BOOKS, $28

BOOKSHELF

Animal adventure tales debunk wildlife myths

Nearly 2,000 years ago, Pliny the Elder reported that hippopotamuses find relief from overeating by piercing their skin in a hippo version of bloodletting. Eventually, scientists learned that the oozing red stuff Pliny described isn't even blood but a secretion that may have antibacterial and sun-blocking properties. While chasing down the truth for herself, Lucy Cooke scooped the goo from a hippo and smeared it on her own skin — if nothing else, her hand was "noticeably silkier," she writes in *The Truth About Animals*.

Cooke, a zoologist and documentary filmmaker, has a storehouse of such tales of animal adventure. She's also the founder of the Sloth Appreciation Society, whose motto is "Being fast is overrated." That motto gives a glimpse into her sense of humor, which shines through page after page, and her affinity for misunderstood creatures. Cooke battles the notion that sloths are lazy or stupid just because they're slow-moving. In her book, she set out to, as she writes, "create my very own menagerie of the misunderstood."

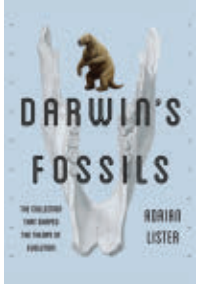
And quite a menagerie it is. Each chapter takes on a different animal — bats, storks, vultures and pandas, among others — long shrouded in myth or misconception. Some, like bats, are unfairly maligned; others are adored despite shocking behavior, such as Adélie penguins, whose sex lives were considered so depraved that, in 1915, London's Natural History Museum boldly marked a paper about the birds' mating behavior as "Not for Publication."

In many cases, science created or perpetuated myths before eventually debunking them. Among the ludicrous ideas once taken as fact: Beavers escape hunters by chewing off their own testicles and dropping them as a distraction. To explain where birds disappear in winter, Aristotle once posited that they transform into different species.

Sloths are wildly misunderstood: They're slow, but they're not stupid.

Even hard-core animal lovers will find surprises in these histories. I knew, for instance, that the long-running mystery over European and American eels' spawning sites eventually led to the North Atlantic's Sargasso Sea (*SN Online: 4/13/17*). But I had no idea that Sigmund Freud was among the many who tried to solve another eel conundrum: where the fish hide their gonads. After disemboweling hundreds of eels to find their testes, Freud threw up his hands and eventually moved on to study the human psyche, perhaps slippery enough.

In the end, the history of zoology reveals as much about our human foibles as about the animals we study. And this book will leave readers more enlightened about both. — *Erika Engelhaupt*



Darwin's Fossils
Adrian Lister
SMITHSONIAN BOOKS, $19.95

BOOKSHELF

Fossils sparked Darwin's imagination

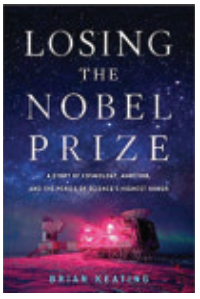
Charles Darwin famously derived his theory of evolution from observations he made of species and their geographic distributions during his five-year voyage around the world on the H.M.S. *Beagle*. But in the introduction of *On the Origin of Species*, the naturalist also cites another influence: the thousands of fossils that he collected on that trip. *Darwin's Fossils* is paleobiologist Adrian Lister's account of that little-appreciated foundation of evolutionary theory.

While sailors on board the *Beagle* charted the coastal waters of South America (the actual purpose of the expedition), Darwin explored the shore and rambled inland on excursions that sometimes lasted weeks. The fossils he unearthed — some relatively fresh, others millions of years old — have tremendous significance in the history of science, Lister contends.

Many of the species Darwin discovered in the fossils were previously unknown to science, including several giant ground sloths, compact car–sized relatives of armadillos called glyptodonts (*SN Online: 2/22/16*) and ancient kin of horses and elephants. Because many of those animals were apparently extinct — but just as apparently related to species still living in the region — Darwin concluded the fossils were strong evidence for the "transmutation," or evolution, of species. This evidence was all the more convincing to him, Lister suggests, because he had unearthed the fossils himself. He saw firsthand the fossils' geologic context, which enabled him to more easily infer how species had changed through time.

Copiously illustrated and suitable for general readers as well as the science savvy, *Darwin's Fossils* is a quick, easy read that provides a fascinating overview of the naturalist's wide-ranging fieldwork during the *Beagle* voyage. His insights from fossils went beyond just biological evolution. Darwin's studies of coral reefs (the mineralized parts of which are, after all, huge fossils) encircling islands in the Pacific and Indian oceans led him to theorize correctly how such reefs form. And his observations of strata containing marine fossils thousands of meters up into the Andes led to an improved understanding of how geologic forces sculpt the world. — *Sid Perkins*

GEORGEPETERS/ISTOCKPHOTO



Losing the Nobel Prize
Brian Keating
W.W. NORTON & CO., $27.95

BOOKSHELF

Science's top honor needs a makeover

Dust may seem insignificant, but in science, it can cost you a Nobel Prize.

That's what happened to Brian Keating, a major contributor to the BICEP2 team that claimed in 2014 to have found the first definitive evidence of cosmic inflation, a period of extremely rapid expansion just after the Big Bang. Months later, the evidence crumbled: A swirling pattern, seen in light released 380,000 years after the universe's birth, was due to cosmic dust bunnies, not inflation (*SN: 2/21/15, p. 13*). Keating's Nobel dreams disintegrated.

The most coveted of scientific honors, the Nobel Prize was a major motivator for Keating. But in *Losing the Nobel Prize*, Keating questions whether the award is good for science. He argues the prize punishes collaboration by rewarding at most three scientists for each discovery and concentrates already limited scientific funding into fields favored by laureates. Plus, the prize has a bias problem: Despite many deserving candidates, only two women have won the physics Nobel.

Likewise, idolatry of that shiny Nobel medal can lead scientists to make bad decisions, especially because the first group to announce big results will usually garner the glory. In one cringeworthy passage, Keating describes how BICEP2 scientists decided to share their findings with the world. Leaders of the experiment, which used a telescope at the South Pole to search for signs of inflation, were concerned that a competitor experiment was hot on the trail. So the team unveiled its results despite some of the evidence resting on dubious foundations. Using this story as a cautionary tale, Keating suggests options for revamping the prize, including shifting its focus to serendipitous discoveries and giving it to groups of scientists.

Losing the Nobel Prize dissects the error-prone humanity of science, but cuts the ugly details with beauty. Keating writes of BICEP, the predecessor to BICEP2, as if it's his adopted child. Even more so, his actual family is entwined with his science. While studying the origins of the universe, he attempts to understand his own origins: In graduate school, Keating reunites with his estranged father.

Charming and clever, *Losing the Nobel Prize* bounces between clear explanations of nitty-gritty science, accounts of personal relationships and historical lessons. Dust, it turns out, has foiled many astronomers before Keating, adding a confounding haze that has altered how scientists have understood the universe over the centuries.

When dust gets in our eyes, we can see things that aren't there. The same goes for the gleam of the Nobel Prize.
— Emily Conover

Congratulations to the Regeneron Science Talent Search 2018 top winners!

Teen scientists win $1.8 million at this year's competition

Benjamin "Benjy" Firester, 18, of New York City, won the top award of $250,000 for developing a mathematical model that uses disease data to predict how weather patterns could spread spores of late blight fungus, which caused the Irish Potato Famine. The plant disease still causes billions of dollars in global crop damages annually.

Second place honors and $175,000 went to **Natalia Orlovsky**, 18, of Chadds Ford, Pa. She examined the response of lung epithelial cells to fluids used in vaping, a practice often promoted as a safer alternative to smoking cigarettes.

Third place honors and $150,000 went to **Isani Singh**, 18, of Aurora, Colo., for her work toward determining if women with Turner syndrome, a rare disease in which all or part of a woman's second sex chromosome is missing, may have some cells with two X chromosomes.

Fourth Place: **Muhammad (Shahir) Rahman**, 17, of Portland, Ore., received a $100,000 award for engineering an internet-enabled microwave oven capable of simultaneously heating different foods on the same plate to optimal temperatures without requiring user input.

Fifth Place: **David Wu**, 17, of Potomac, Md., received a $90,000 award for his project studying the patterns of sequential prime numbers.

Sixth Place: **Kyle Fridberg**, 17, of Boulder, Colo., received an $80,000 award for discovering a new compound that may be useful in improving rechargeable battery technology.

Seventh Place: **Vinjai Vale**, 17, of Exeter, N.H., received a $70,000 award for creating a system that may improve the ability of convolutional neural networks to understand complex scenes.

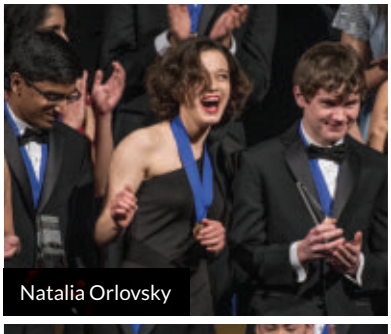
Eighth Place: **Skyler Jones**, 17, of Ossining, N.Y., received a $60,000 award for her study of perovskite crystals used in solar cells. She identified key properties of the perovskite's atomic structure that make it a highly efficient semiconductor, despite its structural defects and low stability.

Ninth Place: **Syamantak Payra**, 16, of Friendswood, Texas, received a $50,000 award for creating a smart bionic leg brace that bends the knee automatically as the wearer walks.

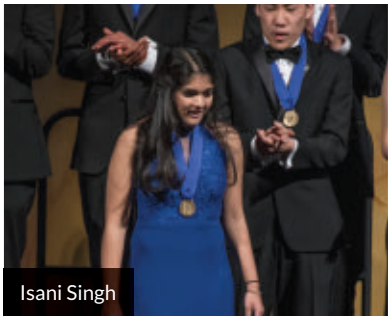
Tenth Place: **Raley Schweinfurth**, 18, of Portland, Ore., received a $40,000 award for her study of honey, soil and tree contamination levels following an insecticide-spraying incident in 2013 in Oregon that killed more than 50,000 bees.

The remaining 30 finalists each received $25,000.

Benjy Firester



Natalia Orlovsky



Isani Singh

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MARCH 3, 2018

In amber, no one can hear you scream

Chimerarachne yingi, an extinct spiderlike animal found in amber, has a tail that stretches several times its body length, **Susan Milius** reported in "This ancient creature resembles a spider, but what's with the tail?" (*SN: 3/3/18, p. 32*). Reader **Ron Bucher** thought the tiny beast should have been named *Chimerarachne riplei*. "Every science fiction buff will immediately recognize it as a miniature version of the creature from the movie *Alien*," he wrote.

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Diagnosis dinosaur

Some scientists are shaking up the dinosaur family tree and raising questions about which features define the ancient reptiles, ***Carolyn Gramling*** *reported in "What makes a dinosaur?"* (SN: 3/3/18, p. 18). "I am a bit put out by the continuing references to dinosaurs as being reptiles," reader **David Persuitte** wrote. Dinosaurs' legs were positioned differently than those of modern reptiles, he noted, and many species may have regulated their body temperature, possibly with feathers. "Dinosaurs should not be referred to anymore as being reptiles," **Persuitte** wrote, but should instead be assigned to a new category. "Finally, it is pretty much accepted now that birds are avian dinosaurs. If dinosaurs are reptiles, shouldn't birds be called avian reptiles?"

Persuitte is correct that dinosaurs' legs were positioned beneath the body, rather than splayed to the side, says **Gramling**. "But how we define a reptile — or how we define a dinosaur — is closely tied to what sort of classification system we're using," she says.

In the original Linnaean system of classification — which focuses on organisms' characteristics such as temperature self-regulation — birds and reptiles are quite different, of course. In phylogenetics, organisms are grouped by ancestry; a reptile in this system includes any animal descended from the original group called reptiles. "That would include both nonavian dinosaurs and, yes, birds," **Gramling** says.

Mission: Venus

Scientists are scraping together ideas for landing on Venus, Earth's hellish neighbor, ***Lisa Grossman*** *reported in "What will it take to go to Venus?"* (SN: 3/3/18, p. 14). Readers on social media had questions about the mysterious planet next door.

Facebook user **Jeremy John Rogers** asked whether Venus would have been habitable billions of years ago when the sun was dimmer than it is now. "Even with [Venus'] slower rotational period, it still received ... more sunlight than Earth does today," he wrote.

The estimates of Venus' past habitability do consider changes in solar heat, says planetary scientist **Darby Dyar** of Mount Holyoke College in South Hadley, Mass. Assuming a rotation rate similar to today, the planet could have had a habitable climate until at least 715 million years ago (*SN Online: 8/26/16*), even if Venus got 70 percent more sunlight than Earth does now, physicist **Michael Way** of NASA's Goddard Institute for Space Studies in New York City and colleagues reported in 2016 in *Geophysical Research Letters*.

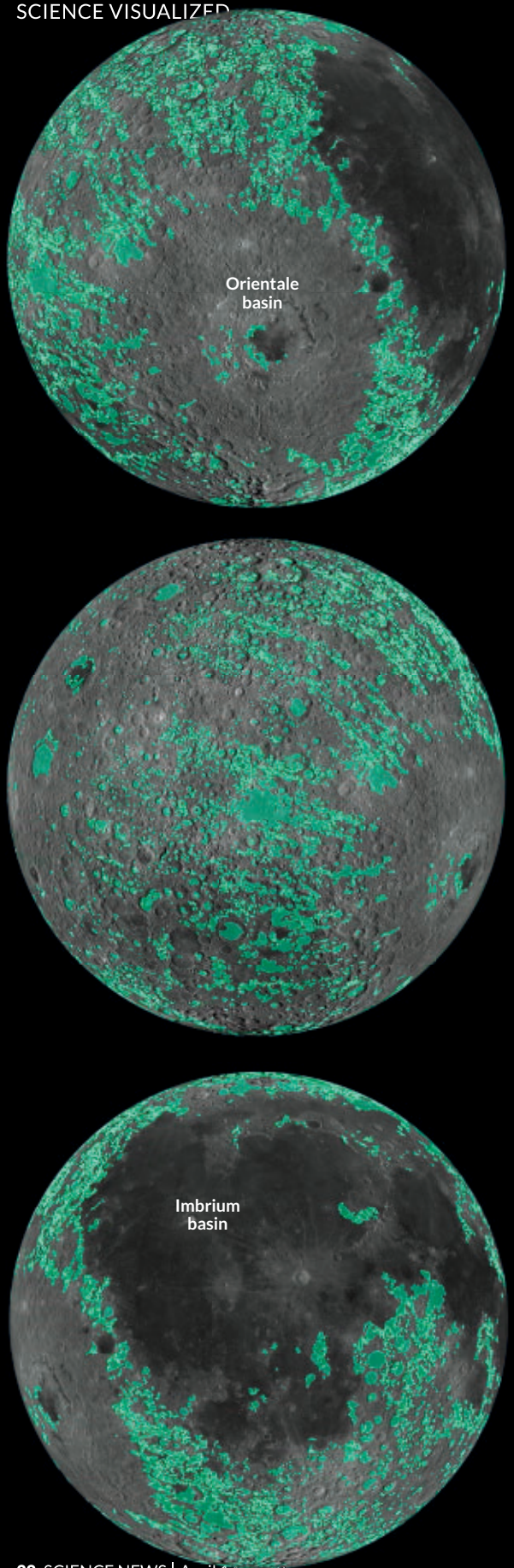
Twitter user **@Harbinger1954** was curious about Venus' atmosphere. "What would be the effect of raising the atmospheric water [and] oxygen content. Would it become more hospitable or less?"

Way's study didn't look at water or oxygen, but did consider how carbon dioxide could have contributed to Venus' past habitability, **Grossman** says. Although CO_2 concentrations may have had some effect by raising the planet's temperature, Venus' slow rotation period still had a larger impact.

Correction

In "From joy to anguish" (*SN: 3/17/18, p. 16*), a graph that showed changes in the hormone progesterone during and after pregnancy incorrectly labeled progesterone as being measured in milligrams per milliliter of plasma (mg/ml). Progesterone was measured in nanograms per milliliter of plasma (ng/ml).

B. WANG



FROM LEFT: H. MEYER, L. DAVIS AND N. ESTES/LROC SOC-ASU; NASA/GODDARD SPACE FLIGHT CENTER SCIENTIFIC VISUALIZATION STUDIO

The moon's giant splat mark gets its picture taken

A new map of light-colored streaks and splotches on the moon links the features to a few large impacts that spread debris all over the surface.

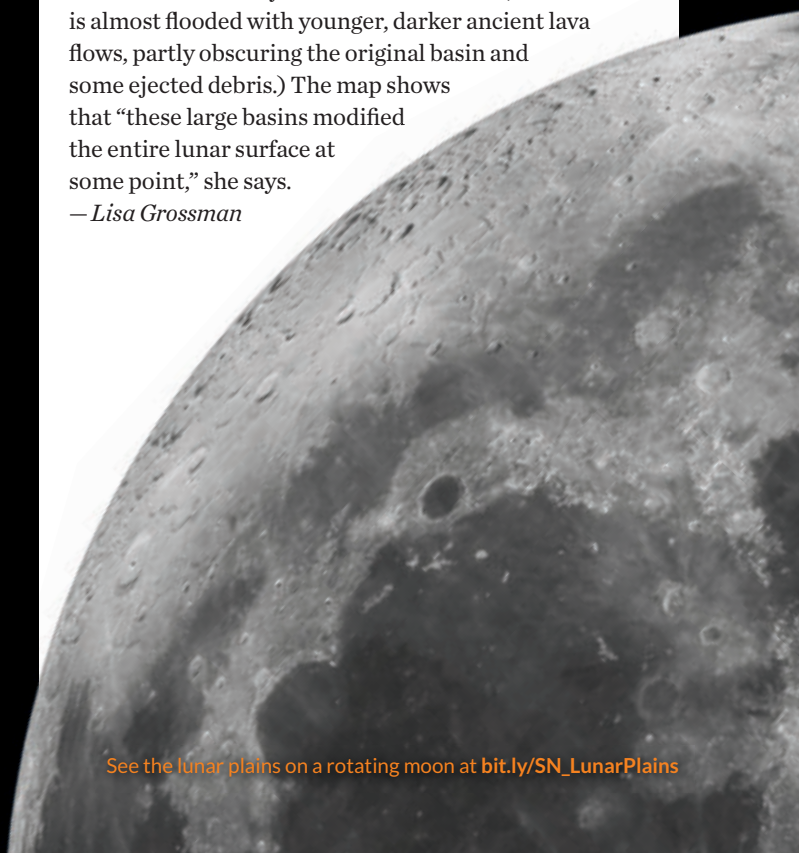
Planetary scientist Heather Meyer, now at the Lunar and Planetary Institute in Houston, used data from NASA's Lunar Reconnaissance Orbiter to make the map, the most detailed global look at these plains (shaded green in images at left). Previous maps had been patched together from different sets of observations, making it hard to be sure that features that looked like plains actually were.

Astronomers originally assumed that the plains were ancient lava flows from volcanoes. But rocks brought back from one of these areas by Apollo 16 astronauts in 1972 did not have volcanic compositions. That finding led some scientists to suspect the plains, which cover about 9.5 percent of the lunar surface, came from giant impacts.

Meyer's map supports the impact idea. Most of the plains, which are visible across the whole moon, seem to originate from debris spewed from the Orientale basin, a 930-kilometer-wide bowl in the moon's southern hemisphere that formed about 3.7 billion years ago. "It looks like there's just a giant splat mark," she says.

About 70 percent of the plains come from either Orientale or a similar basin called Imbrium, Meyer reported March 22 in The Woodlands, Texas, at the Lunar and Planetary Science Conference. (Imbrium is almost flooded with younger, darker ancient lava flows, partly obscuring the original basin and some ejected debris.) The map shows that "these large basins modified the entire lunar surface at some point," she says.

— Lisa Grossman



See the lunar plains on a rotating moon at **bit.ly/SN_LunarPlains**

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