

# SN

SCIENCE NEWS MAGAZINE  
SOCIETY FOR SCIENCE & THE PUBLIC

JULY 7, 2018

Debate Over  
Ancient Chill  
Heats Up

Putting a Lid  
on Rapa Nui  
Statues

Tattoo  
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# ScienceNews



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By Carolyn Gramling

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By Laurel Hamers

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**COVER** CAR-T cells (two shown in yellow) recognize and grab on to a cancer cell (breast cancer shown). *Eye of Science/Science Source*







## Medical breakthroughs come with a human cost

Medical innovations can be risky, as this issue's cover story on new CAR-T cell therapies for cancer reveals. The treatments, which tailor a patient's own immune system cells to attack cancer, can be astonishingly successful (see Page 22). But CAR-T therapy can also be an untamed

beast, unleashing a ferocious immune response that indiscriminately attacks the body. The challenge scientists face now is how to tame the therapy while retaining its cancer-killing powers.

It's hardly the first medical advance to pose risks in its early days. Organ transplants are one of the most famous examples. In the 1960s, before the adoption of immune-suppressing drugs, fewer than 1 in 3 people were alive a year after a liver transplant (*SN*: 3/3/18, p. 4). The early days of open-heart surgery were also frightening. I've never forgotten interviewing pioneering Cleveland Clinic heart surgeon Delos "Toby" Cosgrove, who told me that when he first started performing the surgeries back in the 1970s, "half of my patients went home in a box." He wasn't being flippant; years later, those deaths still weighed on him.

Like those early heart surgery and transplant patients, people willing to try CAR-T therapies have exhausted their options. As reporter Laurel Hamers writes, scientists are trying to reengineer the treatments so they're safer. Paul Martin, a pediatric oncologist at Duke University, told her: "Immunotherapy goes back a long time, but *successful* immunotherapy is just in its infancy."

Medical innovation is truly a partnership that involves patients, researchers and clinicians. If CAR-T therapy turns out to be a winner, the treatment will join other notable advances, including antibiotics, insulin and chemotherapy. Fortunately, not every advance comes at a high human cost. When "test-tube babies" debuted in July 1978, there was widespread fear that the children would be plagued with mental or physical defects (*SN*: 12/9/78, p. 407). Those fears proved unfounded, with millions of healthy IVF babies born since then.

We'll continue to cover the successes and failures of biomedical innovation, and as always, provide the long view. — *Nancy Shute, Editor in Chief*

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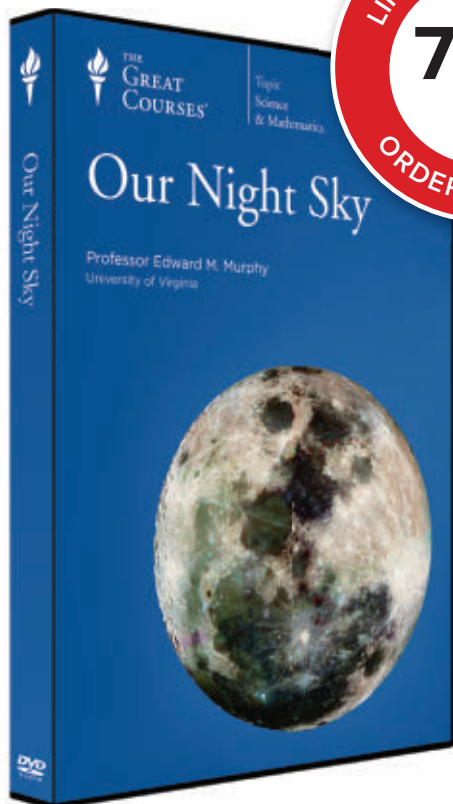
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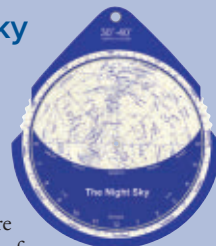
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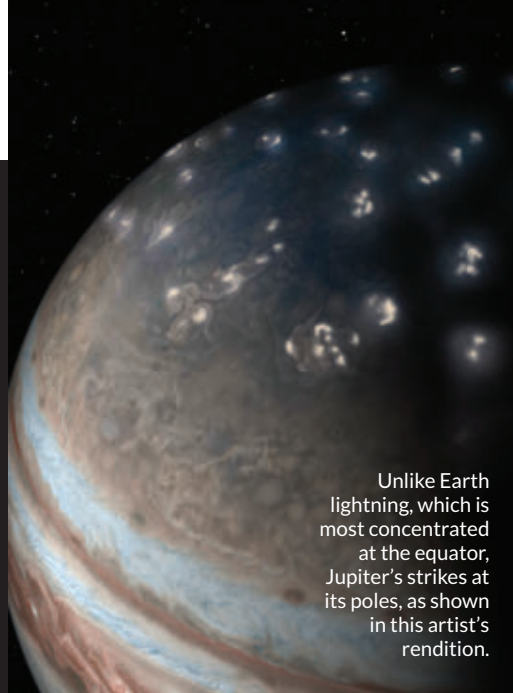
Excerpt from the July 6, 1968 issue of *Science News*

## 50 YEARS AGO

## Next in speedy trains

Future trains, in [Hisanojo] Ozawa's opinion, will all be powered by rockets and run over rollers instead of rails.... His next model will be equipped with three rocket engines and will aim for a speed of 1,180 kilometers an hour, or 0.996 Mach.

**UPDATE:** A rocket-boosted model train from Ozawa, who designed aircraft for the Imperial Japanese Air Force, hit 920 kilometers per hour on a 300-meter course in 1968. But real-world trains get nowhere near that speed. Maybe because none use rockets. Japan's maglev trains, which levitate on superconducting magnets, broke 600 km/h in a 2015 test run — making them the world's fastest. Passengers will have to wait to embark until 2027. In the United States, Amtrak's Acela Express tops out at a comparatively slow 240 km/h. But a line from Los Angeles to San Francisco for trains traveling up to about 350 km/h is under construction, and plans to run a maglev train between New York City and Washington, D.C., received some federal funding in 2015.



Unlike Earth lightning, which is most concentrated at the equator, Jupiter's strikes at its poles, as shown in this artist's rendition.

## MYSTERY SOLVED

## Jupiter lightning is familiar but different

When Voyager 1 revealed lightning on Jupiter in 1979, something about the flashes didn't make sense. From a distance, it seemed like the radio waves from the massive planet's lightning bolts didn't reach the high frequency emitted by lightning on Earth.

But the Juno spacecraft, which has been orbiting much closer to Jupiter's surface for the last two years, has helped solve the mystery. The radio waves emitted by the planet's lightning are, in fact, in a similar

## INTRODUCING

## Amber holds ancient tropical frogs

About 99 million years ago, tiny frogs hopped through a wet, tropical forest — and an unlucky few ran afoul of some sticky tree resin. Four newly described frog fossils, preserved in amber, offer the earliest direct evidence of ancient frogs living in a humid tropical climate — just as many modern amphibians do.

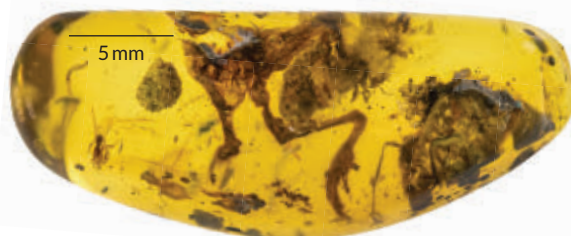
None of the frog fossils are complete, making it difficult to place the frogs within their family tree: One has a partial skull and another a froggy outline, although CT scanning revealed no remaining skeletal material inside the impression. So researchers dubbed all four fossils *Electrorana limoae* (*electrum* for “amber” and *rana* for “frog”) in a study published June 14 in *Scientific Reports*. Anatomy-wise, the ancient frogs most resemble a modern group that includes fire-bellied toads.

The fossil record contains relatively few frogs, despite the amphibians' more than 200-million-year history. The frog fossils that do exist suggest that frogs have looked distinctly — well, froggy — for hundreds of millions of years, says study coauthor David Blackburn, an amphibian biologist at the Florida Museum of Natural History in Gainesville. “The aspects that make them diverse are not their skeletons, it's their ecologies, natural histories, reproductive modes. Things that are really hard to find in the fossil record.”

That's what makes the amber specimens so interesting: The chunks also contain preserved spiders, velvet worms and bamboo — all pointing to a tropical environment. Such paleoecological evidence offers scientists a rare glimpse into the life and times of tropical frogs of old. — *Carolyn Gramling*



These chunks of amber contain fossils of 99-million-year-old frogs that were roughly the size of a postage stamp. The sample above holds a juvenile with a partial skull. The one at right contains a recognizable leg and body.





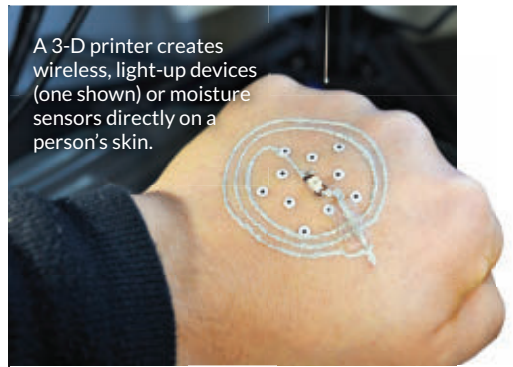
frequency range as our lightning at home, mission scientists report in the June 6 *Nature*. Astronomers couldn't detect anything but the lower frequencies, called "whistlers," until now.

And while solving that mystery, the researchers discovered another twist: Jupiter's lightning may have a similar frequency as Earth's, but it is focused at the planet's poles instead of nearer to the equator, as on Earth.

"Jupiter continues to surprise us," says Shannon Brown, a researcher at NASA's Jet Propulsion Laboratory in Pasadena, Calif., and lead author of the new study. Brown says the difference in

location of the lightning strikes has to do with how the two planets distribute heat. Earth receives most of its heat from the sun, and that heat is focused around the equator. Jupiter, much farther from the sun, creates most of its heat internally, leading to different convection patterns that drive lightning to the poles (*SN*: 3/31/18, p. 10).

Juno had been scheduled to take a mission-ending plunge into Jupiter's atmosphere in July, but on June 6 the mission was extended for another three years — plenty of time to catch more great lightning shows (*SN*: 6/24/17, p. 14). — *Leah Rosenbaum*



A 3-D printer creates wireless, light-up devices (one shown) or moisture sensors directly on a person's skin.

#### TEASER

## Temporary electronic tattoo is 3-D printed

A new 3-D printer draws patterns of electrically conductive material directly onto a person's skin, creating temporary electronic devices.

The new system uses computer vision to compensate for a moving printing surface — say, the back of a fidgety hand, researchers report in the June 6 *Advanced Materials*. Michael McAlpine, an engineer at the University of Minnesota in Minneapolis, and colleagues used this motion-savvy 3-D printer to construct wearable LEDs.

The printer first stuck a premade LED light to the wearer's skin, then drew a circuit around the bulb using a polymer ink laced with silver flakes, which allow the ink to conduct electric current.

After waiting 15 minutes for the ink to dry, the user kept the LED lit by holding a wireless power transmitter over the printed circuit. Future on-the-skin electronics could be powered by 3-D printed batteries, McAlpine says. The researchers also printed moisture sensors, which could monitor sweat accumulation to gauge stress levels.

The wearable devices stay on for at least two hours, but users can peel off the prints with tweezers or wash them off with water. McAlpine's team imagines soldiers toting the compact 3-D printer, which weighs about 1.4 kilograms, in their packs to print chemical or biological agent sensors or solar cells on the fly (*SN Online*: 4/5/18). — *Maria Temming*



#### FOR DAILY USE

## Shade doesn't guarantee a safe car interior

Don't count on a shady parking spot to save a child left in the back seat on a hot day.

A new analysis of temperatures inside parked cars reveals that a toddler in a sunbathed vehicle would reach lethal body temperatures faster than one left in the shade. But even in a shaded car, a child could die from overheating within a few hours, researchers report online May 23 in *Temperature*.

Researchers tracked temps inside a sedan, an economy car and a minivan parked in the sun, and another three vehicles parked in the shade. Each car started at the outdoor air temperature or 29.4° Celsius, whichever was cooler. On days that got hotter than 38° C (about 100° Fahrenheit), the average ambient temperature inside the shaded vehicles reached 38.3° C in an hour. Cars in the sun hit a scorching 46.7° C in an hour.

The researchers then simulated how the body temperature of a 2-year-old child would rise under those conditions. On average, a toddler's body would reach the potentially lethal temperature of 40° C (104° F) after about 1.4 hours in the sun and about 2.4 hours in the shade. It happened faster in some cars than in others — a child left in a sunbaked sedan could die from overheating in just an hour.

Each year, an average of 37 children in the United States die from heatstroke inside vehicles. Among the 700 children who died of heatstroke in a vehicle from 1998 to 2017, more than half had simply been forgotten. Car or smartphone alerts reminding drivers to check the back seat could help prevent these deaths, says study coauthor Jennifer Vanos, an extreme heat and public health researcher at the University of California, San Diego. — *Maria Temming*

# News

EARTH & ENVIRONMENT

## Antarctic melting is speeding up

Since 1992, ice loss has totaled nearly 3 trillion metric tons

BY LAUREL HAMERS

Antarctica is losing ice at an increasingly rapid pace. In just the last five years, the frozen continent has shed ice nearly three times faster on average than it did over the previous 20 years.

An international research team has combined data from two dozen satellite surveys in the most comprehensive assessment of Antarctica's ice sheet mass yet. The continent lost an estimated 2,720 billion metric tons of ice from 1992 to 2017. Much of that loss occurred in recent years, particularly in West Antarctica. Before 2012, the continent shed ice at an average rate of 76 billion tons each year. From 2012 to 2017, the rate increased to 219 billion tons yearly.

Combined, all that water raised global sea level by an average of 7.6 millimeters, the team reports in the June 14 *Nature*. About two-fifths of that rise occurred in the last five years.

"When we place that against the [Intergovernmental Panel on Climate Change's] sea level projections, prior



An iceberg floats near the Antarctic Peninsula. The melting of the continent's ice sheet from 1992 to 2017 raised the global sea level by an average of almost eight millimeters.

to this, Antarctica was tracking the low end of sea level-rise projections," says study coauthor and earth scientist Andrew Shepherd of the University of Leeds in England. "Now it's tracking the upper end."

Antarctica holds enough frozen water to raise the oceans by 58 meters. Melting Antarctic ice is a major driver of the sea level rise that threatens to flood coastal communities and ecosystems around the world as the climate changes (*SN*: 12/27/14, p. 29). A good estimate of the continent's ice loss will help scientists better predict future sea level rise as Earth continues to warm, Shepherd says.

In a place as big as Antarctica, it's not easy to measure ice and how it fluctuates. Satellites collect different kinds of data to inform estimates, measuring the mass of the ice sheet or the depth of the ice or the speed at which glaciers flow into the ocean. Sorting out seasonal changes, such as ice added from winter snowfall, from more meaningful long-term ones is difficult.

Shepherd and colleagues made their last big estimate of Antarctica's shrinking ice sheet in 2012 and found that it had lost 1,320 billion tons of ice from 1992 to 2011 (*SN*: 12/29/12, p. 10). The new analysis paints a more dire picture. "In 2012, we concluded that ... Antarctica had been losing ice at a steady rate," Shepherd says. But the new findings indicate that the rate of ice loss has now tripled compared with the 1992–2011 average rate.

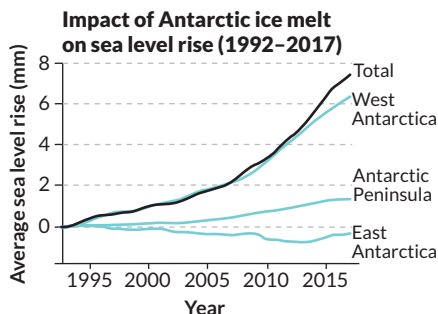
The new study combines data from

three types of satellite measurements to come up with a composite number. West Antarctica dominates the melting. The region was losing about 53 billion tons of ice each year on average from 1992 to 1997. Now the area sheds about 159 billion tons of ice annually.

West Antarctica's ice sheet is probably more vulnerable to ice loss than other parts of the continent because it mostly sits on the seabed submerged in water. Even a small increase in sea temperature, say, half a degree Celsius, transfers a lot more heat to that ice than a comparable increase in air temperature, says Shepherd. And when warm water eats away at an ice shelf from underneath, the warming thins the shelf and hastens melting even further.

East Antarctica's ice sheet, which sits at a higher elevation than the West Antarctic ice sheet, seems more stable. East Antarctica appears to have even slightly gained mass in recent years, but those measurements are more uncertain.

"It's fair to say that the more work that gets done, the picture we get of Antarctica is that it's more dynamic and more capable of rapid change than we used to think," says Steve Rintoul, an oceanographer at CSIRO, the Commonwealth Scientific and Industrial Research Organisation, based in Hobart, Australia. Rintoul cowrote a perspective in the same issue of *Nature* on Antarctica's future. Scientists had thought that such a large mass of ice was relatively resilient, he says. Now its vulnerabilities are showing. ■



**Sea swell** In the last five years, the rate at which Antarctica's melting ice has fueled global sea level rise sped up. The majority of the ice loss is happening in West Antarctica.

SOURCE: A. SHEPHERD ET AL./NATURE 2018

PHOTO: A. SHEPHERD/UNIV. OF LEEDS



## Conservation strategy backfires

Isolated quolls quickly lose a fear response to predators

BY LEAH ROSENBAUM

Conservationists are stuck in a catch-22: In trying to save some species, the would-be protectors may be giving animals an evolutionary disadvantage. A new study describes how efforts to protect the endangered northern quoll, a kitten-sized marsupial native to Australia, by placing a population on a threat-free island may



have undermined a key survival instinct.

After 13 generations, just 13 years, the northern quolls had lost their fear response to longtime predators, researchers report in the June *Biology Letters*.

“Evolution can happen very rapidly” for animals with fast breeding times, says evolutionary biologist Rick Shine of the University of Sydney, who was not involved in the study.

Separating endangered species from predators — often in zoos, fenced enclosures or on islands — is a common conservation technique. The approach allows a species to build up its population before being reintroduced into the wild.

Northern quoll (*Dasyurus hallucatus*) populations have been drastically reduced in recent decades by invasive cane toads. Quolls die after eating the poisonous toads. In 2003, government officials tried to preserve the quolls in part by moving 45 of them to a toad-free island.

In 2016, University of Melbourne ecologist Chris Jolly and colleagues

After 13 generations on an island free of feral cats and dingoes, northern quolls no longer avoided the scent of either predator.

reintroduced some of the quolls to the mainland. But the effort was halted after dingoes and feral cats killed new arrivals.

To figure out what happened, the researchers tested the fear responses of wild mainland quolls, island-born quolls and offspring from both groups. Quolls were given boxes of mealworms, some of which were tainted with the scent of cats or dingoes. Wild quolls shied away from predator-scented worms, but island quolls slurped them down. Quoll babies in each group showed the same behavior as the adults, suggesting that the lost fear response was not learned but had evolved over 13 generations.

The findings may have implications for other endangered animals. “For many of Australia’s mammals, the future is fenced,” says Alexandra Carthey, an ecologist at Macquarie University in Sydney.

But for quolls, there may be other solutions. Perhaps quolls could be trained to avoid cane toads, Jolly and colleagues suggested last October in *Austral Ecology*. Or a small number of predators could be added to isolated locations to put the fear back into the endangered marsupials. ■

## Bees know something about nothing

In experiments, the social insects rank zero as less than one

BY SUSAN MILIUS

A little brain can be surprisingly good at nothing. Honeybees are the first invertebrates to pass a test of recognizing where zero goes in numerical order.

Even small children struggle with recognizing “nothing” as being less than one, says cognitive behavioral scientist Scarlett Howard of the Royal Melbourne Institute of Technology in Australia. But bees trained to fly to images of greater or fewer dots or whazzits tended to rank a blank image as less than one, Howard and colleagues report in the June 8 *Science*.

Despite decades of discoveries, non-human animals still don’t get due credit beyond specialists studying intelligence, laments Lars Chittka of Queen Mary University of London, who has

explored bees’ mental capacities. For the world at large, he emphasizes that the abilities described in the new paper are “remarkable.”

Researchers recognize several levels of complexity in grasping zero. Most animals, maybe all, can understand the simplest level — that the absence of something differs from its presence, Howard says. Grasping the notion that absence could fit into a sequence of quantities, though, seems harder. Previously, only some primates such as chimps, plus an African gray parrot, have demonstrated this level of understanding zero (*SN: 12/10/16, p. 22*).

In a series of experiments, the researchers trained honeybees to choose between images with different numbers

of elements, such as dark circles of different sizes. Some bees were trained to fly to the image with the lower number of objects, while other bees were taught to go to the higher-number image. The researchers offered the bees a sweet treat for the correct image and a bitter quinine solution for a wrong answer.

Trained bees then performed a series of tests with no rewards. In one test that offered the bees a choice between a single-shape image versus a blank image, bees trained to pick the lower number of objects flew to the blank image — the zero — 63 percent of the time. Overall, test results showed the bees treating zero as being less than one, Howard says.

The results convince evolutionary behavioral biologist Rafael Rodríguez of the University of Wisconsin–Milwaukee that bees get the basics of zero. Now he’s wondering about earlier studies that might hint that certain spiders would be worth testing, too. ■

## BODY &amp; BRAIN

# Dogs harbor a variety of flu viruses

Strains don't appear to infect humans but could someday

BY TINA HESMAN SAEY

Some dogs in China carry a mixed bag of influenza viruses. The discovery raises the possibility that dogs may be able to pass the flu to people, perhaps setting off a pandemic.

About 15 percent of pet dogs tested, all that went to the vet because of respiratory infections, carried flu viruses often found in pigs, researchers report June 5 in *mBio*. Of the virus strains detected, three have recombined in dogs to form new varieties.

That mixing generates genetic diversity in the viruses, making them potentially a pandemic threat, says study coauthor and virologist Adolfo García-Sastre of the Icahn School of Medicine at Mount Sinai in New York City.

Evolution of the flu viruses in dogs has been very rapid, occurring in just a few years, García-Sastre says. There's no sign yet that the dog flu viruses can infect people, but that could change. "The more diversity of viruses there is in an animal reservoir, the higher the chances that it will lead to a version of the virus that is able to jump" to humans, he says.

Pigs and birds remain the prime suspects for mixing up the next human pandemic influenza virus, says Amesh Adalja, an infectious disease physician at Johns Hopkins University. Even if a dog flu virus infected a person, the pathogen may not be able to transmit easily from person-to-person — an important characteristic a virus must have before it can circulate around the world.

But because most people encounter dog noses far more often than pig snouts, it's worth keeping an eye on the pups, Adalja says. "Knowing that dogs could contribute is important for preparing for the next pandemic, because we don't know exactly what that virus will be."

The first flu virus in dogs was discov-

ered in 2004 in the United States. That virus, from a horse flu virus called H3N8 that had jumped to canines, sometimes spreads among dogs in animal shelters. In 2010, researchers reported that some dogs in Asia carry a version of the H3N2 virus from birds. (Cats can catch the dog H3N2 flu virus, but don't easily transmit it to other cats, as far as scientists know.)

In the new study, the team swabbed the noses of 800 dogs in the Guangxi region of southern China from 2013 to 2015. All of the dogs had respiratory illnesses, but only 116 were infected with influenza viruses. To the scientists' surprise, the

dogs had various swine H1N1 flu viruses. The researchers determined the genetic makeup of 16 of the samples and discovered that some of these swine viruses had previously circulated in people and pigs in Europe and Asia. Some are strains of bird flu that have infected pigs.

The viruses swapped genes among themselves in pigs, creating new varieties, some of which were passed to dogs. A virus genetically similar to one of the swine viruses passed to dogs was found in a person in China, raising the possibility that some swine flus can strike both pups and people. Dogs remixed some of the viruses from the pigs with bits of dog flu virus in Asia, creating the three new canine influenza virus strains, the researchers found.

Since the study collected samples from only one part of China, the team doesn't know how widespread flu is among dogs, or how many canine-infecting influenzas may be out there.

Finding flu viruses in dogs isn't cause for alarm. But researchers should monitor the situation and use vaccines, quarantine and other infection-control methods to limit outbreaks and keep the canine viruses from catching hold in humans, García-Sastre says. ■

"Knowing that dogs could contribute is important for preparing for the next pandemic."

AMESH ADALJA

## ATOM &amp; COSMOS

# Methane on Mars goes up and down

Curiosity rover also finds more organics on the Red Planet

BY LISA GROSSMAN

To Martian methane, there is a season.

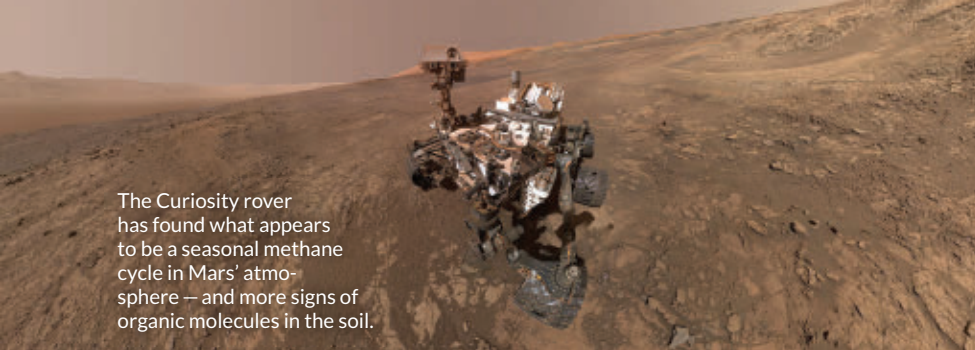
NASA's Curiosity rover has found evidence that methane in Mars' atmosphere varies during the year. Higher concentrations appear in late summer and early autumn and lower concentrations occur in the winter and spring in the northern hemisphere, researchers report in the June 8 *Science*.

Curiosity has also spotted organic molecules never before seen on Mars, some of the same researchers, along with other colleagues, report in another study in the same issue of *Science*. Neither methane nor the other organics alone are a sign of life, but the implications for astrobiology are "potentially huge," says planetary scientist Michael Mumma of NASA's Goddard Space Flight Center in Greenbelt, Md., who was not involved in the studies.

In 2009, Mumma and colleagues reported observations of methane plumes spewing into Mars' atmosphere. The plumes, detected with telescopes on Earth, had methane concentrations as high as 45 parts per billion. Methane doesn't last long in the Martian atmosphere before the sun's ultraviolet radiation destroys it, so something must have been creating or releasing the gas as scientists watched. On Earth, most methane is made by living creatures, so the plumes raised hopes that Mars supports life.

But when Curiosity landed on the Red Planet in 2012, the rover initially found no methane to speak of (*SN: 10/19/13, p. 7*). "A lot of people were disappointed," says Christopher Webster, a planetary scientist at NASA's Jet Propulsion Laboratory in Pasadena, Calif., and a coauthor of the new methane study. But in 2014, after more searching, the Curiosity team confirmed traces of methane, though much less than what was expected based





The Curiosity rover has found what appears to be a seasonal methane cycle in Mars' atmosphere — and more signs of organic molecules in the soil.

on the earlier results (*SN: 1/10/15, p. 11*).

Now after over two Martian years (55 Earth months) of observing, the team reports that the annual average concentration of methane in Mars' atmosphere is 0.41 ppb. But methane levels seem to rise and fall with the seasons, ranging from 0.24 ppb in winter to 0.65 ppb in summer. The researchers also saw relatively large methane spikes, up to about 7 ppb, at apparently random intervals.

Seepage from an underground reservoir could explain the seasonal cycle and the spikes, Webster says. A network of rock, dust and ice crystals in the surface could hold onto the methane in winter and release it when warmed in the summer.

Occasionally, something in the rocks could break loose, releasing larger spurts. Similar features are found on Earth.

Scientists can't say what produced the stored methane in the first place. "While we think it likely that it's produced abiotically [by a geologic process]," Webster says, "we cannot rule out the possibility of a biological or microbial source."

If Curiosity is at the edge of a plume, then the methane concentrations in the spikes that the rover sees are consistent with the previous plumes seen from Earth, Mumma says. But he's not sure if a seasonal cycle is the only explanation for the data: A flat methane level could fit within the errors of the measurements.

Webster disagrees. "Even to the untrained eye, there is a clear, repeatable rise in the summertime," he says of the results. "The seasonal cycle is real."

In the other new paper, astrobiologist Jennifer Eigenbrode of NASA Goddard and colleagues analyzed samples from 3.5-billion-year-old Martian mudstone that was once part of a lake, and found chemical evidence of organic molecules. In 2014, Curiosity had detected organic molecules in a different spot. The new finding shows signs of larger, more complex organic molecules than had been seen before, including some that are similar to coal and black shale found on Earth.

"There were a lot of people who didn't think we were going to find organic matter using the drill on the Curiosity rover, because it only goes down five centimeters," Eigenbrode says. The surface is bombarded with radiation that can break up organics. That organics survive means digging deeper may yield even more. ■

## ATOM & COSMOS

# Fusion may unite dark matter particles

Hypothetical process could help physicists solve a galaxy puzzle

BY EMILY CONOVER

Fusion may have a dark side. A hypothetical process called "dark fusion" could be occurring throughout the cosmos.

Standard fusion occurs when two atomic nuclei unite to form a new element, releasing energy in the process. "This is why the sun shines," says physicist Sam McDermott of Fermilab in Batavia, Ill. A similar process — dark fusion — could occur with particles of dark matter, McDermott suggests in the June 1 *Physical Review Letters*.

If real, the phenomenon may help resolve a puzzle related to dark matter, a poorly understood substance believed to bulk up the mass of galaxies. Without dark matter, scientists can't explain how galaxies' stars move the way they do. But some of the quirks of how dark matter is distributed within a galaxy are a mystery.

Dark matter is thought to be made of reclusive particles that don't interact

much with ordinary matter, the stuff that makes up stars, planets and living creatures. That introverted nature makes the particles hard to detect. But dark matter may not be totally antisocial. "Why wouldn't the dark matter particles interact with each other? There's really no good reason to say they wouldn't," says Manoj Kaplinghat, a physicist at the University of California, Irvine.

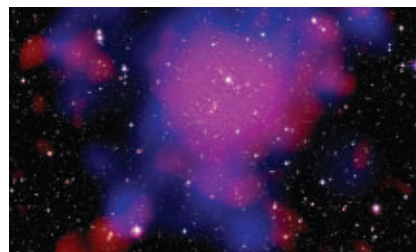
Scientists have suggested that dark

matter particles might ricochet off one another. The new study goes further: Pairs of dark matter particles could fuse, forming other dark matter particles.

Such dark fusion could help explain why dark matter near the centers of galaxies is more evenly distributed than expected. In computer simulations of galaxy formation, the density of dark matter rises sharply to a cusp in the center of a galaxy. But in reality, galaxies have a core evenly filled with dark matter.

Those simulations assume dark matter particles don't interact. But, the new study finds, dark fusion could change how the particles behave, giving them the energy needed to escape entrapment in a galaxy's dense cusp, thereby producing an evenly filled core.

"You can kick [particles] around through this interaction, so that's kind of cool," says physicist Annika Peter of Ohio State University. But, she says, dark fusion might end up kicking the particles out of the galaxy entirely, which wouldn't mesh with expectations: The particles could escape the halo of dark matter that scientists think surrounds each galaxy. ■



Galaxies are surrounded by dark matter (illustrated in blue over an image of a galaxy cluster; red indicates gas). Particles of such dark matter may undergo "dark fusion."

## EARTH &amp; ENVIRONMENT

# How your food choices affect climate

Greenhouse gas emissions vary by product and producer

BY SUSAN MILIUS

From beef to beer, coffee to chocolate, there are environmental costs in what people eat and drink. Now a study that quantifies the impact of producing and selling 40 different foods shows how these choices make a difference.

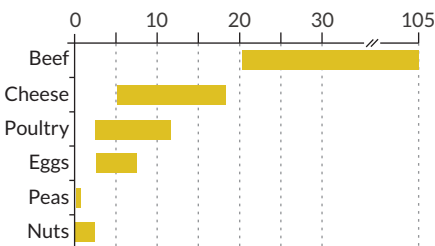
Agricultural data from 38,700 farms plus details of processing and retailing in 119 countries show wide differences in environmental impacts—from greenhouse gas emissions to water used—even among producers of the same product, says environmental scientist Joseph Poore of the University of Oxford. The amount of climate-warming gases released in the making of a pint of beer, for example, can more than double under high-impact production scenarios. For dairy and beef cattle combined, high-impact providers released about 12 times as many greenhouse gases as low-impact producers, Poore and colleague Thomas Nemecek report in the June 1 *Science*.

Those disparities mean there's room for high-impact producers to tread more

lightly, Poore says. If consumers could track such differences, he argues, purchasing power could push for change.

But the greatest effect of a person's diet on the planet would still come from choosing certain kinds of food over others. On average, producing 100 grams of protein in beef leads to the release of 50 kilograms of greenhouse gas emissions,

**Kilograms of CO<sub>2</sub> equivalent released with 100 grams of protein produced**



**Farm to table** Proteins are not equal in the amount of greenhouse gases (CO<sub>2</sub> equivalent shown) emitted during production. Even for the same food, there's a big range (yellow bars) between low- and high-impact producers. (For some nut producers, emissions can actually be slightly negative when carbon sequestration is factored in.)

which the researchers calculate as a carbon dioxide equivalent. By comparison, producing 100 grams of protein in cheese releases 11 kilograms and 100 grams of protein in tofu releases two kilograms.

Replacing meat and dairy foods from producers that have above-average environmental effects with plant-based products could make a notable difference in emissions. If cuts came from these higher-impact suppliers, replacing half of each kind of animal product with something from a plant could reduce food's share of emissions by 36 percent. That's not too far from the 49 percent drop that could be achieved if the whole world went vegan. Producing food overall accounts for 26 percent of global climate-warming emissions, the researchers say.

The case for switching to a plant-based diet was already pretty powerful, says Ron Milo of the Weizmann Institute of Science in Rehovot, Israel, who studies cell metabolism and environmental sustainability. The new data "make it even stronger, which is an important thing given how strongly we tend to adhere to our food choices," he says.

After the first year of putting the study together, Poore himself stopped eating animal products. ■

## EARTH &amp; ENVIRONMENT

# Tropical cyclones have slowed down

Lingering hurricanes could release more rainfall over land

BY CAROLYN GRAMLING

Tropical cyclones don't travel as fast as they used to.

The fierce, swirling storms move 10 percent slower, on average, than they did nearly 70 years ago, a study finds. Such lingering storms can potentially cause more damage by dumping even more rainfall on the land beneath them.

Atmospheric scientist James Kossin examined changes in how quickly tropical cyclones, which are called hurricanes in the Atlantic Ocean, moved across the

planet from 1949 to 2016. Storms slowed at different rates depending on region, Kossin reports in the June 7 *Nature*.

Over that same period, Earth's average surface temperature rose by about half a degree Celsius. Scientists already predict that average wind speeds will increase in cyclones as oceans warm due to global warming. The study suggests that climate change is also altering how quickly these storms travel across land or water.

The effect was even more pronounced as storms moved over land, with those originating in the western North Pacific, such as near Japan, slowing by 30 percent, says Kossin, of the National Oceanic and Atmospheric Administration's National Centers for Environmental Information in Madison, Wis.

The cyclone slowdown is consistent with a weakening in atmospheric circu-

lation in tropical regions, a result of global warming, Kossin found. Global warming is also expected to increase how much water vapor the atmosphere can hold, which means storms could accumulate more moisture before releasing it as rain.

Slow-moving Hurricane Harvey, which dumped record levels of rain while lingering for days over Texas in 2017, could be a harbinger of things to come. But it's not yet clear whether the slowdown will continue, or how it might vary regionally, says atmospheric scientist Christina Patricola of Lawrence Berkeley National Laboratory in California. Most previous work has focused on how climate change will affect storms' wind speeds rather than how quickly storms travel. "To have the best information for building resilience to storms, we need to understand these other characteristics," she says. ■



LIFE & EVOLUTION

# Ancient African baobabs are dying

Experts debate what recent deaths mean for the trees

BY SUSAN MILIUS

The last 13 years have been terrible for African baobab trees. Nine of the 13 oldest either lost stems or died altogether after having lived for more than a millennium, researchers report June 11 in *Nature Plants*. But just what the demise means for the iconic species is up for debate.

“Whilst we are saddened about the death and collapse [of the old trees], current evidence does not indicate that this is affecting the entire population,” says plant scientist Sarah Venter, who was not involved with the report. Venter, of the University of the Witwatersrand in Johannesburg, does not see an immediate threat to the species. These trees of extreme age “were probably more

vulnerable to dry conditions,” she says. “Tree mortality is complex and can be attributed to many causes, including climate change and droughts.”

The *Adansonia digitata* baobab is the longest-living kind of flowering tree. With its mass of skinny branches dividing like rootlets over a fat trunk, the species sometimes gets teased as an upside-down tree. People have long cherished baobabs for food, medicine and spiritual value.

Of the 13 oldest known *A. digitata*, four have died since 2005, says study coauthor Adrian Patrut, who specializes in inorganic and nuclear chemistry at Babeş-Bolyai University in Cluj-Napoca, Romania. Five others across the African continent have lost enormous chunks of their stems, Patrut and colleagues report.

The oldest to die, the Panke tree in Zimbabwe, had lived about 2,500 years before it collapsed over the course of 2010 and 2011. The other three trees that died were 1,250 to 1,500 years old.

Patrut doesn’t think mere old age caused their demise — something more



After living some 1,400 years, this African baobab in Botswana toppled and died in 2016.

troubling may be going on. “There were no signs of an epidemic,” he says. He suspects that a warming trend observed in southern Africa may be playing a role.

As famous as baobabs are, much of their drought biology and other basic matters remain mysterious. “Does anyone really know the rooting structure of baobabs?” asks plant ecologist Eugene Moll of the University of the Western Cape in Bellville, South Africa. For understanding Africa’s plants, “philosophies and paradigms that originate north of 40° N do not necessarily apply down here in the Southern Hemisphere,” he says. “We humans like symmetry, but nature is certainly not always symmetrical.” ■



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## HUMANS &amp; SOCIETY

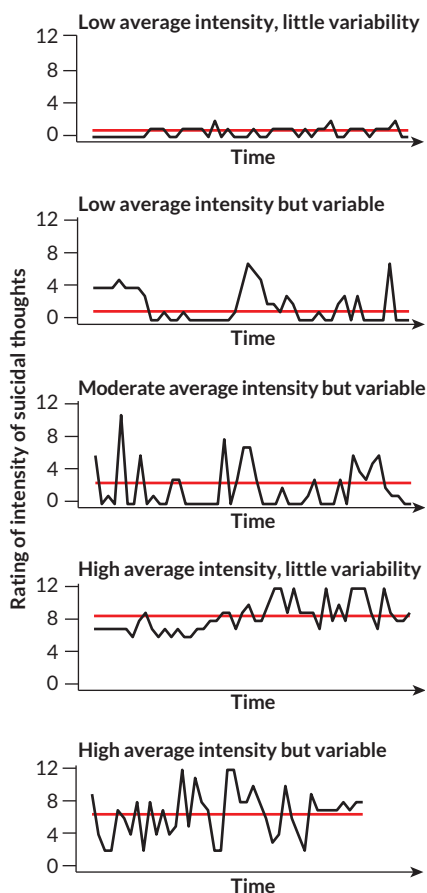
# Tracking suicidal thoughts in real time

Smartphone monitoring could help improve prevention tactics

BY BRUCE BOWER

Suicide research is undergoing a timing shift, and not a moment too soon. A new breed of studies that track daily — and even hourly — changes in suicidal thinking is providing intriguing, although still preliminary, insights into how to identify people on the verge of trying to kill themselves.

## Patterns of suicidal thoughts among people who attempted suicide in the previous year



**Ups and downs** In a study of people with past-year suicide attempts, smartphone-assisted ratings of the intensity of suicidal thoughts every four to eight hours revealed five patterns of thinking (representative patterns shown, red line in each graph is average intensity). Suicide attempts in the month before the study clustered among those reporting severe suicidal thoughts with few fluctuations (fourth graph from top).

SOURCE: E. M. KLEIMAN ET AL./DEPRESSION AND ANXIETY 2018

Monitoring ways in which suicidal thoughts wax and wane over brief time periods, it turns out, can potentially strengthen suicide prevention strategies.

Digital technology has made these investigations possible. Smartphone applications alert study participants to report on suicidal thoughts as they arise in real-world settings. Scientists have traditionally been limited to tracking suicidal thinking over intervals of weeks, months and years, often in research labs and hospitals.

But risk factors that do a decent job of predicting the emergence of suicidal thoughts and acts over the long haul, such as persistent feelings of hopelessness, provide little help in tagging those who will become suicidal in the coming hours and days. Depression, often cited as a main driver of suicide, displays a strong link to suicidal thoughts but not to attempting or committing suicide in the near future.

Despite increasing efforts to combat suicide and declining rates during the 1990s, U.S. suicide rates rose from 1999 to 2016 and now roughly equal those of 100 years ago (see next page). The high-profile suicides of fashion designer Kate Spade and chef and television star Anthony Bourdain in June attracted more attention to this problem.

“The field of suicide research needs to move away from its obsession with long-term risk studies,” says psychologist David Klonsky of the University of British Columbia in Vancouver. A better understanding of how particular suicidal thoughts play out in daily life will lead to the identification of the most telling warning signs of impending suicide attempts, Klonsky predicts. Current theories focus on a range of potential factors that transform suicidal thoughts into life-ending actions, including feeling like a burden to others and suffering from unrelenting pain and

hopelessness (SN: 1/9/16, p. 22).

Researchers can’t yet pinpoint suicide alarms for specific groups of people. That makes it even more vital for people contemplating suicide to contact suicide hotlines, psychotherapists and friends for help, Klonsky says.

Real-time, digital monitoring holds promise for giving clinicians a heads-up as to who is in the most immediate danger of acting on suicidal thoughts. A handful of studies published since 2009 have found that thoughts of suicide often appear rapidly in individuals with past suicide attempts, and can vary dramatically from hour to hour.

A team led by psychologist Evan Kleiman of Harvard University has taken digital monitoring a step further. The researchers recruited 51 adults from online forums related to suicide and self-harm and 32 adults hospitalized at a Boston psychiatric facility for recent suicide attempts or severe suicidal thoughts. Smartphones carried by these volunteers prompted them four times daily, between four and eight hours apart, to rate the intensity of their current desire to kill themselves, their intention to carry out the act and their ability to resist suicidal urges. Those in the online group provided responses for 28 consecutive days. Hospitalized participants provided responses until they were discharged, a period that typically lasted one to two weeks.

The same five patterns of suicidal thinking appeared in both groups, Kleiman’s team reports in a paper scheduled for publication later this year in *Depression and Anxiety*. One of those profiles may be associated with the greatest risk for trying to kill oneself in the near future, the researchers say.

Some individuals reported, on average, low levels of suicidal thoughts that either stayed constant, varied moderately or fluctuated greatly throughout the day. Others reported severe suicidal thoughts that varied either a little or a lot from one report to the next.

Among people who had attempted suicide in the past year, suicide tries in the month before the study clustered



among those reporting severe suicidal thoughts with few fluctuations. No such association appeared in the hospitalized group. Nearly everyone in that group had been admitted and studied shortly after suicide attempts. Studying these people for several more months might yield a link between a specific profile of suicidal thinking and previous or new suicide attempts, Kleiman says.

Kleiman is now involved in a similar study, directed by Harvard psychologist Matthew Nock, of 300 adults and 300 adolescents with histories of suicide attempts who will be monitored for six months after discharge from psychiatric facilities. Participants will respond to smartphone questions and wear sensors that monitor sleep and activity cycles. "Some people have difficulty recognizing how distressed they are in the moment, so we need to capture distress with nonverbal measures," Kleiman says. By identifying these individuals, clinicians could help them to recognize physical signs of distress in themselves and devise a plan to get help when such signs occur, Klonsky adds.

A related idea holds that at least two forms of suicidal thinking exist and demand closer study in smartphone studies. Psychiatrist Maria Oquendo of the University of Pennsylvania's Perelman School of Medicine and colleagues suspect that the first one, related to spikes in distress, consists of sudden bursts of suicidal thoughts following stressful experiences, possibly rooted in stress sensitivity due to child abuse or other early traumas. The second is linked to a consistently depressed mood that likely leads to carefully planned suicide attempts. Oquendo and her colleagues have found evidence for these two types of suicidal thinking in surveys of more than 6,700 U.S. college and graduate students.

Stress, or the lack of it, might play a role in some or all of the patterns of suicidal thinking identified by Kleiman's group. Sleep and activity data in Kleiman and Nock's upcoming study may provide an indirect look at how stress affects suicidal thoughts.

## HUMANS & SOCIETY

# Suicide rates are up in most U.S. states

Across the United States suicide rates have increased — rising by more than 30 percent in half of the states, according to a report from the U.S. Centers for Disease Control and Prevention based on public health data from 1999 to 2016.

Among suicide victims counted in 2015 in 27 states, 54 percent had no known mental health condition, researchers report in the June 8 *Morbidity and Mortality Weekly Report*. Circumstances surrounding the suicides included relationship or job problems, loss of a home, legal troubles and physical health issues.

"There's no one cause. It's a confluence of contributors at a particular stress point in time," says clinical psychologist Jill Harkavy-Friedman, vice president of research at the American Foundation for Suicide Prevention in New York City. "It's not just mental illness. It's many factors." Overall, close to 45,000 Americans died by suicide in 2016. Suicide is one of three top causes of death on the rise in the country, and has contributed to a drop in U.S. life expectancy (*SN Online*: 12/21/17).

"Suicide is a public health problem that can be prevented," Anne Schuchat, the CDC's principal deputy director, said in a June 7 news conference. "That's why it's so important to understand the range of factors and circumstances that contribute to suicide risk." — *Aimee Cunningham*

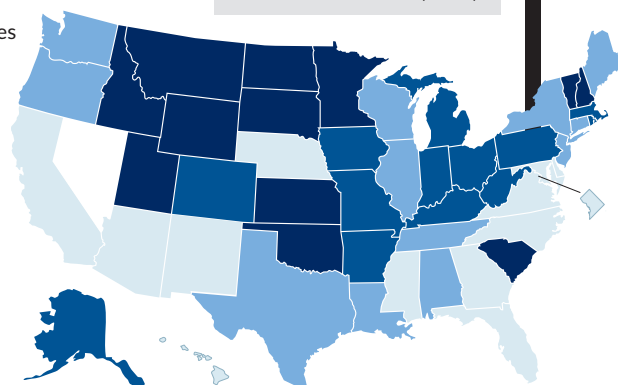
To reach the National Suicide Prevention Lifeline, call 1-800-273-TALK (8255).

**Alarming trend** Suicide rates have increased by more than 30 percent in 25 states since 1999, a new report finds.

## Percent change in annual suicide rate by state (1999–2016)

- Increase of 38–58%
- Increase of 31–37%
- Increase of 19–30%
- Increase of 6–18%
- Decrease of 1%

SOURCE: CDC NATIONAL VITAL STATISTICS SYSTEM 2018



Another digital-monitoring study in the works is by Catherine Glenn, a psychologist at the University of Rochester in New York. She is assembling a smartphone-and-sensor study that will track 50 teenagers hospitalized following suicide attempts for one month after discharge. "It's still unclear how much suicidal thoughts fluctuate over short periods of time, especially in youth," Glenn says.

Despite its promise, digital monitoring of people at risk for suicide works only if people respond to repeated sur-

veys. Consider that U.S. Army soldiers who refused to answer a survey question about the duration of their suicidal thoughts were especially likely to try later to kill themselves. A team led by Harvard's Nock reported that finding in the February *Journal of Abnormal Psychology*. Glenn adds that some teens recently released from psychiatric facilities go offline for a couple of days before being hospitalized again for a suicide attempt.

"Suicide is such a complicated area of study," Glenn says. ■

## EARTH &amp; ENVIRONMENT

# Sunshine helped Gulf oil linger

Deepwater Horizon spill persists 8 years later

BY LAUREL HAMERS

Sunlight shapes oil spills' long-term legacies.

In the days and weeks after the 2010 Deepwater Horizon oil spill in the Gulf of Mexico, sunlight hit the oil slicks on the water's surface. That triggered chemical reactions that added oxygen to oil molecules — once just chains of carbon and hydrogen atoms. These oxygenated hydrocarbons are sticking around eight years later with little evidence of degradation, researchers report online May 29 in *Environmental Science and Technology*.

While investigating the oily soup of

molecules floating in the Gulf post-disaster, chemist Christopher Reddy of Woods Hole Oceanographic Institution in Massachusetts and colleagues got a surprise: More than half of the degrading oil by-products found in oil slicks were these oxygenated hydrocarbons, the team reported in 2012. They had gone relatively unnoticed after previous spills and so were mostly unstudied in that context.

Now the team has evidence that these oxygenated hydrocarbons aren't just a major by-product of the spill, but also a particularly persistent one. The scientists analyzed more samples collected from the water surface and from sandy beaches in the years since the spill. All of the sand samples had roughly the same proportion of oxygenated hydrocarbons between years, suggesting that in the eight years since the disaster, these molecules still haven't broken down.

"A natural process took what was

released from the [spill] and made something either as tough or tougher," Reddy says. The team did identify one relatively small category of oxygenated hydrocarbons that appear to be more soluble in water, so perhaps not entirely resistant to breaking down.

Sunlight probably affects how other oil spills break down too, but perhaps less dramatically, says organic geochemist Zhanfei Liu of the University of Texas at Austin. The Gulf receives brighter, more direct sunlight than more temperate regions, and the 2010 spill was spread widely, exposing a large area to the sun.

One big, unanswered question, Liu adds, is just how toxic this stuff is. The persistence of the by-products means that they're still hanging out in the environment. But, Reddy agrees, it's too soon to say whether aquatic organisms are taking the pollution in at a level that could harm health. ■

## LIFE &amp; EVOLUTION

# What narwhals sound like underwater

Submersible recorders pick up animals' clicks, calls and buzzes

BY LEAH ROSENBAUM

Narwhals are among the most elusive of whales. But for the first time, researchers have been able to eavesdrop on the creatures for days at a time as these unicorns of the sea dove, fed and socialized.

Biologist Susanna Blackwell and colleagues listened in on the specialized sounds of the East Greenland narwhal (*Monodon monoceros*). The team's findings, published June 13 in *PLOS ONE*, provide a peek into the daily behavior of the long-toothed whale. The research could help reveal how human-made noises may affect narwhals as the Arctic warms due to climate change and shipping lanes become more open.

Many whale sounds are recorded using hydrophones, underwater microphones that dangle in the water. But these devices can't sense the depth or direction from which noise comes and can't detect which animal is making a sound. Blackwell's team instead attached



At the ocean's surface, narwhals communicate with whistles and trumpetlike sounds.

acoustic recording devices directly to the narwhals. "It is really like sitting on the back of a narwhal for a few days and experiencing the world," Blackwell says.

With the help of native Greenland hunters, the researchers tagged six of the skittish creatures from 2013 to 2016. The devices were attached with suction cups, and held in place for several days by a nylon string threaded through a ridge of cartilage on the narwhals' backs.

Tagging was stressful for the whales, says Blackwell, of Greeneridge Sciences, Inc., the Santa Barbara, Calif., company that manufactures the acoustic devices (*SN Online*; 12/7/17). But after a day of silence, the narwhals resumed normal behavior.

Like other toothed whales, narwhals use echolocation. "They're like wet bats," says Kate Stafford, an oceanographer at the University of Washington in Seattle.

The researchers found that the narwhals clicked while diving to locate their prey, often arctic and polar cod or squid. When closing in on a meal, the clicking sounds turned into a rapid buzzing noise. At the surface, the narwhals used whistle and trumpetlike calls to communicate with one another.

"We were very surprised that they actually have a very specialized way of using sound," says study coauthor Mads Peter Heide-Jørgensen, a biologist at the Greenland Institute of Natural Resources based in Copenhagen. Sounds varied not only with activity, but also with depth.

"Having some of this baseline data from an area that is relatively pristine is going to be really valuable going forward," Stafford says. ■



# Easter Islanders' hat trick explained

Few workers were needed to cap statues, a theory suggests

BY BRUCE BOWER

The story of how some of the massive stone statues on Rapa Nui, also known as Easter Island, ended up wearing stone hats involves ramps, ropes and remarkably few workers, a contested analysis suggests.

No more than 15 people were needed to manipulate ropes that rolled stone cylinders, or pukao, up ramps to the top of forward-leaning statues, say archaeologist Sean Hixon of Penn State and colleagues. The hatlike cylinders were then tipped over to rest atop statues, the researchers propose online May 31 in the *Journal of Archaeological Science*.

After clearing the ramp away, workers then carved statues' bases flat so that the figures assumed their upright positions.

Several possible ways in which Rapa Nui inhabitants put pukao on statues have previously been proposed, including sliding pukao up wooden ramps.

"Our group is the first to consider which pukao transport and placement scenario is most consistent with the archaeological record of these multiton objects," Hixon says. The researchers accounted for possible ways that stone cylinders with the physical features of pukao could have been leveraged onto statues' heads.

Covering 164 square kilometers, Rapa Nui sits in the Pacific Ocean about 3,700 kilometers west of Chile. Polynesian



Polynesians reached Rapa Nui, or Easter Island, by the 13th century and made nearly 1,000 human statues, some of which had hats.

travelers first reached the island by the 1200s (*SN Online*: 1/5/15).

Those people made nearly 1,000 human statues from volcanic rock. Hundreds of them, measuring up to 10 meters tall and weighing up to 74 metric tons each, were moved to stone platforms, many on the coast. A team led by study coauthor Carl Lipo of Binghamton University in New York concluded in 2013 that islanders used ropes to rock upright statues enough so that the huge stones waddled down prepared dirt roads to display sites. Some statues fell along the way and were left on the side of the road. Those left-behind rocks reveal bases carved on a slight diagonal rather than flat.

Pukao were carved from a red-hued rock. Weighing up to nearly 12 metric tons, the cylinders were probably laid on their sides, rolled down dirt roads to statue sites and carved into their final

shapes, the researchers say. Rock chips are still scattered around the statue sites from that activity.

Ramps made of soil and stones provided access to the tops of statues, Hixon's group proposes. A technique called parbuckling would have enabled a small group of people to roll cylinders up ramps. In that scenario, islanders would have wrapped a long, doubled-over rope made from a local shrub around a cylinder placed on its side. One of the rope's ends would be anchored at or near the ramp's top and held in place by several individuals. Another group would have pulled on the rope's free end to roll the cylinder uphill.

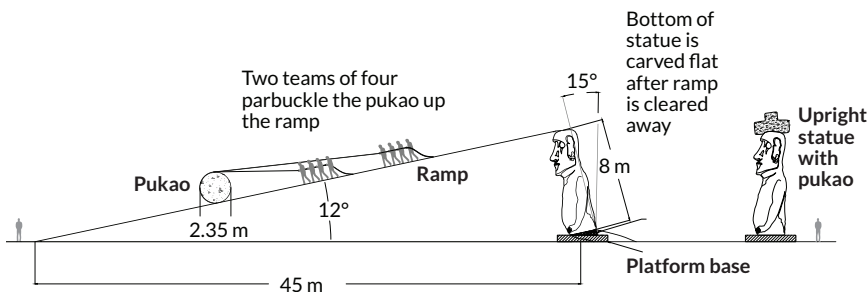
At the top of the ramp, islanders would have tipped the pukao into place on a statue's head, though it's unclear precisely how the tipping was done. Shallow indentations on the bottoms of cylinders, identified on 3-D models of 10 pukao left at a quarry site, enabled a snug fit atop the statues, the researchers say.


Archaeologist Jo Anne Van Tilburg of UCLA regards the new scenario as dubious. Base angles on Rapa Nui statues varied considerably, making them difficult and dangerous to maneuver upright, Van Tilburg says. And parbuckling pukao up long ramps would not have reduced the total effort required to move the massive cylinders to where they needed to be, she contends.

A more plausible plan, in Van Tilburg's view, involved transporting statues and pukao together. Van Tilburg directed a 1998 experiment in which a tree-trunk frame was used to transport a replica stone statue and pukao to an experimental platform. Ropes were used to pull the frame-encased replicas, lying horizontal, across the rungs of a wooden, ladderlike ramp up to the platform. Six to eight families could have completed this process, she estimates.

However Rapa Nui's statues and pukao were moved and set up, they along with other impressive stone monuments, such as England's Stonehenge (*SN Online*: 9/6/12), were built by small communities rather than states or kingdoms, Lipo says. ■

**Rock 'n' roll** A proposal for how Rapa Nui islanders placed colossal hatlike cylinders, known as pukao, atop massive statues suggests few people were needed. In this diagram, workers use a rope technique called parbuckling to roll a cylinder up a makeshift ramp to a forward-leaning statue. After tipping the hat onto the statue, carvers even out the base of the statue so it stands upright.





This artist's impression shows an infant planet as it swirls gas and dust around itself while orbiting a young star.

#### ATOM & COSMOS

### Swirling gases reveal baby planets

Baby planets growing around an infant star have been identified and weighed for the first time. In the June 10 *Astrophysical Journal Letters*, two teams of astronomers describe a way to observe newborn planets with unprecedented precision.

One team found two roughly Jupiter-mass protoplanets around a young star called HD 163296, about 330 light-years from Earth. Another team spotted a third protoplanet about twice Jupiter's mass in a farther orbit around the star.

Both groups used data from ALMA, the Atacama Large Millimeter/submillimeter Array of radio telescopes in Chile. ALMA data had previously revealed gaps and rings in the disks around some young stars that may have been carved out by the gravity of protoplanets. But random fluctuations in the gas and dust can produce rings and spirals without planets.

Instead of relying on the shape of the star's disk to give young planets away, the teams independently developed a way to measure the velocity of the gas by watching the shift in the wavelength of light emitted by carbon monoxide molecules.

Gas motions were best explained by a planetary pull, says Richard Teague, leader of one of the groups. Teague, of the University of Michigan in Ann Arbor, hopes to use the technique on other stars to see what kinds of protoplanets are most common. — *Lisa Grossman*

#### MATTER & ENERGY

### Heavy element's atomic nucleus is shaped like a football

A heavy element's nucleus is all bent out of shape. Nobelium, element 102 on the periodic table, has an atomic nucleus that is deformed into the shape of a football, scientists say in the June 8 *Physical Review*

*Letters*. The element is the heaviest yet to have its nucleus sized up.

By probing individual nobelium atoms with a laser, an international research team gauged the oblong shape of three kinds of nobelium isotopes. These different forms of the element each contain 102 protons but varying numbers of neutrons. The shape is not uncommon for nuclei, but the researchers also determined that nobelium-252 and -254 contain fewer protons in the center of the nucleus than the outer regions — a weird configuration known as a “bubble nucleus” (*SN: 11/26/16, p. 11*).

Elements heavier than uranium, number 92, aren't found in significant quantities in nature and must be created artificially. Currently, the heaviest element on the periodic table is number 118, oganesson. But scientists hope to go even heavier, in search of a potential “island of stability,” a proposed realm in which elements are more stable than other heavy elements.

Better understanding the heaviest known elements, including the shape of their atomic nuclei, could help scientists gauge what lies just out of reach.

— *Emily Conover*

#### MATH & TECHNOLOGY

### AI can pick a voice out of a crowd

Much like someone listening to a conversation at a crowded party, a new artificial intelligence can tune out background noise in videos to hear what a particular person on screen is saying.

Humans are good at focusing on specific voices amid the din — a phenomenon known as the cocktail party effect. But until now, programs designed to listen for specific speakers in noisy audio tracks have struggled to mimic humans' selective mental muting. The new AI is designed to

use both audio and visual cues, such as mouth movements, to separate sounds produced by different speakers in videos.

Researchers at Google tested the AI on cocktail party-like video clips that featured two or three people talking over each other, with various levels of background noise. By watching and listening to the videos, the AI could distinguish which sounds were coming from each speaker much more accurately than a similar algorithm that simply listened to the audio.

To be presented at the SIGGRAPH 2018 meeting in Vancouver in August, this AI could be used to caption videos more accurately than current transcription systems, among other tasks. — *Maria Temming*

#### BODY & BRAIN

### This flu season was especially bad

What felt like a miserable flu season this last year was, in fact, miserable. The 2017–2018 influenza season was classified in the “high severity” category overall, according to a report from the U.S. Centers for Disease Control and Prevention. It was only the third use of this designation since 2003.

The CDC recently applied a new method of evaluating severity to every annual flu outbreak back to the 2003–2004 season. The evaluation considers the percentage of flu-related visits to outpatient clinics, rates of hospitalizations and the percentage of deaths linked to flu or pneumonia.

The most recent flu season was among the worst for hospitalizations and also a bad year for flu-related deaths among children, with 171 fatalities counted as of June 1. Only 22 percent of these child victims who were eligible for this year's flu vaccine were vaccinated before becoming ill, researchers write in the June 8 *Morbidity and Mortality Weekly Report*.

Last season's flu vaccine was about 36 percent effective overall, according to interim estimates, but only 25 percent effective against the predominant viruses from the H3N2 subtype of influenza A. Still, even in years of low effectiveness, the flu vaccine is the best protection against the illness, the CDC says (*SN: 10/28/17, p. 18*). — *Aimee Cunningham*



# » GEOLOGIC ROAD TRIP OF THE MONTH

## PIPESTONE NATIONAL MONUMENT

Pipestone National Monument, 1.5 miles north of the town of Pipestone, is known as the source of pipestone, valued for at least four hundred years by numerous Native American tribes. They carved pipes from the soft, red, clay-rich rock found here. The pipestone was originally deposited as mud about 1,700 million years ago. The primary layer used for pipestone is a layer of mud several inches thick between beds of quartz sand. The sand has since been cemented into the very hard pink Sioux Quartzite, which was deposited by streams long before there was any vegetation on the land. The heat and pressure of burial has altered the mud to pipestone. The pipestone has been named catlinite in honor of artist and historian George Catlin, who in 1836 described the pipestone quarries and the Native Americans who dug the stone.

Walk the 0.75-mile-long Circle Tour that starts at the visitor center. You will see the quarries, both rock types, a waterfall, and native prairie plants. Many of the rock surfaces are faceted and polished by northwest winds. Pipestone's downtown Historic District includes twenty buildings that are on the National Register of Historic Places, each built of the local quartzite between 1880 and 1900. See a more detailed description of the Sioux Quartzite in the road guide for US 75:Ortonville—Interstate 90.

Along the road into the monument are large granite boulders called the Three Maidens. Seven pieces, including three large ones, were once part of a single large boulder since fractured by frost action. The Native Americans realized that the rock was not local in origin and gave it special spiritual significance. The granite boulder, very unlike the surrounding quartzite, was transported here by glaciers from granite near Millbank, South Dakota, or the Ortonville area, about 90 miles to the north.



*Quarry in Sioux Quartzite at Pipestone National Monument.  
The dark red layer at water level is the pipestone.*



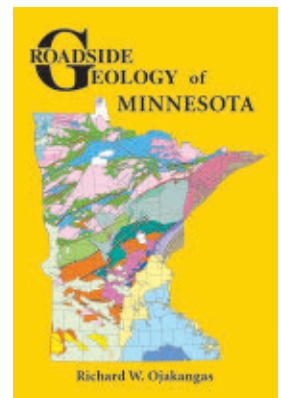
*Cross-bedded Sioux Quartzite on a trail at Pipestone National Monument.*

### EXCERPT FROM **ROADSIDE GEOLOGY OF MINNESOTA**

**RICHARD W. OJAKANGAS**

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# The Impact Hypothesis THAT WON'T DIE



About 13,000 years ago, during the Pleistocene Epoch, bison, mammoths and other large mammals roamed North America.

Critics are still unconvinced that a comet caused a mysterious cold snap 12,800 years ago

**By Carolyn Gramling**

**A**round 13,000 years ago, Earth was emerging from its last great ice age. The vast frozen sheets that had covered much of North America, Europe and Asia for thousands of years were retreating. Giant mammals — steppe bison, woolly mammoths and saber-toothed cats — grazed or hunted across tundra and grasslands. A Paleo-Indian group of hunter-gatherers who eventually gave rise to the Clovis people had crossed a land bridge from Asia hundreds of years earlier and were now spread across North America, hunting mammoth with distinctive spears.

Then, at about 12,800 years ago, something strange happened. Earth was abruptly plunged back into a deep chill.

Temperatures in parts of the Northern Hemisphere plunged to as much as 8 degrees Celsius colder than today. The cold snap lasted only about 1,200 years — a mere blip, in geologic time. Then, just as abruptly, Earth began to warm again. But many of the giant mammals were dying out. And the Clovis people had apparently vanished.

Geologists call this blip of frigid conditions the Younger Dryas, and its cause is a mystery. Most researchers suspect that a large pulse of freshwater from a melting ice sheet and glacial lakes flooded into the ocean, briefly interfering with Earth's heat-transporting ocean currents. However, geologists have not yet found firm evidence of how and where this



happened, such as traces of the path that this ancient flood traveled to reach the sea (*SN*: 12/29/12, p. 11).

But for more than a decade, one group of researchers has stirred up controversy by suggesting a cosmic cause for the sudden deep freeze. About 12,800 years ago, these researchers say, a comet — or perhaps its remnants — hit or exploded over the Laurentide Ice Sheet that once covered much of North America (*SN*: 6/2/07, p. 339).

Pieces of the comet most likely exploded in Earth's atmosphere, the researchers suggest, triggering wildfires across North America. Those fires would have produced enough soot and other compounds to block out the sun and cool the planet. Most scientists think that a similar aboveground explosion, known as an airburst, happened on a far smaller scale in 1908 over Siberia's Tunguska region. That event produced as much energy as 1,000 Hiroshima bombs (*SN Online*: 7/28/09). A similar but even larger cataclysm at the onset of the Younger Dryas, according to the hypothesis's proponents, would neatly solve several prehistoric puzzles, including what caused the extinctions of large animals and what happened to the Clovis people.

For more than a decade, scientific journals have been the battleground for skirmishes over this impact hypothesis. The idea has drawn opponents from a spectrum of scientific fields, including paleoclimatology, physics and archaeology. The critics contend that there is little to no reproducible or incontrovertible evidence for many of the key arguments of the hypothesis.

"Over and over and over, there are these things that are claimed to be proxies for an impact," says Vance Holliday, an archaeologist and geologist at the University of Arizona in Tucson. "And they're all debatable, every single one."

Allen West, a retired geophysicist who owned GeoScience Consulting in Dewey, Ariz., has long been a lead proponent of the impact hypothesis. West acknowledges that the hypothesis has been battered on all sides. "We have different battles with different disciplines," he says. He compares these battles to the fights that raged in the 1980s over whether an asteroid struck Earth 66 million years ago, killing off all dinosaurs except birds — an idea that he notes is now widely accepted.

"There were just vicious, nasty attacks for nearly a decade on that," West says. "People said it just couldn't have happened, and then they found the crater. That's probably what it would take with us, too."

Indeed, no craters have been found dating to the Younger Dryas, and the landscape of North America — the likely ground zero for such an impact,



A 1908 airburst, probably from a comet exploding in Earth's atmosphere over Siberia's Stony Tunguska River, flattened millions of trees.

proponents say — has been pretty thoroughly checked out. In the absence of direct evidence of an impact, West and colleagues have turned to indirect evidence, releasing a steady stream of papers outlining numerous possible signs of an impact, all dating to about 12,800 years ago.

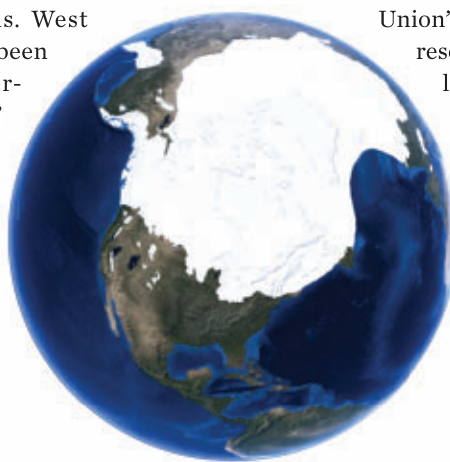
The latest salvo came in March, when West and more than two dozen researchers published a pair of papers in the *Journal of Geology*. The papers include data from ice cores as well as sediment cores from land and sea. The cores contain signatures of giant wildfires that support the idea of a widespread burning event about 12,800 years ago, West says.

The papers promptly elicited exasperation from some opponents, including Holliday. "We have 10 years of this we have to deal with. They keep building on their past record, ignoring the critiques," he says. "It just drives me crazy."

## Birth of a hypothesis

The first formal description of the Younger Dryas impact hypothesis came in 2007, when four researchers sat in front of a gaggle of reporters at the American Geophysical Union's spring meeting in Acapulco, Mexico. The researchers, including West, had taken a close look at about two dozen sites across North America showing a "boundary layer" of sediments dating to the onset of the Younger Dryas. Half a dozen of the sites also have thin layers of organic-rich sediments called "black mats" immediately overlying the boundary layer. Several of those sites show signs of occupation by the Clovis people.

The mats apparently mark the line between occupation and absence at the Clovis sites: For example, a black mat at a site called Murray Springs, in Arizona, sits above a trove of Clovis artifacts, a fire pit and an almost fully articulated skeleton of an adult mammoth. But above the mat, there are no such artifacts; at Murray Springs and elsewhere, the fluted stone



About 20,000 years ago, the Laurentide Ice Sheet covered much of North America. As ice melted about 12,800 years ago, a slug of fresh-water may have entered the North Atlantic Ocean, interfering with ocean circulation and triggering the Younger Dryas cold period.



At Arizona's Murray Springs, an organic clay layer, or black mat, dating to around 12,800 years ago, sits on top of deposits containing Clovis artifacts (spearpoint, below) and skeletons of large game. Some researchers say the layer holds markers of an extraterrestrial impact.



spearpoints made by the Clovis culture disappear from the archaeological record, leading to speculation that the people mysteriously and abruptly vanished.

Those Younger Dryas boundary layers, West and colleagues reported in 2007, contain a variety of intriguing items, including tiny round magnetized grains called microspherules, other magnetized grains of sediment, little spherules of carbon, hollow round carbon molecules called fullerenes and nanodiamonds. Chemical analyses also revealed spikes in iridium and nickel concentrations and in charcoal and soot.

Taken alone, these items may or may not be signs of an extraterrestrial impact: Microspherules, for instance, form when a material heats up and then rapidly cools. They can form during a volcanic eruption, from industrial pollution or as a result of an extraterrestrial impact.

But when taken together, such a suite of markers could point only to an extraterrestrial impact, the researchers concluded: Something struck Earth and exploded in its atmosphere at the onset of the Younger Dryas, about 12,800 years ago. The soot and charcoal suggested that the impact triggered widespread burning that blocked out the sun and brought about a thousand years of near-glacial temperatures in the Northern Hemisphere.

Because no impact crater dating to this time has been found, the researchers suggested that the impactor was probably already fragmented when it entered Earth's atmosphere. Smaller fragments would have done plenty of damage as they exploded in the atmosphere over the retreating Laurentide Ice Sheet, but they wouldn't have left much of a smoking hole in the ground.

The news made a splash — and scientists were intrigued (*SN*: 6/2/07, p. 339). The prospect of layers rich in impact markers found scattered across a continent was definitely worth investigating further. Mark Boslough, a physicist at the University of New Mexico in Albuquerque, says that initially, he took the data at face value. "I thought, 'they're on to something interesting,'"

## Frustrations mount

Then scientists, Boslough included, began to do their own independent analyses. And questions arose. Some researchers claimed that they couldn't find strong evidence of some of the purported impact markers, such as the microspherules and nanodiamonds. Others questioned the precision of the dating at many of the Younger Dryas boundary layer sites, which would undermine the idea that one event affected them all simultaneously.

Boslough says he took issue with the physics of the proposed impact mechanisms, which have ranged from a single object striking the ice sheet to multiple fragments exploding in the atmosphere. But none of the scenarios make sense, Boslough says. Either the pieces of a fragmented comet would have been too small to generate much energy or they would have been too large not to leave craters, he wrote in 2012.

Holliday, meanwhile, says that when it comes to the apparent disappearance of the Clovis culture, the Younger Dryas impact hypothesis is a solution to an archaeological problem that doesn't exist. Hunter-gatherers like the Paleo-Indian people who made Clovis points didn't stay at one site for long; it's no surprise that they would have moved on, Holliday says.

More important, he adds, "there is no mysterious 'gap' in the archaeological record following the time that Clovis artifacts were made." Immediately following the Clovis period, a different style of projectile points, called Folsom points, appeared. Paleo-Indian peoples probably just changed their spear technology due to a shift from hunting mammoth and mastodon to bison, Holliday says.

As for those large Ice Age animals such as mammoths, he adds, they were in decline, but their disappearance wasn't that sudden. "All these animals running around and then, boom, at 12,800 years ago they just go away? That's just not the case," Holliday says. "These extinctions were global and happened at different times around the world."

The March papers focus mainly on the wildfires, a long-standing aspect of the original hypothesis. Greenland ice cores show peaks in ammonium dating to the onset of the Younger Dryas, which the researchers say, suggests large-scale biomass burning. These data were previously presented in 2010 by astrophysicist Adrian Melott of the University of Kansas in Lawrence and colleagues. They suggested that the ammonium ions in those ice cores could be best explained by an extraterrestrial impact. A similar spike dating to 1908 — the year of the airburst over Siberia — had also been found in those same cores. The papers also describe finding peaks in charcoal that date to the start of the cold snap.

"The big thing here is a careful comparison of [many possible impact markers], normalized to the same dating method," says Melott, one of the authors on the new impact papers. Those markers, including previously described evidence of microspherules, iridium and platinum dust, are consistent with having been caused by the same event, he says.

However, Jennifer Marlon, a paleoecologist and



paleoclimatologist at Yale University and an expert on biomass burning, has taken her own look at sediments in North America dated to between 15,000 and 10,000 years ago. She sees no evidence for continent-wide fires dating specifically to the onset of the Younger Dryas.

"I've studied charcoal records for many years now," Marlon says. In 2009, she and colleagues reported data on charcoal and pollen in lake sediments across North America. Importantly, the sediment records in her study encompassed not only the years of the Younger Dryas cold episode, but also a few thousand years before and after.

Her team found multiple small peaks of wildfires, but none of them were near the beginning of the Younger Dryas. "Forests burn in North America all the time," she says. "You can't find a cubic centimeter of sediment in any lake on this continent that doesn't have charcoal in it."

Such fires could be triggered by rapid climate change, when ecosystems are quickly reorganizing and more dead fuel might be available. "That can cause major vegetation changes and fires," Marlon says. "We don't need to invoke a comet."

The problem with the data in the recent papers, Marlon says, is that the researchers look only at a narrow time period, making it difficult to evaluate how large or unusual the signals really were. From her data, there appeared to have been more burning toward the *end* of the Younger Dryas, when the planet began to warm abruptly again.

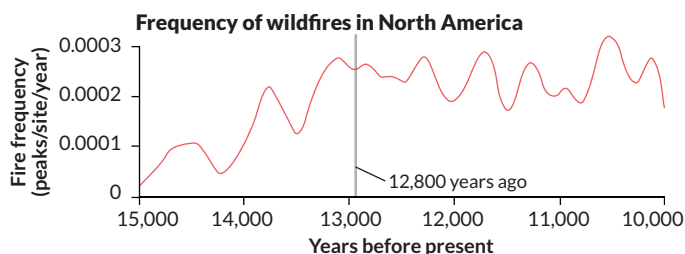
"That speaks to my fundamental problem with the biomass burning part of the papers," Marlon says. "I don't understand why they're zooming in. It's what makes me skeptical."

Holliday echoes that criticism. "Most of the time they sample only around this time interval," he says. What would be more convincing, he says, are data from cores that span 15,000 to 20,000 years, sampled every five centimeters or so. "If this is a unique event, then we shouldn't see anything like it in the last 15,000 years."

West says that other peaks are irrelevant, because the impact hypothesis doesn't imply that there was only one wildfire, just that one occurred around 12,800 years ago. He adds that the new papers suggest that Marlon and her colleagues didn't correctly calibrate the radiocarbon dates for their samples. When done correctly, he says, one spike in fires that Marlon estimated at around 13,200 years ago actually occurred several hundred years later — right around 12,800 years ago.

Radiocarbon dating for such old events is challenging regardless of calibration, Marlon says. That's why she analyzed and compared her sites in several different ways, yet still found no unusual peak at 12,800 years. In fact, she says, many of the sites show no signs of burning at that time.

As for whether the impact hypothesis proponents have ignored scientific criticisms, West rejects this. "We have directly



**Missing peak** Charcoal records from 15 lake sediment cores from across North America show how often fires occurred at each site over 5,000 years. The records show no peak in burning about 12,800 years ago, as would be expected if there were continent-scale fires.

SOURCE: J.R. MARLON ET AL./PNAS 2009

rebutted those criticisms multiple times," he says. An upcoming paper he and others are preparing will describe in detail those rebuttals, such as errors he says previous critics made in properly reproducing the analyses West and his colleagues used to identify a key impact marker, the magnetic spherules.

Yet critics of the Younger Dryas impact hypothesis say that too many questions remain unanswered. Holliday says he and others are preparing a response to the *Journal of Geology* papers, outlining numerous points of contention.

"Confronting and dealing with critical reviews and contradictory data is a significant problem in this debate," Holliday says. None of the rebuttals have dealt with various criticisms, he adds, such as the proper dating of rock layers and soils, and the contradictory data over animal extinctions and Paleo-Indian archaeology.

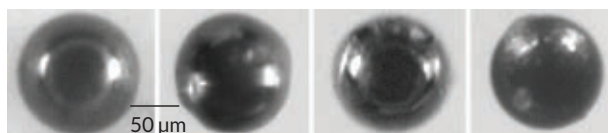
"We all love a good debate," Marlon says, "but I know there's a lot of frustration in the community" that this hypothesis persists. Like many opponents of the impact hypothesis, she says that the data presented in the new papers have done nothing to change her mind about the comet strike. "It didn't happen."

All the same, Marlon understands the allure. "I have had pet theories, too. We are pattern-seekers. We tend to see things that look like a signal and so many times they're not. A comet is simpler and more visually compelling — more appealing, in a way — than trying to sort out what Earthbound trigger might have caused such an abrupt climate change.

"I wish the evidence were stronger for [an impact]," she says. "It's not as much fun when it turns out to be a more complicated, nuanced story." ■

## Explore more

- Wendy S. Wolbach *et al.* "Extraordinary biomass-burning episode and impact winter triggered by the Younger Dryas cosmic impact ~12,800 years ago." [papers 1 and 2.] *The Journal of Geology*. March 2018.
- Vance T. Holliday *et al.* "The Younger Dryas impact hypothesis: A cosmic catastrophe." *Journal of Quaternary Science*. August 2014.



Researchers wrangle over the meaning of impact markers (microspherules shown) in black mats.



Connor McMahon (second from left), his parents Don and Michelle and brothers Declan and Sean are shown here on a visit to Colorado last November.

# CAR-T 2.0



Can the risks of this promising immune therapy for cancer be tamed?

By Laurel Hamers

This wasn't 15-year-old Connor McMahon's first time in the hospital. But the 107° fever he'd been running for three days had his dad frightened. The teen was hallucinating, talking gibberish and spouting curses.

"I thought he was going to die," says Connor's father, Don McMahon, who stayed close as his son received and recovered from an experimental treatment for leukemia. "It was really hard to watch." But the fever finally broke, and Connor returned home. Just a month later, in November 2016, he was cancer-free and back on the ice in his hockey skates and pads.

That episode was Connor's third bout with acute lymphoblastic leukemia. The experimental treatment was a last hope for the boy, who was first diagnosed at age 3. He has spent a total of six years of his life receiving chemotherapy. When the cancer came back in 2016, the doctors said the prognosis wasn't good.

At that point, "it was about quality of life, not quantity," McMahon says. But when he and his wife, Michelle, learned about the experimental

treatment, called CAR-T cell therapy, the family decided it wasn't time to give up yet.

McMahon enrolled Connor in a clinical trial for a CAR-T cell therapy at Duke University Children's Hospital, five hours from the family's Atlanta home. Days later, doctors extracted immune cells called T cells from Connor's blood and shipped them off to a lab in New Jersey. There, the cells were genetically modified to target and kill the cancer cells coursing through Connor's bloodstream.

A month later, doctors injected those modified T cells into the teen's body, where they multiplied. Over the next few weeks, that five-minute T cell infusion racked Connor's body but also knocked the levels of cancer cells in his bloodstream down to zero.

CAR-T cell therapy has captivated cancer researchers and patients alike because of stories like Connor's. The U.S. Food and Drug Administration approved two versions in late 2017. In clinical trials, the treatment that Connor took, called Kymriah, wiped away all signs of acute lymphoblastic leukemia in 52 of 68 children



and young adults. Of those, 75 percent were still cancer-free six months later. And in a study of 101 patients taking Yescarta, a CAR-T therapy for adults with certain types of lymphoma, 51 percent of patients showed no sign of cancer after treatment. (In May, the FDA also approved Kymriah for people with certain lymphomas.) These results were particularly exciting because the patients in these trials were dealing with a recurrence of cancer or had been through at least two other treatments that didn't work.

But these new therapies can come with scary side effects. A majority of patients who receive CAR-T cell therapy react like Connor did, with varying degrees of severity. Those same T cells that are outfitted to attack the cancer can send the immune system into overdrive by instigating a surge of proteins called cytokines into the bloodstream, triggering inflammation. Cytokine release syndrome, as it's called, can cause high fevers, make patients' hearts race out of control and send blood pressure plummeting. The cytokines can also attack the brain, causing seizures.

In a large, multihospital study of Kymriah, 54 of 68 patients experienced some form of cytokine release syndrome. Symptoms were severe enough in 32 patients to require intensive care hospitalization. Neurological problems are a risk as well. In 2016, five patients died from fatal brain swelling in a CAR-T cell clinical trial run by Seattle-based Juno Therapeutics. The company stopped the trial, and the deaths intensified questions about the treatment's safety.

These side effects are one reason why both therapies are approved for only a narrow range of patients: people with a few very select kinds of blood cancers—certain types of leukemia and lymphoma—and only those whose cancer hasn't responded to conventional treatments. And CAR-T therapy is offered only at select cancer treatment centers with trained teams that follow rigorous safety protocols to control side effects. Yescarta, for example, is available at just over 50 U.S. hospitals.

Many oncologists are convinced, however, that someday CAR-T cells could be used on a much wider group of patients and for a broader spectrum of cancers. Researchers are designing new forms of the treatment, changing the way that patients' T cells are engineered to make the therapy less risky. Scientists are installing safety switches that can turn off CAR-T cells on command and designing T cells that activate only under certain conditions. Others are adding features

**System overdrive** CAR-T cell therapy can cause severe side effects in cancer patients. Doctors need to be vigilant to manage those problems in the clinic.

Cytokine release syndrome	How is it managed?
High fever	An interleukin-6 inhibitor plus supportive care
Low blood pressure	
Delirium	
Fatigue	
Other side effects	How is it managed?
Brain swelling	Corticosteroids, for severe cases
Neurotoxicity	
Seizures	
Reduced numbers of healthy immune cells	Long-term immunoglobulin

that help the T cells more specifically target cancer cells but ignore healthy cells, or reduce collateral damage from T cell-boosting drugs. Meanwhile, doctors are learning how to better manage the side effects for patients.

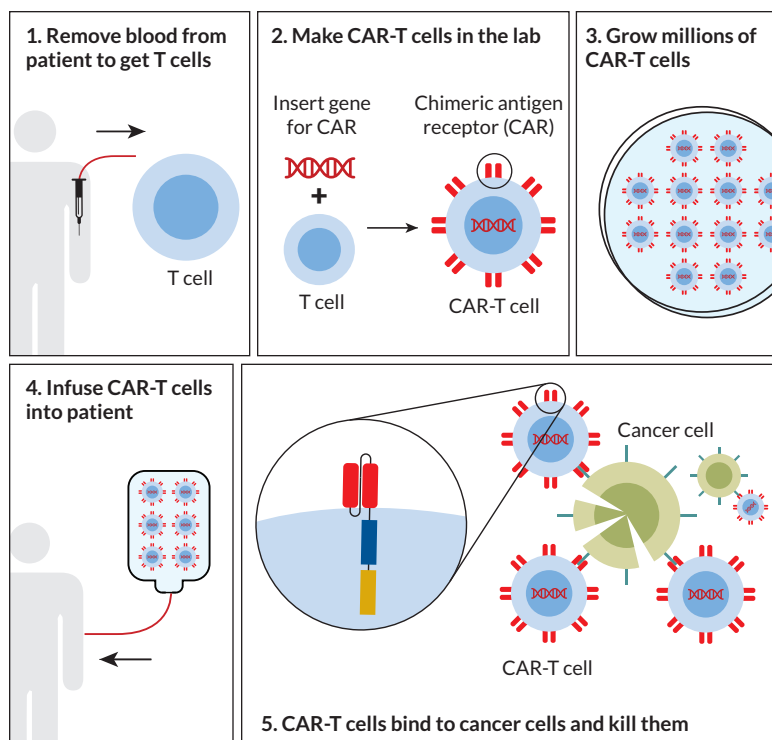
"I think this is an incredibly exciting time," says David Maloney, a physician and CAR-T cell researcher at the Fred Hutchinson Cancer Research Center in Seattle. The CAR-T cell technology is rapidly improving, and "our job is to do this safely and make it even more effective."

## Building a better T cell

Some immune system cells recognize cancer cells as abnormal and kill them, but sometimes that's not enough. Researchers have tried for decades to harness the immune system to fight cancer more effectively. Doctors have used vaccines or given patients lab-made versions of immune system proteins to heighten patients' immune responses.

"Immunotherapy goes back a long time, but *successful* immunotherapy is just in its infancy," says Paul Martin, a pediatric oncologist at Duke University who treated Connor with CAR-T cells. He says CAR-T therapy is part of a new, more promising wave of immune therapies against cancer.

The underpinnings of CAR-T cell therapy were developed in research labs in the 1990s, and the first CAR-T cells fought off cancers in mice in the early 2000s. But with last year's FDA approvals for the two CAR-T cell therapies, interest has exploded (*SN: 12/23/17, p. 29*). As of June 14, the government's registry of clinical studies, ClinicalTrials.gov, included 272 active studies for CAR-T cell therapies, mostly in the United States, China and Europe. Hundreds more variations are



### Made to order

Each batch of CAR-T cell therapy is created for a specific patient. First, T cells are removed from the patient (1) and genetically modified to recognize the cancer (2). Batches of the new CAR-T cells are grown (3), then returned to the patient in one infusion (4). The CAR, or chimeric antigen receptor, has parts on the outside (red) of the T cell that help it recognize the cancer cell and components on the inside (dark blue and gold) that help it communicate with and attack cancer cells (5).

SOURCE: NATIONAL CANCER INSTITUTE

being designed and tinkered with in research labs around the world.

CAR-T cell therapy works by taking advantage of cells' natural communication systems. The surface of every cell is studded with proteins that send messages between cells in a sort of molecular semaphore. The engineered T cells have a chimeric antigen receptor, or CAR, on their surface — a synthetic protein that has a laser-focus lookout for a specific protein that appears on the surface of certain cancer cells. Most CAR-T cells developed to date are aimed at a molecule called CD19 found on the surface of B cells, another kind of immune cell that, when it multiplies unchecked, leads to certain blood cancers.

So far, CAR-T cell therapy has been approved only for certain leukemias and lymphomas that start in B cells. Those cancers are among the easiest to develop such a treatment for, Martin says. "This was the low-hanging fruit." Blood cancers are easier to root out than solid tumors, which have hard-to-reach cells buried within and develop a fortress of defense against cancer therapies. A handful of CAR-T therapies aimed at solid tumors are in early patient studies.

### Hitting the bull's-eye

Right now, the CAR-T cells' aim isn't perfect — they often hit healthy B cells that also display the protein the T cells are targeting, sending ripple

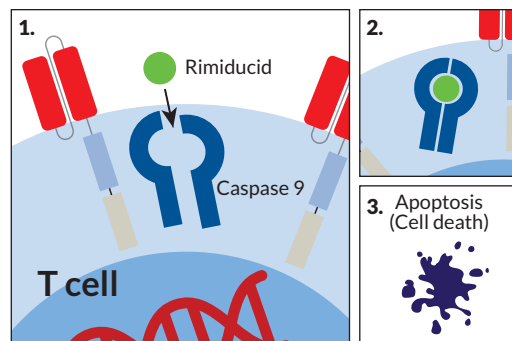
effects through a patient's immune system. For CAR-T therapy to be anything other than a treatment of last resort, scientists will need a better level of control over the cells than exists now, says Kole Roybal, an immunologist at the University of California, San Francisco.

Roybal is working on a system to control when and where in the body engineered T cells are activated. It adds an extra step to turning on the T cells, like a Breathalyzer test that a driver must pass before a car can be started.

The system relies on a synNotch receptor — a second synthetic protein that scientists can add to the surface of T cells in addition to a CAR. Just like a CAR, the synNotch receptor recognizes a specific protein on a cancer cell's surface, and then latches on.

But synNotch, which hasn't been tested in patients yet, doesn't trigger the T cell to kill the cancer cell. Instead, when synNotch sees a cancer cell, it directs the T cell to make a CAR appear on the cell surface. That way, the only T cells with killing potential are the ones that are in the presence of cancer cells, Roybal says. His team reported the development of CAR-T cells with synNotch receptors in February 2016 in *Cell*. In tests in human cells and in mice, T cells with synNotch receptors targeted cancer cells more selectively than CAR-T cells without the synNotch receptors.

Other scientists are working on a different problem: how to turn CAR-T cells off once they've done their job. That's important to do because Connor and patients like him will have a small number of CAR-T cells hanging out in their bloodstream for their entire lives. Those cells will kill healthy B cells, weakening the body's ability to fight off ordinary illnesses. To counteract the effect, Connor needs years of weekly infusions of a protein called immunoglobulin, his father says.



**Off switch** To flush out CAR-T cells, the drug rimiducid activates the protein caspase 9 in the T cells, launching T cell death. SOURCE: BELLICUM PHARMACEUTICALS

So scientists are building several versions of CAR-T cells with an “off” switch. The cells are designed to self-destruct when they encounter a particular synthetic small molecule or protein that is not normally found in the body. The patient could take the small molecule as a drug when it’s time to turn off the T cells. The drug-induced off switch could be used to flush CAR-T cells out of a patient’s system once the treatment has run its course, or to disable the T cells if a patient starts experiencing dangerous side effects.

Some of these switches are already being tested in patients. One switch, designed by Houston-based Bellicum Pharmaceuticals, responds to the drug rimiducid. A CAR-T cell therapy with this switch is in early testing in children, says Bellicum spokesperson Brad Miles.

Other, more sophisticated versions are being developed in the lab as well. For example, the pharmaceutical company Cellectis, based in New York and Paris, is testing an all-in-one safety CAR; the self-destruct switch is part of the CAR itself rather than a separate apparatus on the cell. Integrating the two is a tougher engineering challenge than adding a separate safety switch, says Julien Valton, a Cellectis researcher. In lab tests of the all-in-one prototype, it takes about 10 minutes to shut off the cells if they’re in a petri dish, Valton says, but about four days for cells circulating in the bloodstream of a mouse.

### Safer cytokines

There may be a more targeted way to amplify the power of the engineered T cells within a patient.

For instance, the cytokine interleukin-2 is a master driver of the immune system. Normally, IL-2 is present in small quantities, and can boost the size of the body’s T cell population.

In theory, giving IL-2 to patients on CAR-T cell therapy could be a way to make the modified T cells mount a stronger response against the cancer. But it also makes regular, nonengineered T cells multiply. That’s risky: The influx of T cells quickly sends the immune system into hyperdrive, making people very sick. “It sounds good on paper, but in practice, it’s not what these molecules were evolved to do,” says Jonathan Sockolosky, who modified IL-2 while at Stanford University. He has since moved on to other projects at South San Francisco-based Denali Therapeutics.

By tweaking the way IL-2 interacts with the immune system, Sockolosky and his team found a way to make CAR-T treatment more targeted, they reported in *Science* in March. With the

Normal receptor and normal IL-2



Normal receptor and modified IL-2



Modified receptor and modified IL-2



Modified receptor and normal IL-2



**Focus on the right T cells** By changing the shape of the cytokine IL-2 as well as the T cell receptor that it links with, scientists have found a way to affect only the T cells involved in the treatment. The IL-2 communicates only with the engineered T cells in a patient’s body, leaving alone the normal ones. SOURCE: J.T. SOCKOLOSKY ET AL/SCIENCE 2018

chemical modifications, the IL-2 communicates with and boosts production of only the modified T cells designed to fight cancer, not the rest of the body’s T cells. In tests in mice, the IL-2 that enhanced the CAR-T cell activity barely bound to the body’s normal T cells at all.

### A universal CAR-T cell

Making CAR-T cells better isn’t all about making them more specific, though. A big limitation of today’s CAR-T cell therapies is that they must be personalized for each patient, which makes them time- and cost-intensive to produce. Right now, one dose of Kymriah, which is usually all a patient needs, costs \$475,000.

Some scientists are working on a universal CAR-T cell therapy — one that doesn’t rely on cooking up small batches of personalized T cells for each patient. Hospitals could carry a stock of CAR-T therapies much like a stash of antibiotics or pain meds. Moving away from the made-to-order treatments could make it easier for smaller cancer centers to provide the therapy, increasing access for patients. It could also shorten the wait time for patients to be treated, since cells wouldn’t need to be shipped to a lab to be modified and duplicated.

From a drug company’s perspective, it’s advantageous to develop a single uniform product rather than to market a procedure, which is essentially what other available CAR-T cell therapies are, says André Choulika, CEO and cofounder of Cellectis.

The universal approach would work much like today’s CAR-T cell therapies, Choulika says. But it would use T cells from a healthy donor instead of the patient with cancer. So a lab could make many doses of engineered T cells from the same starting cells. The cells would be edited to remove the genetic instructions that normally help T cells distinguish foreign cells from the body’s own cells. That’s an important step, because normally a patient’s immune system won’t accept an infusion



of T cells from someone else's immune system.

Universal CAR-T cells are already being tested in people, but the road has not been smooth: In 2017, Cellectis was forced to temporarily halt clinical trials for one of its products after a patient died from severe cytokine release syndrome. The trials have since restarted with a lower dose of CAR-T cells and tighter restrictions on who can participate. Choulika estimates it will be three to four years before any of the company's universal CAR-T treatments make it through the clinical trials process.

Meanwhile, Boston University biomedical engineer Wilson Wong is trying to address the smorgasbord of challenges presented by CAR-T therapies in one streamlined system — something like the Swiss army knife of CAR-T cells, he says. His design splits up the CAR into multiple pieces, forcing the T cells to recognize two different proteins on the cancer cell's surface to kill it. That helps reduce the off-target effects.

And the system is adaptable on the fly. Right now, Wong says, CAR-T cells are engineered to have a specific protein on the outside — one that recognizes a certain matching protein on the cancer cell's surface. But not all kinds of cancer

cells have a protein that's specific only to the cancer and not also found on healthy cells. And sometimes cancer cells mutate and change the proteins they show on their surfaces, allowing the cancer to hide from CAR-T cells.

In Wong's system, the cancer cell-sensing proteins aren't built directly into the CAR-T cell. Instead, they're attached to a drug that's engineered to stick to the T cell. When the drug is injected into a patient's bloodstream, it tracks down and attaches to the CAR-T cells, only then giving those engineered cells the ability to hunt and kill cancer cells.

That adds a lot of flexibility to the system, Wong says, because doctors can easily switch up the drug given to patients if the cancer mutates, showing new proteins, and treatment stops working. "Then you can change really quickly without having to reengineer the T cells." And it could be a way to make CAR-T cells work in other kinds of cancer. Wong and colleagues described their approach in the May 31 *Cell*, and they're working to license the idea to a pharmaceutical company for clinical testing.

### CAR-T cell futures

It's far too soon to say that Connor has been cured of cancer. But he's been cancer-free for more than 18 months — an outcome that in 2016, he and his family couldn't have imagined. He just dyed his hair blond. In March, his hockey team took second place in its division at the USA Hockey Youth Nationals in Wayne, N.J.

Don McMahon understands why, right now, CAR-T cell therapy is so limited. But he also marvels at his family's luck: Connor had exactly the right kind of cancer to receive the treatment, and he met the stringent criteria to participate in the clinical trial. Other patients might not be so lucky. "It seems so arbitrary," he says, while acknowledging that the restrictions are in place for good reasons. He hopes that, as research progresses, CAR-T cell therapy can help more patients.

As CAR-T therapy improves, it may do what McMahon hopes. "We'll still need chemo and radiation and surgery," says Martin, Connor's oncologist, "but now we're going to have a whole new addition — immunotherapy." ■

### Explore more

- National Cancer Institute. "CAR T cells: Engineering patients' immune cells to treat their cancers." December 14, 2017. [bit.ly/NCI-CART](http://bit.ly/NCI-CART)

Connor McMahon is back on the ice protecting the net. His team recently won second place in its division in the USA Hockey Youth Nationals.



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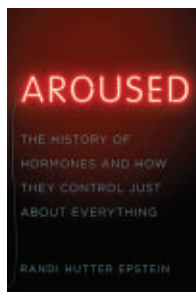
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**Aroused**  
Randi Hutter Epstein  
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two of his backyard roosters. The cocks' red combs faded and shrank, and the birds stopped chasing hens.

Then things got really weird. The doctor castrated two more roosters and implanted a testicle from each into the *other's* abdomen. As Randi Hutter Epstein writes in a new book, each rooster "had nothing between his drumsticks but a lone testicle in his gut — yet he turned back into a full-fledged hen-chaser, red comb and all." It was the first glimpse that certain body parts must produce internal secretions, as hormones were first known, and that these substances — and not just nerves — were important to the body's control systems.

Today, we know that hormones are chemical messengers shaping everything from sex and development to sleep, stress, mood, metabolism and behavior. Yet few of us know much about these powerful substances coursing through our bodies. That ignorance makes *Aroused* — titled for the Greek meaning of the word *hormone* — an invaluable guide.

Epstein, a medical writer and M.D., tells the history of hormone research from that first rooster experiment, but cleverly moves back and forth through time, avoiding any hint of dry recitation. She explores the scientists who discovered and deciphered the effects of important hormones, as well as the personal stories of how people's lives have been profoundly changed by these chemicals.

There's Barbara Balaban, who launched a nationwide campaign to

## BOOKSHELF

## The promise and peril of hormones

The first scientific experiment on hormones took an approach that sounds unscientific: lopping off roosters' testicles.

It was 1848, and Dr. Arnold Berthold castrated

collect pituitary glands from cadavers' brains to extract growth hormone for her short-statured son. Readers also meet Bo Laurent, born intersex, as well as Nate Snizek, whose rare endocrine disorder makes him insatiably ravenous.

And among the scientific heroes profiled is Rosalyn Yalow, who developed the radioimmunoassay that makes measuring hormones and treating imbalances possible — a feat that earned her a Nobel Prize in physiology or medicine in 1977 (*SN*: 10/22/77, p. 260).

One striking lesson from the book is that we have, over and over again, tried to use hormones to our advantage before really understanding how they work. The hormone from testicles wasn't isolated and named testosterone until 1935. But by the 1920s, men already were looking for ways to get more of this unknown essence of virility.

The Viennese physiologist Eugen Steinach believed that getting a vasectomy would boost the substance in men (it doesn't), and Sigmund Freud and William Butler Yeats were among the many men "Steinached" in an effort to restore youthful vim and vigor.

Many new hormones discovered since have been met with similar excitement, hope and hype — often followed by mistakes and fears. Following the popularity of the birth control pill, many women were eager to ease menopause symptoms using estrogen. But then a large 2002 study linked hormone replacement therapy to strokes and breast cancer, and prescriptions plummeted. Doctors have since spent years sorting fact from fiction about the hormone treatment (*SN*: 1/20/18, p. 18).

One of the latest hormones to be ballyhooed is oxytocin, which is involved in maternal-child bonding and other social behaviors. Since a 2005 study linked it to trust (*SN*: 6/4/05, p. 356), the hormone has been billed as the "moral molecule." You could even buy

a spritzer of so-called "liquid trust." As Epstein details, many of those promises hinge more on hope than science.

Even testosterone has made a commercial comeback. Rebranded as "low-T" therapy, testosterone injection is a booming business. Once again, aging men are lining up before testosterone therapy's risks and benefits are made clear (*SN*: 4/1/17, p. 8).

In the end, Epstein paints a portrait of how hormones control us and how we yearn to control them. Perhaps appropriately, it's a history marked by our shifting moods. — *Erika Engelhaupt*

## BOOKSHELF



### The Rise and Fall of the Dinosaurs

Steve Brusatte

A paleontologist offers an up-to-date account of the dinosaurs' long reign on Earth. *William Morrow*, \$29.99



### Burning Planet

Andrew C. Scott

Roughly 400 million years of history reveal the vital roles that wildfires play in shaping Earth's landscapes. *Oxford Univ.*, \$27.95



### Tasting the Past

Kevin Begos

A journalist travels the world to retrace the origins of wine, meeting a diverse array of scientists along the way. *Algonquin Books*, \$26.95

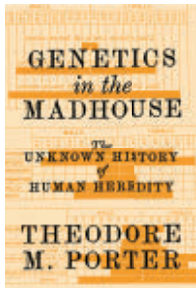


### The Travel Diaries of Albert Einstein

Ze'ev Rosenkranz, ed.

Journal entries from 1922 to 1923 offer new insights into the inner life of the famed physicist. *Princeton Univ.*, \$29.95





**Genetics in the Madhouse**  
Theodore M. Porter  
PRINCETON UNIV., \$35

## BOOKSHELF

### Heredity's big data start

England's King George III descended into mental chaos, or what at the time was called madness, in 1789. Physicians could not say whether he would recover or if a replacement should assume the throne. That political crisis jump-started the study of human heredity.

Using archival records, science historian Theodore M. Porter describes how the king's deteriorating condition

invigorated research at England's insane asylums into the inheritance of madness. Well before DNA's discovery, heredity started out as a science of record keeping and statistical calculations. In the 1800s, largely forgotten doctors in both Europe and North America meticulously collected family histories of madness, intellectual disability and crime among the growing numbers of people consigned to asylums, schools for "feeble-minded" children and prisons.

Some physicians who specialized in madness, known as alienists, saw severe mental deficits as a disease caused by modern life's pressures. But most alienists regarded heredity, the transmission of a presumed biological factor among family members, as the true culprit. Asylum directors launched efforts to track down all sick relatives of patients. The increasing number of people institutionalized for men-

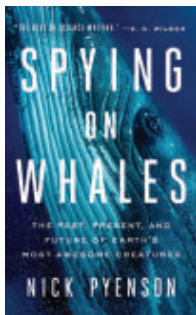
tal deficits fueled the view that individuals from susceptible families should be discouraged from reproducing.

Porter documents a mid-1800s push for standardized asylum statistics. Asylum directors turned to the correlation table, which drew statistical links between pairs of variables, such as disease type and percentage of people cured. In 1859, Norwegian researcher Ludvig Dahl published family pedigrees of mental illness, using detailed census records.

Dahl and his predecessors laid the groundwork for well-known statisticians, such as Francis Galton, to launch the eugenics movement by 1900. Gregor Mendel's plant-breeding experiments raised eugenicists' hopes that people inherit mental health or illness as systematically as peas inherit smooth or wrinkled skins. That idea was rejected as simplistic by 1920.

German researchers then organized an unprecedented project to collect data on family traits of asylum patients, intellectually disabled students and prisoners. The work expanded under the Nazis. Eugenics' horrific crescendo didn't stop investigators worldwide from approvingly citing German work on inheritance for several decades after World War II.

Porter takes a fascinating look at early attempts to tame unruly minds with big data and statistics. Those efforts had some lasting effects. Family pedigrees, for instance, remain part of research into the inheritance of mental disorders. A few sections featuring hereditary tables and family data can be skipped without detracting from the book's major theme: In an era of molecular genetics, heredity's statistical history calls for a huge dose of scientific humility. — *Bruce Bower*



**Spying on Whales**  
Nick Pyenson  
VIKING, \$27

## BOOKSHELF

### A whale of a tale

Just before humans evolved, whales and dolphins were, pound for pound, the brainiest creatures on Earth. Another cetacean superlative: Today's biggest whales are heftier than the largest dinosaurs that ever lived. The evolutionary trends that produced big, brainy marine animals are just a few of the fascinating tales told in *Spying on Whales*.

Paleontologist Nick Pyenson studies whale fossils, but he's also been known to cut up a few modern-day carcasses. As laid out in his new science-book-cum-midcareer-memoir, the anatomical info gained from both endeavors provides strong evidence for evolution in action. That process has transformed cetaceans' dog-sized, four-legged ancestors, which returned to the water around 50 million years ago, into today's seafaring behemoths. Pyenson's research hasn't been all lab work, though: His field studies have taken him from whaling stations in Iceland to a site in South America's Atacama Desert where ancient whales repeatedly washed ashore (*SN Online*: 2/28/14).

Blue whales are about 10,000 times as massive as their land-lubber ancestors, Pyenson notes. One evolutionary innovation that enabled the immensity of blue whales and some of their close kin is baleen, the flexible sheets of fingernail-like keratin that hang by the hundreds from the roofs of these creatures' toothless mouths. Using these frayed and overlapping sheets, baleen whales filter immeasurable numbers of tiny prey from mouthfuls of water the volume of a large living room. For some baleen whale species, another undoubted asset is the sensory organ that Pyenson and colleagues discovered in the "chins" of fin whales, among others. That nerve-rich glob of goo helps the whales sense dense clouds of prey and better recognize the position of their own jaws as they open and close their mouths.

When Pyenson looks to whales' future, there's mixed news. Most countries have phased out commercial whaling, but collisions with ships still threaten cetaceans' long-term survival. On the other hand, Pyenson notes, a decline in summer sea ice in the Arctic may be allowing gray whales to stray over the pole from the North Pacific to the North Atlantic and beyond, possibly setting up new populations (*SN*: 12/24/16, p. 23).

All in all, *Spying on Whales* is a delight to read, from the author's descriptions of the sights, sounds and smells of the lab and field to the joys of hunting fossils, whether with his colleagues or his young son. — *Sid Perkins*

## SOCIETY UPDATE



Intel ISEF 2018 top three (from left): Meghana Bollimpalli, Oliver Nicholls and Dhruvik Parikh celebrate in Pittsburgh.

## Congratulations to Intel ISEF 2018 Winners!

At this year's Intel International Science and Engineering Fair (ISEF), **Oliver Nicholls**, 19, of Sydney, Australia, was awarded first place for designing and building a prototype of an autonomous robotic window cleaner for commercial buildings. In essence, a flying dronelike device is tethered to the roof of a building and equipped with a powerful spray nozzle and rotating scrubbers. The \$2,300 device can withstand 28-mile-per-hour winds and could replace traditional methods that can exceed \$11,000 per cleaning, as well as reduce injuries in this high-risk occupation. Nicholls received the Gordon E. Moore Award of \$75,000, named in honor of the Intel cofounder and fellow scientist.

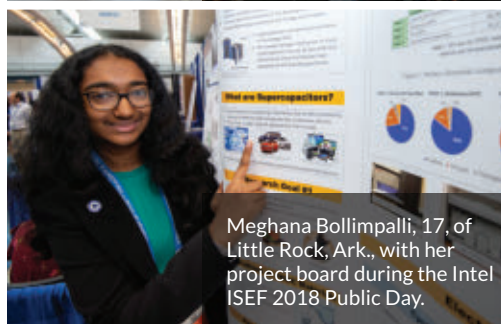
**Meghana Bollimpalli**, 17, of Little Rock, Ark., received one of two Intel Foundation Young Scientist Awards of \$50,000 for her novel, low-cost approach for synthesizing materials that could greatly cut the production and energy costs of making electrodes for devices like supercapacitors. She found that combining common substances like tea and molasses with nitrogen and phosphorus in a commercial microwave formed a powder that could be used as a coating for electrode-like materials, giving the materials properties similar to more expensive metals like platinum.

**Dhruvik Parikh**, 18, of Bothell, Wash., received the other Intel Foundation Young Scientist Award of \$50,000 for his development of less expensive yet more robust ion exchange membranes for use in large, industrial-scale batteries for storing solar- or wind-generated electricity for later distribution. His composite membrane has 10 times the proton conductivity of the industry's standard membrane, while reducing production costs by about 30 percent.

Intel ISEF is a program of Society for Science & the Public and is the world's largest international pre-college science competition. This year's competition featured nearly 1,800 young scientists selected from 420 affiliate fairs in 81 countries, regions and territories. In addition to the top winners, approximately 600 finalists received awards and prizes for their innovative research, including 22 "Best of Category" winners, who each received a \$5,000 prize in addition to a \$3,000 first-place award. The Intel Foundation also awarded a \$1,000 grant to each winner's school and to the affiliated fair that the winner represented.



Oliver Nicholls, 19, of Sydney, Australia, with his award-winning autonomous robotic window-cleaner prototype.



Meghana Bollimpalli, 17, of Little Rock, Ark., with her project board during the Intel ISEF 2018 Public Day.



Dhruvik Parikh, 18, of Bothell, Wash., with his project board during the Intel ISEF 2018 Public Day.

View the full list of Grand Award winners at [www.societyforscience.org/2018-ISEF-Winners](http://www.societyforscience.org/2018-ISEF-Winners)





MAY 26, 2018

## Think before you spit

Consumers are jumping on the genetic testing bandwagon. While the test results can be fun and informative, many people don't know what else might be in store. As part of *Science News*' special multipart series "Genetic testing goes mainstream" (SN: 5/26/18, p. 20), **Cassie Martin** reported on the potential privacy risks. Read "Privacy and consumer genetic testing don't always mix" on the Science & the Public blog (SN Online: 6/5/18), at [bit.ly/SN\\_GeneticPrivacy](http://bit.ly/SN_GeneticPrivacy)



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IMAGE POINT FR/SHUTTERSTOCK

## What lies beneath

*Liquid pumped into the ground to generate geothermal power may have triggered a large earthquake that shook part of South Korea last November, **Carolyn Gramling** reported in "Quake linked to geothermal power" (SN: 5/26/18, p. 8).*

Reader **Elizabeth McDowell** asked if there may be a link between geothermal power generation at a plant in Hawaii and the ongoing Kilauea eruption.

"Did the geothermal plant inject so much water down those wells that it not only caused earthquakes but a huge eruption?" she asked. "Maybe the lava is pointing an accusatory finger at the cause by encroaching on the geothermal plant itself.... I think Hawaii should be the researchers' next case study!"

South Korea's geothermal plant is an "enhanced geothermal system" that involves injecting fluids at high pressures into the subsurface to produce energy. These high-pressure injections have been identified as likely culprits in earthquakes near enhanced geothermal plants in Switzerland as well. But Hawaii's geothermal power plant doesn't require any high-pressure injections; its location next to a volcano is no accident. The subsurface there is already fractured and very hot, well-suited for geothermal power generation, **Gramling** says. In other words, injections didn't cause Kilauea to erupt.

## Break it down

*Researchers created a new kind of plastic polymer that could, in theory, be infinitely recyclable, **Laurel Hamers** reported in "Recycle this plastic over and over again" (SN: 5/26/18, p. 12).*

Online reader **Mark S.** wondered how the plastic could be commercialized.

"Without an easy way to separate recyclable plastic from the mass of non-recyclable plastic, it doesn't seem like there would be much [of a] market," he wrote. He suggested embossing the new plastic with a bar code that would allow an artificial intelligence sorting system to separate it.

Throwing the new recyclable plastic

in with your regular recycling pickup would probably be a waste of the plastic's unique properties, **Hamers** agrees. "This isn't necessarily a barrier to commercialization. Existing biodegradable and compostable plastics face a similar challenge. Such plastics break down only under the right microbial conditions, but can end up in a landfill without those environments," she says. A challenge will be to figure out how to divert these special recyclables into their own production streams, perhaps by using bar codes, as **Mark S.** proposes, or through a direct-to-manufacturer return process, she says.

## Bye-bye, birdie

*After human activities shrunk dusky seaside sparrows' breeding grounds in 1968, the last of the species died in captivity nearly 20 years later at the Walt Disney World Resort in Orlando, Fla., **Bethany Brookshire** reported in "The dwindling dusky" (SN: 5/26/18, p. 4).*

"Inquiring minds want to know why the world's last dusky sparrow suffered the indignity of dying at Disney World, amid thousands of parents who were wishing they were dead," online reader **Jan Steinman** wrote.

The bird lived in captivity on Discovery Island, a now-defunct zoological park. Discovery Island housed a sparrow breeding program as part of Disney's wildlife conservation efforts. "No word from the birds on how they felt about it," **Brookshire** says.



## How volcanoes claim lives

Guatemala's Fuego volcano erupted explosively on June 3, sending a cloud of hot gas and rock racing downhill in what's known as a pyroclastic flow. At least 110 people were killed.

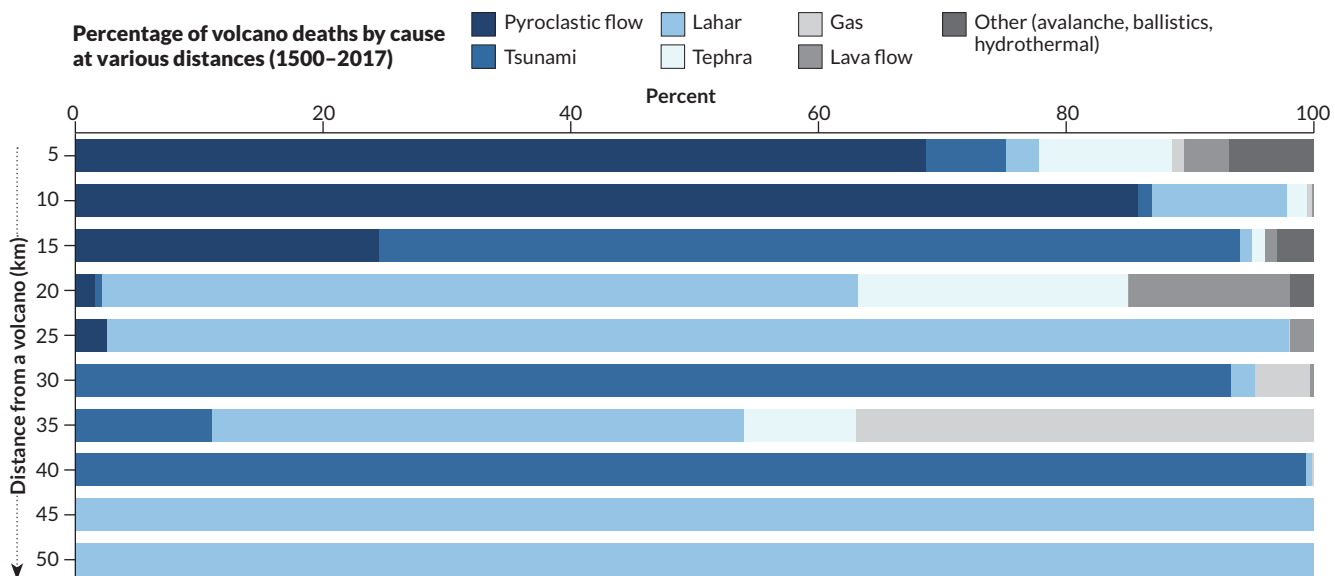
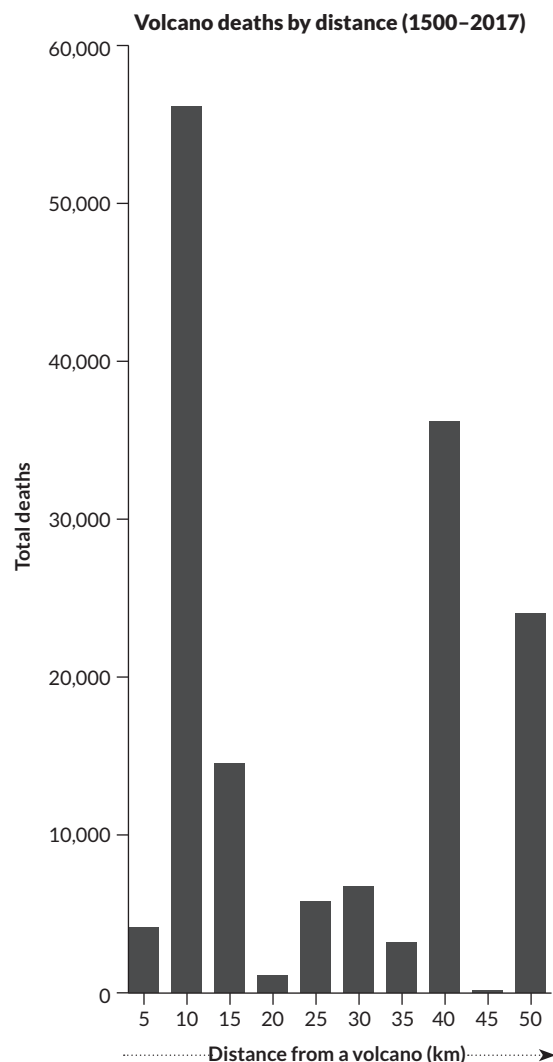
The tragedy offers a grim reminder of the dangers posed by volcanic eruptions. While pyroclastic flows figure prominently in an exhaustive list of how volcanoes kill people, published last year by British scientists in the *Journal of Applied Volcanology*, there are many other potential threats including toxic gas and ejected fragments of ash and rock called tephra. After compiling a database of nearly 217,000 deaths directly caused by eruptions from 1500 to 2017, the team investigated the distance from a volcano at which fatalities occurred and the ways in which volcanoes kill. (Indirect causes of death such as famine or seismic activity were excluded from the analysis.)

Volcanoes aren't just deadly close up, the data show. About 47 percent of recorded deaths occurred at or within 20 kilometers of a volcano, with a dramatic increase in the number of deaths at 10 kilometers away versus at five kilometers (graph at right). But over 50 percent of fatalities took place at more than 20 kilometers away.

How volcanoes kill also varies with distance (graph below). At or within 10 kilometers of a volcano, pyroclastic flows claim the highest percentage of lives. On the Caribbean island of Martinique in 1902, for example, a pyroclastic flow from Mount Pelée killed nearly all 28,000 people in a nearby town; survivors included a prisoner saved by his cell.

At greater distances, the deadliest hazards include volcanic mudflows called lahars, caused by heavy rainfall or when an eruption melts ice atop a volcano, and tsunamis triggered by eruptions. In 1985, the Nevado del Ruiz volcano in Colombia erupted and sent lahars rushing down its slopes, killing roughly 25,000 people. Lava flows, in comparison, have claimed many fewer lives, no matter the distance.

"Pinpointing these lethal ranges is quite important" in helping officials better prepare, says study coauthor Sarah Brown, a volcanologist at the University of Bristol in England. — *Alexandra Witze*







# CONGRATULATIONS

## Broadcom MASTERS International!

Broadcom Foundation salutes the amazing young scientists and engineers from around the world who participated in the 2018 Broadcom MASTERS International in Pittsburgh, Pennsylvania.

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