

An aerial photograph of a two-lane road completely submerged in floodwater. A dark-colored car is driving away from the viewer in the center of the road. The water reflects the sky and the surrounding landscape, which includes trees and some buildings in the distance. The overall tone is somber due to the flooding.

SN

Sizing Up
Earth's
Impact
Craters

Calculating
a Proton's
Heft

Patching
Broken
Hearts

Vanilla Goes
Way Back

SCIENCE NEWS MAGAZINE
SOCIETY FOR SCIENCE & THE PUBLIC

DECEMBER 22, 2018 & JANUARY 5, 2019

The Road Ahead

Climate change hits home
and other top science
stories of 2018

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market."* — Business Insider



Rating of A+

ScienceNews

2018 Year in Review

16 TOP 10 STORIES: Climate change held tight to the lead spot on our list of top science stories of the year even after late-breaking news of gene-edited babies and a newfound impact crater. A lake buried under ice near Mars' south pole (shown), mosquito eradication, high-energy neutrinos and other big stories round out the list.

PLUS: Artificial intelligence learned a lot, some space missions launched and others ended, and science's #MeToo movement sparked some changes. *Science News* writers also share their predictions for the coming year.

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The Society's Top 10 achievements in 2018

COVER Climate change intensified Hurricane Florence's rains, which caused the Waccamaw River in South Carolina to overflow. Jason Lee/The Sun News via AP





To assemble a Top 10 list, *Science News* starts in June

When most people were thinking about summer vacation, we were contemplating the biggest science stories of 2018.

Yep, it takes more than six months of effort to put together *Science News*' annual issue on the Top 10 science stories of the year. 2018 was no different, though we were hit with some exciting twists that had us revisiting our decisions just a week or so before closing the issue.

The early discussions tend to be more about themes — climate emerged as a big one, even before the recent reports linking increased severity of hurricanes, floods and wildfires to climate change. Reporters lobby to get the stories that intrigued them the most or the discoveries that mark critical turning points onto the short list.

By August, our editors have identified contenders for the top of the list and are assigning stories so writers can get to work. We try to keep the choices under wraps; it's part of the fun. All of the stories are assigned by October 1. By then, we're also planning illustrations, graphics and bonus items, like our much-loved list of favorite science books of the year (see Page 36). By Thanksgiving, we've nailed down the "map" for the magazine, including story order and page designs.

And then news happens. This year was particularly rich in breaking news that had us reshuffling the deck. That included the discovery of an impact crater hidden under Greenland's ice, which some scientists argue contributed to the die-off of the mammoths (Page 24). That story broke on November 14 (*SN*: 12/8/18, p. 6).

Then there was the U.S. report on domestic climate change impacts, which was released the Friday after Thanksgiving. A few days later came an even bigger surprise: A Chinese scientist claimed that he had created the world's first gene-edited babies. The announcement unleashed a torrent of criticism from scientists around the world.

So what would you pick as the No. 1 science story of the year? After much discussion, our editorial team decided to stick with our original choice of climate change, considering the extraordinary amount of new data released this year and the import of those findings (Page 18). The Chinese babies elbowed their way into the No. 2 slot (Page 20). Even though the scientist's claim may prove false, the technology has clearly advanced to the point where scientists and governments must act to set ethical standards for human gene editing.

Note to our readers: The magazine will be taking a break over the holidays. The next issue you receive will be dated January 19. But we'll still be hard at work reporting on developments in science, medicine and technology; visit us at www.sciencenews.org for the latest. In 2019, we'll publish four double issues, in May, July, October and December. These special issues include more features and in-depth coverage of topics like last summer's "Water woes," which included reporting from Mumbai, India. We love having the opportunity to dig deep on pressing issues and hope you enjoy the results. Thank you for being part of the *Science News* community. We wish you joyous holidays and an evidence-based new year. — *Nancy Shute, Editor in Chief*

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EDITOR IN CHIEF Nancy Shute

EDITORIAL

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NEUROSCIENCE Laura Sanders
PHYSICS Emily Conover
TECHNOLOGY Maria Temming
STAFF WRITER Laurel Hamers
EDITORIAL ASSISTANT Kyle Plantz
SCIENCE WRITER INTERN Jennifer Leman
CONTRIBUTING CORRESPONDENTS
Laura Beil, Tom Siegfried, Alexandra Witze

DESIGN

CHIEF DESIGN OFFICER Stephen Egts
DESIGN DIRECTOR Erin Otwell
ASSISTANT ART DIRECTORS Chang Won Chang, Tracee Tibbitts

SCIENCE NEWS FOR STUDENTS

EDITOR Janet Raloff
MANAGING EDITOR Sarah Zielinski
STAFF WRITER Bethany Brookshire
WEB PRODUCER Lillian Steenblik Hwang

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1719 N Street NW, Washington, DC 20036
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Editorial/Letters: editors@sciencenews.org

Science News in High Schools: snhs@societyforscience.org

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Excerpt from the December 21, 1968 issue of *Science News*

50 YEARS AGO

Apollo 8: Options on the way

Just two months after the end of the successful first manned Apollo flight ... three astronauts are ready to fly this Saturday to within 70 miles of the lunar surface.... The Apollo 8 plan is for the astronauts to fly as many as 10 orbits around the moon before heading home.

UPDATE: Seven months after the U.S. Apollo 8 ferried astronauts into orbit around the moon for the first time, Apollo 11 astronauts landed on the lunar surface. Humans haven't been back to the moon since 1972, but that may change soon. President Donald Trump instructed NASA in December 2017 to focus on returning astronauts to the moon, and the agency now plans to build a space station in lunar orbit. This outpost, to be launched in several pieces and assembled in space, would send robots, and eventually astronauts, to the moon's surface. The first piece of the station is slated to launch in 2022. Meanwhile, China is expected to explore the farside of the moon (SN: 11/24/18, p. 14).

Wombats, marsupials native to Australia, stack their cubelike droppings to mark their territory.

MYSTERY SOLVED

Here's how wombats poop in cubes

Of all the poops in the world, only wombats' are shaped like cubes.

The varied elasticity of the wombat intestine helps the marsupials sculpt their scat into cubelike nuggets, instead of the round pellets, messy piles or tubular coils made by other mammals, researchers reported November 18 in Atlanta at a meeting of the American Physical Society's Division of Fluid Dynamics.

Wombats mark their territories with small stacks of scat. Cuboid feces stack better than rounder ones and don't roll away as easily.

But cubic shapes in nature are very unusual, says mechanical engineer David Hu of Georgia Tech in Atlanta. Making and maintaining flat facets and sharp corners takes energy. So it's surprising that wombat intestines — which look much like those of other mammals — would create that shape.

When Hu and his Georgia Tech colleague Patricia Yang received the intestines from two roadkill wombats that were collecting frost in an Australian

colleague's freezer, "we opened those intestines up like it was Christmas," Hu says.

The intestines were packed with poop, Yang says. In humans, a feces-filled bit of intestine stretches out slightly. In wombats, the intestine stretches to two to three times its regular width to accommodate the feces.

Yang used skinny balloons, the type that get sculpted into animals at fairs, to inflate the intestines and measure their stretchiness in different places. Some regions were more stretchy; some were stiffer. The stiffer regions probably help create the distinct edges on the feces as the waste moves through the gut, Yang proposes.

Sculpting the poop into cuboid nuggets appears to be a finishing touch for the wombat digestive tract. Over a typical 6-meter-long wombat intestine, the dung takes on distinct edges only in the last half-meter or so, Hu says. Up to that point, the waste gradually solidifies as it moves through the gut.

The finished turds are especially dry and fibrous, which may help them retain their signature shape when they're squeezed out, Yang says. They can be stacked or rolled like dice, standing up on any of their faces. (Yang knows from experience.)

In the wild, wombats deposit their droppings on top of rocks or logs as territory markers, sometimes forming small piles. The animals seem to prefer to poop in elevated spots, Hu says, but they're also limited by their stubby legs.

To confirm that the elasticity variation really does form the cubes, Yang and Hu are trying to simulate the wombat digestive tract using panty hose. — *Laurel Hamers*



Cubelike scat doesn't roll off of rocks as easily as round droppings would.

SCIENCE STATS

When it rains, it pours

Half of the world's annual rain and snow falls on the year's 12 wettest days. As climate change brings more intense downpours, the same amount of precipitation could take just 11 days by the end of the century, scientists report online November 4 in *Geophysical Research Letters*.

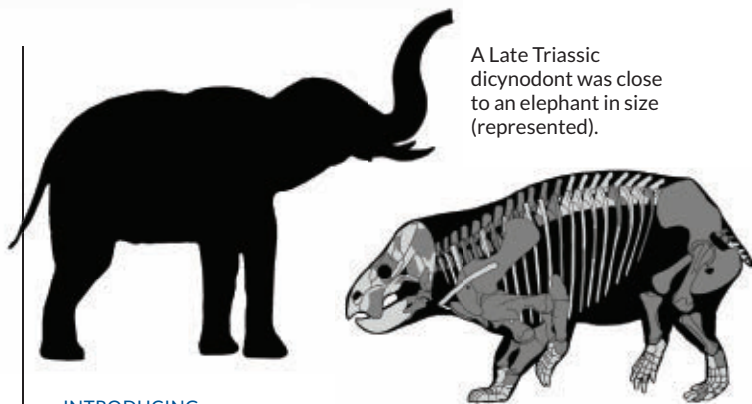
"Climate scientists generally have this notion that precipitation falls unevenly in time," says climate scientist Angeline Pendergrass of the National Center for Atmospheric Research in Boulder, Colo. She wanted to quantify that unevenness. So Pendergrass and colleague Reto Knutti of the Institute for Atmospheric and Climate Science at ETH Zurich looked at daily precipitation data from 185 weather stations worldwide from 1999 through 2014, and satellite data for areas in Africa and South America with fewer stations. The team used climate simulations to estimate precipitation up to 2100.

As the atmosphere warms, it holds more moisture, leading to more precipitation. While the overall annual number of wet days does not change, more intense deluges mean it would take fewer days to accumulate the same amount of rain and snow, the researchers found.

12
days

Time in which half the world's annual rain and snow falls

"The increase in precipitation that we see [in simulations] is mostly coming from extreme events, so on days that are already wet, we expect them to get wetter," Pendergrass says. — *Kyle Plantz*



A Late Triassic dicynodont was close to an elephant in size (represented).

INTRODUCING

Huge herbivore mingled with dinos

A new species of herbivore probably overshadowed its ancient relatives, scientists report online November 22 in *Science*. Unlike most enormous animals that lived during the Late Triassic, 237 million to 201 million years ago, this creature wasn't a dinosaur — it was a dicynodont.

Dicynodonts were four-legged animals related to mammals' ancestors. The scientists who found the animal's fossils in Poland in 2008 say the species, *Lisowicia bojani*, was at least 4.5 meters long and weighed about nine tons — far larger than any other dicynodont found to date. The species had upright forelimbs, which may have helped support its body weight, instead of splayed forelimbs seen on other dicynodonts. Coauthor Grzegorz Niedzwiedzki, a paleontologist at Uppsala University in Sweden, calls it "one of the most unexpected fossil discoveries from the Triassic of Europe." — *Laurel Hamers*

PICTURE THIS

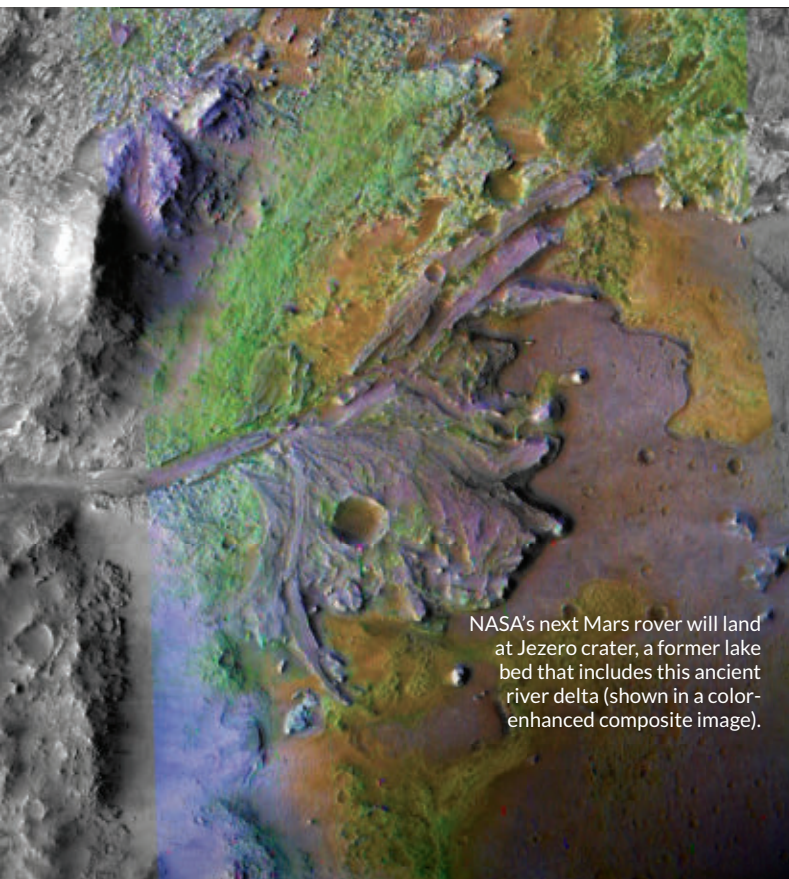
NASA's Mars 2020 rover will scour a former river delta for signs of life

The next NASA Mars rover will hunt for signs of ancient life in what used to be a river delta.

The vehicle, launching in July 2020 and landing on Mars in February 2021, will seek out signs of past life in the sediments and sands of Jezero crater, NASA announced November 19. The region was once home to a river delta that flowed into a 250-meter-deep lake.

"This is a major attraction from our point of view for a habitable environment," project scientist Ken Farley of Caltech said in a news conference. Evidence of life that might have existed in the lake or the river could be preserved in the rocks. The rover will have a special container to store samples until another mission, possibly in the 2030s, can collect and return them to Earth for more study.

Jezero crater is within 28 kilometers of another site called Midway, which contains some of the Red Planet's most ancient rocks. Scientists have suggested visiting both sites during the 2020 mission. — *Lisa Grossman*



NASA's next Mars rover will land at Jezero crater, a former lake bed that includes this ancient river delta (shown in a color-enhanced composite image).

HUMANS & SOCIETY

Hominids reached North Africa early

Stone tools found in Algeria date to 2.4 million years ago

BY BRUCE BOWER

Ancient stone-tool makers spread into parts of North Africa surprisingly early, a new study finds. Discoveries in Algeria underscore how toolmaking traditions enabled Stone Age *Homo* groups to travel long distances and adapt to different environments, researchers say.

Hominids used simple cutting and chopping implements to remove meat from animal carcasses in North Africa about 2.4 million years ago, archaeologist Mohamed Sahnouni and colleagues report online November 29 in *Science*. That's about 200,000 years after the first known appearance of such tools in East Africa. Early members of the human genus, *Homo*, either continued to make these tools after moving from East Africa or independently created similar tools in East and North Africa, the scientists conclude.

Previous excavations at two other Algerian sites had found stone tools dating back no more than 1.8 million years.

No hominid fossils have been found at any of the North African locations. But the discovery of stone tools strewn among butchered animals at Algeria's Ain Boucherit site adds to evidence that *Homo* evolution didn't just occur in East Africa. "Our ancestors ventured into all corners of Africa," says Sahnouni, of the National Research Center on Human Evolution in Burgos, Spain.

Discoveries at Ain Boucherit "show that the North African savanna corridor and the East African one were connected and early [*Homo*] started using stone tools and eating meat basically simultaneously in both areas," says Manuel



Animal fossils and stone artifacts from Algeria, including this rock from which flakes were removed, are evidence of ancient butchery.

Domínguez-Rodrigo, an archaeologist at Complutense University in Madrid who was not part of the research.

Sahnouni's group excavated two sediment layers at Ain Boucherit. Excavations from 2006 to 2016 produced a total of 17 stone artifacts from a lower, older sediment layer and 236 similar specimens from an upper layer.

Identification of previously dated reversals of Earth's magnetic field recorded in the soil and estimates of the time since sediment had been buried

provided ages of about 2.4 million years for the lower layer and about 1.9 million years for the upper layer.

Fossils found among the artifacts at Ain Boucherit came from savanna-dwelling animals such as elephants, horses, rhinos and crocodiles. Incisions typical of butchery appeared on 17 of 296 bones from the lower layer and two of 277 bones from the upper layer. The marks were mainly on limbs, ribs and skulls, suggesting activities such as skinning and removing flesh. Another four bones from the lower layer and seven from the upper layer had hammering and smashing marks, probably from marrow removal.

"The Ain Boucherit evidence could be pointing at some kind of confrontational scavenging where [hominids] were stealing kills from carnivores before carcasses were fully defleshed," says archaeologist Ignacio de la Torre of University College London, who did not participate in the study. That tactic appears most likely, he says, given that evidence of hunting in Africa from this time is scant. ■



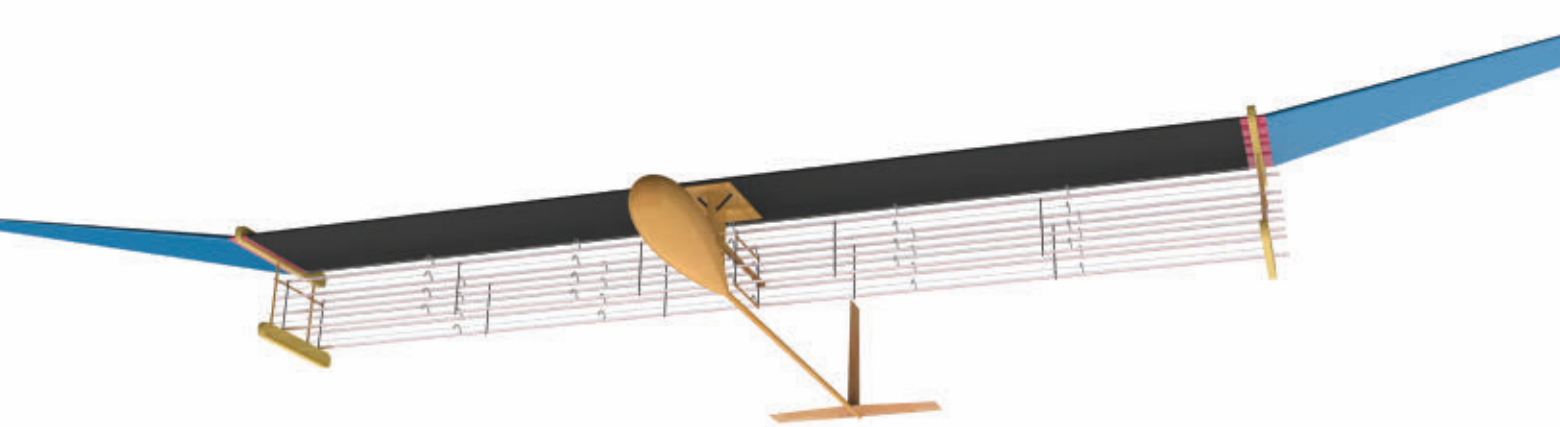
HUMANS & SOCIETY

Stone Age people scaled the Tibetan Plateau

People settled down high up, really high up, by about 40,000 years ago. That's the earliest known date of humans inhabiting Asia's Tibetan Plateau, about 4,600 meters above sea level, scientists say. Until now, evidence of humans colonizing this high-altitude area went back only about 8,000 years (*SN*: 2/4/17, p. 8).

Archaeologist Xiaoling Zhang of the Chinese Academy of Sciences in Beijing and her colleagues excavated 3,683 stone artifacts (some shown above) from three sediment layers at a site called Nwya Devu on the Tibetan Plateau. The oldest layer dates to about 40,000 to 30,000 years ago. The artifacts were all made from local, high-quality rock, the researchers report in the Nov. 30 *Science*. Zhang's group suspects people used the site as a toolmaking workshop.

Ecological conditions on the Tibetan Plateau during the late Stone Age would have enabled seasonal visits by people who could have hunted prey such as gazelles and yaks, the researchers say. — Bruce Bower



MATH & TECHNOLOGY

New plane flies on charged molecules

Nearly silent aircraft doesn't need propellers or turbines

BY LAUREL HAMERS

A newly designed airplane prototype does away with noisy propellers and turbines.

Instead, the plane is powered by ionic wind: charged molecules, or ions, flowing in one direction and pushing the plane in the other. That setup makes the aircraft nearly silent. Such stealth planes could someday be useful for monitoring environmental conditions or capturing aerial imagery without disturbing natural habitats below.

The aircraft is the first of its kind to be propelled in this way, researchers report in the Nov. 22 *Nature*. In 10 indoor test flights, the small plane, which weighs about as much as a Chihuahua, traveled 40 to 45 meters for almost 10 seconds at a steady height, even gaining, on average, about half a meter of altitude over the course of a flight.

Most planes rely on spinning parts to move forward. In some, an engine turns a propeller that pushes the plane forward. Or a turbine sucks in air with a spinning fan and then shoots out jets of gas that propel the plane forward.

Ionic wind is instead generated by a high-voltage electric field around a positively charged wire, called an emitter. The electricity, often supplied by batteries, makes electrons in the air collide with atoms and molecules, which then release other electrons. That creates a swarm of positively charged air

molecules around the emitter, which are drawn to a negatively charged wire called a collector. The movement of molecules between the two wires, the ionic wind, can push a plane forward. The current design uses four sets of these wires.

Moving ions have helped other things to fly through the air, such as tiny airborne robots. But conventional wisdom said that using the approach to move something as big as an airplane through the air wasn't possible, because adding enough battery power to propel a plane this way would make it too heavy to stay aloft. (The ion thrusters that propel spacecraft through the vacuum of space work in a very different way and aren't functional in air.) Attempts to build ion-propelled aircraft in the 1960s weren't successful.

MIT aeronautics researcher Steven Barrett thought differently. With the right aircraft design and light enough batteries, flight might be possible, his initial calculations suggested. So he and his team used equations to optimize various features of the airplane — its shape, materials and power supply — and to predict how each version would fly. Then the researchers built prototypes of promising designs and tested the planes at an indoor track at MIT, launching them via a bungee system.

"The models and the reality of construction don't always match up perfectly," Barrett says, so finding the right design took a lot of tries. But in the new study, he and collaborators report success with an aircraft that has a 5-meter wingspan and weighs just under 2.5 kilograms.

Barrett and colleagues weren't the only researchers who thought the ionic

A prototype aircraft with a 5-meter wingspan (illustrated) is propelled forward by streams of charged molecules moving among wires.

wind method might take off. Based on calculations done in his lab, "we were confident that this could be done," says Franck Plouraboué of the Toulouse Fluid Mechanics Institute in France. "Here they've done it, which is fantastic!"

It's an example of distributed electric propulsion, in which a plane's thrust-generating parts are spread out instead of having a centralized source, Plouraboué says. Distributed electric propulsion is a hot area for aircraft research right now. NASA's experimental X-57 Maxwell plane, for instance, bears 14 battery-operated motors along its wings. Increasing the number of propellers makes the plane go farther on the same amount of energy, Plouraboué says, but also increases the drag. With ionic wind propulsion, increasing the number of wires doesn't increase drag very much.

The new plane still needs some upgrades before it's ready for the real world: Its longest flight was only 12 seconds. And while the aircraft can maintain steady flight for a short time once launched, it can't actually get off the ground using ionic wind.

Even with improvements, ion-propelled aircraft won't find their niche as passenger planes, predicts Daniel Drew, an aerodynamics researcher at the University of California, Berkeley who has designed miniature flying bots that use ionic propulsion. It's probably not feasible to scale up to something the size of a Boeing 747; there are efficiency trade-offs as planes get bigger, he says. But down the road, the approach might be useful for small, uncrewed planes. ■

EARTH & ENVIRONMENT

Urban expansion boosts wildfire risks

Booming development puts more Californians in harm's way

BY LAUREL HAMERS

2018 was a record-setting year for California wildfires. In January, Southern Californians were dealing with the aftermath of the Thomas Fire. It was the state's largest wildfire ever — until the Mendocino Complex Fire burned through nearly 1,900 square kilometers of Northern California over the summer. And then in November, the Camp Fire set another record, becoming the deadliest and most destructive wildfire in the state's history. The blaze killed at least 88 people and destroyed the town of Paradise.

Such disasters are likely to occur even more frequently in the coming years, recent data suggest.

That's in large part because urban development is creeping farther into woodlands, prairies and other natural areas and putting more communities in the path of wildfires. California's recent fires were fueled by drought and high winds, but it was the proximity to people

that made the fires especially damaging, burning through areas where housing abuts grasslands or forests, or where natural vegetation is mixed in with homes.

From 1990 to 2010, these wildland-urban interface areas expanded almost 20 percent in California, covering a total of about 27,000 square kilometers, according to data released by the U.S. Forest Service last year. The number of homes in that zone increased by almost 34 percent, to more than 4.4 million.

Urban expansion into natural areas isn't unique to California. Nationwide, the wildland-urban interface grew about 33 percent from 1990 to 2010, researchers who worked on the Forest Service dataset reported in March in the *Proceedings of the National Academy of Sciences*. Other Western states that face frequent wildfires have seen even larger leaps: Colorado's wildland-urban interface areas expanded by 65 percent, Montana's by 67 percent and Idaho's by 72 percent.

Meanwhile, climate change is contrib-



The Camp Fire incinerated the town of Paradise in Northern California in November, leaving behind rubble and ash where houses and businesses once stood.

uting to more intense droughts and a longer fire season in California and other Western states. The types of wildfires that once occurred every few years are now happening multiple times a year, says Kurt Henke, a retired chief from the Sacramento Metropolitan Fire District.

But other Western states “don't have the population centers” that California has, Henke says. That new fire regime in a place like California, with lots of people living close to ample fire fuel, is a “recipe for disaster,” he says.

Wildland-urban interface fires are hard to manage because there aren't yet good

ATOM & COSMOS

How the proton's mass adds up

New calculations confirm contributions to particle's bulk

BY EMILY CONOVER

A proton's mass is more than just the sum of its parts. And now scientists know just what accounts for the subatomic particle's heft.

Protons are made up of even smaller particles called quarks, so you might expect that simply adding up the quarks' masses should give you the proton's mass. However, that sum is much too small to explain the proton's bulk. And now, detailed calculations show that only 9 percent of the proton's heft comes from the mass of constituent quarks.

The rest of the proton's mass comes from complicated effects occurring inside the particle, researchers report in the Nov. 23 *Physical Review Letters*.

Quarks get mass from a process connected to the Higgs boson, an elementary particle. But “the quark masses are tiny,” says study coauthor Keh-Fei Liu, a theoretical physicist at the University of Kentucky in Lexington.

Instead, most of the proton's 938 million electron volts of mass is due to complexities of quantum chromodynamics, or QCD, the theory that accounts for the churning of particles within the proton. Making calculations with QCD

is extremely difficult, so to study the proton's properties theoretically, scientists rely on a technique called lattice QCD, in which space and time are broken up into

a grid, upon which the quarks reside.

Using this technique, physicists had previously calculated the proton's mass (*SN: 12/20/08, p. 13*). But scientists hadn't divvied up where that mass comes from until now, says André Walker-Loud, a theoretical physicist at Lawrence Berkeley National Laboratory in California. “It's exciting because it's a sign that ... we've really hit this new era” in which lattice QCD can be used to better understand nuclear physics.

In addition to the 9 percent of the proton's mass that comes from quarks' heft, 32 percent comes from the energy of the quarks zipping around inside the proton, Liu and colleagues found. That's because energy and mass are two sides of the same coin, as described by Einstein's famous equation, $E=mc^2$.

9

percent

Proportion of a proton's mass that comes from the mass of its quarks

computer simulations for predicting how they'll behave (*SN*: 10/27/18, p. 24), says Volker Radeloff, a landscape ecologist at the University of Wisconsin–Madison who coauthored the March study. Dealing with such fires doesn't fall squarely under the expertise of wildland firefighters or municipal firefighters. "The wildland-urban interface sort of falls through the cracks. It's a messy middle—a little wild, but not truly wild," Radeloff says.

The problem will probably get worse as people continue to build homes closer to natural areas. Radeloff and colleagues calculated urban-interface expansion in each U.S. state using 2010 U.S. census data and will update the findings once the 2020 census results are released.

California has some of the strictest fire codes in the country, including regulations on new construction in the wildland-urban interface. Buildings must be made of fire-resistant materials, for example, and residents are required to clear brush away from near their houses.

But even housing developments built recently may not be able to withstand the severity and frequency of today's fires, Henke says. "We're going to have to go back and take another look." ■

Other occupants of the proton, massless particles called gluons that help hold quarks together, contribute another 36 percent via their energy.

The remaining 23 percent arises due to quantum effects that occur when quarks and gluons interact in complicated ways within the proton. Those interactions cause QCD to flout a principle called scale invariance. In scale invariant theories, stretching or shrinking space and time makes no difference to the theories' results. Massive particles provide QCD with a scale, so when the theory defies scale invariance, protons also gain mass.

The results aren't surprising, says theoretical physicist Andreas Kronfeld of Fermilab in Batavia, Ill. Scientists have long suspected that the proton's mass was made up in this way. But, he says, "this kind of calculation replaces a belief with scientific knowledge." ■

ATOM & COSMOS

Star's flickering befuddles astronomers

Aliens probably aren't to blame for the object's erratic behavior

BY LISA GROSSMAN

There's another oddly flickering star in the galaxy. Astronomers have discovered a star whose strange dimming and brightening of light is reminiscent of Tabby's star, which was once suggested to host an alien megastructure.

The megastructure idea was later quashed by data suggesting that the dips are probably from dust particles obscuring the star's light (*SN Online*: 1/3/18). The new star's behavior is probably not due to aliens, either. But it is baffling, says astronomer Roberto Saito of the Federal University of Santa Catarina in Florianópolis, Brazil. Saito and his colleagues report the star's flickering online November 6 at arXiv.org.

"We don't know what the object is," he says. The star could have some sort of orbiting debris that periodically blocks the starlight, but Saito's group says more observations are needed to figure out if that's possible or if the flickering is caused by something else.

The researchers had been searching for supernovas, stars that suddenly brighten as they explode, when the team spotted the object in data from the VISTA telescope in Chile. The data were part of the VISTA Variables in the Vía Láctea, or VVV, survey of the Milky Way's center.

Instead of brightening, this star suddenly dimmed. The team called it VVV-WIT-07, for "What is this?"

From 2010 to 2018, the star's brightness waxed and waned with no pattern. That

lack of pattern is similar to the Tabby's star's behavior, except VVV-WIT-07's light dropped by up to 80 percent; Tabby's star dimmed by only about 20 percent.

Another flickering star, J1407, might be a closer match. That star periodically dims by up to 95 percent, astronomer Eric Mamajek of the University of Rochester in New York and colleagues reported in 2012. Astronomers think J1407 hosts an orbiting planet with an enormous ring system that periodically eclipses the star (*SN*: 3/7/15, p. 5).

Finding multiple stars that all dim sporadically could mean that the sources of such flickering, whatever they are, must be relatively routine, says astronomer Tabetha Boyajian of Louisiana State University in Baton Rouge, who Tabby's star is named after. "If this phenomenon is the same as what's happening with Tabby's star, then we can't invoke an elaborate explanation for what's happening in both systems." But she's not yet convinced that the stars are similar.

Because VVV-WIT-07 is located in the plane of the galaxy, the view from Earth to the star is full of dust, making it hard to make out details such as the star's distance and even what kind of star it is. If it's a young variable star, for instance, then its light dips might be internal. Then astronomers wouldn't need to invoke orbiting rings or even stranger things.

"Pretty much everything's on the table for it right now," Boyajian says. "We need more data." ■



A newly identified star's light dims irregularly, similar to Tabby's star (shown in this illustration).

HUMANS & SOCIETY

Earliest signs of vanilla found in Israel

Extract didn't originate in Mexico, 3,600-year-old residues hint

BY BRUCE BOWER

Three jugs placed as offerings in a roughly 3,600-year-old tomb in Israel have revealed a sweet surprise: evidence of the oldest known use of vanilla.

Until now, vanilla was thought to have originated in Mexico, perhaps 1,000 years ago or more. But jugs from the Bronze Age site of Megiddo contain remnants of two major compounds in natural vanilla extract, vanillin and 4-hydroxybenzaldehyde, archaeologist Vanessa Linares reported November 16 at a meeting of the American Schools of Oriental Research. Chemical analyses also uncovered residues of plant oils, including a component of olive oil.

“Bronze Age people at Megiddo may have used vanillin-infused oils as additives for foods and medicines, for ritual purposes or possibly even in the

embalming of the dead,” said Linares, of Tel Aviv University.

Vanillin comes from beans in vanilla orchids. About 110 species of these flowers are found in tropical areas around the world. The chemical profile of the vanillin in the Megiddo jugs best matches present-day orchid species in East Africa, India and Indonesia, Linares said.

Extensive Bronze Age trade routes probably brought vanillin to the Middle East from India and perhaps also from East Africa, she suggested.

“It’s really not surprising that vanillin reached Bronze Age Megiddo given all the trade that occurred between the [Middle East] and South Asia,” says archaeologist Eric Cline of George Washington University in Washington, D.C. No evidence yet exists of trade at that time between Middle Eastern

societies and East Africa, he says.

However Bronze Age Middle Easterners ended up with vanilla orchids and their beans, the Megiddo discoveries challenge the idea that vanilla use began in Mexico and then spread, Cline says.

The vanillin-containing jugs came from a tomb of three “highly elite” individuals who were interred with six other people of lesser social rank, said Melissa Cradic, an archaeologist at the University of California, Berkeley and a member of the Megiddo research team.

The tomb, discovered in 2016, lies in an exclusive part of Megiddo near a palace and a monumental city gate. The tomb’s primary burials consist of an adult female, an adult male and an 8- to 12-year-old boy. Elaborate jewelry was found on and around the three skeletons. Several identical pieces of jewelry appeared on all three individuals.

“We can’t definitively say that these three people were royals,” Cradic said. “But they were elites in Megiddo and may have belonged to the same family.” ■

MEETING NOTES

Meteor may have wiped out ancient Dead Sea cities

A superheated blast from the skies obliterated cities and farming settlements north of the Dead Sea about 3,700 years ago, preliminary findings suggest.

Radiocarbon dating and minerals that instantly crystallized at high temperatures indicate that an airburst caused by an exploding meteor instantaneously destroyed civilization on a 25-kilometer-wide plain called Middle Ghor, said archaeologist Phillip Silvia. The event may have pushed a brine of Dead Sea salts over farmland. People did not repopulate the area for 600 to 700 years, Silvia, of Trinity Southwest University in Albuquerque, reported November 17 at a meeting of the American Schools of Oriental Research.

Excavations at five sites in Jordan indicate that all were occupied for at least 2,500 years until a sudden collapse toward the end of the Bronze Age. Up to about 65,000 people lived in the area when the cosmic calamity hit, Silvia said.

The clearest evidence of destruction caused by a meteor explosion comes from the city of Tall el-Hammam. Mud-brick walls of nearly all structures suddenly disappeared about 3,700 years ago, leaving only stone foundations.

What’s more, the outer layers of many pottery pieces from the time show signs of having melted into glass. Zircon crystals in those glassy coats formed within one second at very high temperatures, Silvia said. High-force winds created

spherical mineral grains that rained down on Tall el-Hammam and have been found on pottery there, he said. — *Bruce Bower*

Bronze Age game turns up far from home

A dotted pattern pecked into stone at a rock-shelter in Azerbaijan represents a Bronze Age game that was thought to have existed at that time only in Mesopotamia, Egypt and other Near Eastern regions. Archaeologist Walter Crist of the American Museum of Natural History in New York City described his discovery of a roughly 4,000-year-old example of the game, known as 58 Holes, November 15 at a meeting of the American Schools of Oriental Research.

Azerbaijan sits between the Caucasus Mountains and the Caspian Sea, some 1,000 to 2,000 kilometers north of the Near East. “Bronze Age herders in that region must have had contacts with the Near Eastern world,” Crist said. “Games often passed across cultures and acted as a social lubricant.”

While conducting an internet search about 58 Holes, Crist saw what looked like an example of the game’s layout in a photo of a rock-shelter in an online magazine called *Azerbaijan International*. Crist traveled to the site in April but found that it had been bulldozed. Still, he learned of a nearby rock-shelter with the same dot pattern. When he visited that Bronze Age site, Crist recognized the two-person game, a precursor of backgammon. — *Bruce Bower*

DEGREES OF IMPACT

Dr. Herrera-Estrella, the President's Distinguished Professor of Plant Genomics, will serve as the director of the Center for Functional Genomic of Abiotic Stress, which will examine how plants adapt to thrive in the presence of environmental stresses such as extreme heat and cold, drought and in the presence of brackish water sources. Known and respected worldwide for his work in cotton genomics, Dr. Herrera-Estrella was named one of the 100 most influential people in biotechnology by Scientific American in 2015. His arrival at Texas Tech was made possible by a \$5 million grant from the State of Texas Governor's University Research Initiative (GURI) and matched by the university.



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Luis Rafael Herrera-Estrella
National Academy of Sciences, Member
College of Agricultural Sciences & Natural Resources
Department of Plant and Soil Science

BODY & BRAIN

Peanut therapy lessens allergy

At the end of a study, children tolerated small exposures

BY LAURA SANDERS

Carefully calibrated doses of peanut protein might help kids with extreme allergies. At the end of a year of slowly increasing exposure, most children who started off severely allergic could eat the equivalent of two peanuts, researchers report in the Nov. 22 *New England Journal of Medicine*.

That reversal “will be considered life-transforming for many families with a peanut allergy,” says Michael Perkin, a pediatric allergist at St. George’s, University of London who wrote an accompanying editorial in the journal.

Peanut exposure came in the form of a drug called AR101, described in the study as a “peanut-derived investigational

biologic oral immunotherapy drug,” or as Perkin puts it, “peanut flour in a capsule.” AR101 is carefully meted out. The smallest doses used in the study contained precisely 0.5 milligrams of peanut protein — the equivalent of about one six-hundredth of a large peanut.

In the study, 372 children ages 4 to 17 began by taking the lowest dose of AR101. Peanut protein doses increased every two weeks until the kids topped out at 300 milligrams, which is equal to one peanut.

For the next 24 weeks, participants in the United States, Canada and Europe took that dose daily. When the trial ended, the children were challenged with increasing doses of peanut protein under close supervision. Two-thirds of the children who received the regimen, or 250 participants, could tolerate a peanut protein dose comparable to about two peanuts. In contrast, only five of 124 children who received placebos could tolerate the same dose.

The goal of the therapy is to guard against the potentially dangerous effects

of accidental peanut exposure, such as a child mistakenly taking a bite of a friend’s PB&J. “What we’re trying to do is free people up from the fear and anxiety associated with the potential bad things that can happen with minute quantities of peanut exposure,” says study coauthor Daniel Adelman, an allergist and immunologist at Aimmune Therapeutics, a company based in Brisbane, Calif., that makes AR101 and sponsored the trial.

Nearly all of the children who took the drug had allergic reactions to it, though most of the reactions weren’t severe, such as a rash or slight abdominal pain.

Parents, or even doctors, shouldn’t attempt a similar treatment by measuring peanut protein themselves. Without exact measurements, peanut exposure could be dangerous. “This is treating peanut like a medicine, not a food,” says pediatric allergist Scott Sicherer of the Icahn School of Medicine at Mount Sinai in New York City. Sicherer also cautions that, while the regimen is promising, it is not a cure. ■

BODY & BRAIN

New patch could treat heart attacks

Needle-covered bandage helps promote muscle cell growth

BY MARIA TEMMING

An implantable bandage could help mend broken hearts. Each bandage is a thin film that oozes a cocktail of molecules to heal tissue damaged during a heart attack. In animal tests, the patches helped minimize scarring and preserve the heart’s ability to pump blood, researchers report November 28 in *Science Advances*. Such devices might someday curb heart attack survivors’ risk of heart failure.

The base of each heart-healing film is a polymer sheet studded with tiny needles. The patch is similar to other microneedle patches that deliver vaccines but is designed to stick to the heart rather than the skin (*SN: 8/5/17, p. 8*). The other side of the patch is coated in a gel containing cardiac stromal cells, a type of support cell. These cells secrete molecules, such as proteins and tiny pieces of genetic

material known as microRNAs, that support the growth of heart muscle cells.

The patch is like a little pharmacy, says Ke Cheng, a biological engineer at North Carolina State University in Raleigh. When a patch is attached to the heart, the microneedles funnel curative molecules from the stromal cells directly into the damaged tissue.

Three weeks after Cheng’s team induced heart attacks in rats, the animals with microneedle patches had about 40 percent healthy tissue in heart regions

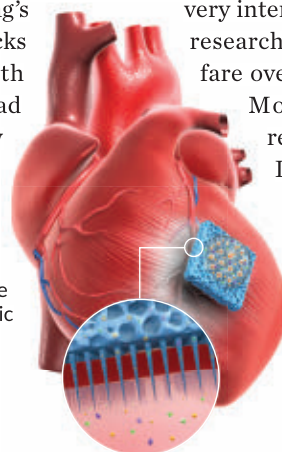
A new microneedle patch (illustrated in blue) that latches onto the surface of the heart could deliver therapeutic molecules to damaged tissue in heart attack survivors.

affected by the heart attack. Untreated rats had only about 10 percent.

In pigs, the team tracked how much blood was pumped from the left ventricle to the rest of the body with each heartbeat. Four hours after a heart attack, each heartbeat released about 56 percent of all the blood in the left ventricle, in both treated and untreated pigs. But 48 hours after the attack, hearts treated with patches pumped about 60 percent of the left ventricle’s volume while untreated hearts pumped about 50 percent.

The new microneedle design is “a very interesting and exciting” idea, but researchers need to see how animals fare over longer periods, says Tamer Mohamed, a cardiovascular researcher at the University of Louisville in Kentucky.

Before the patches are used in humans, Cheng’s team plans to swap out the polymer used in this study for a material that gradually dissolves inside the body. ■



LIFE & EVOLUTION

Wind-pollinated hemp attracts bees

Cannabis plants may provide a late-season source of pollen

BY SUSAN MILIUS

Fields of hemp might become a late-season pollen bonanza for bees.

Industrial hemp plants, the no-high varieties of cannabis, are becoming a more familiar sight for American bees as states create pilot programs for legal growing. Neither hemp nor the other strains of the *Cannabis sativa* species grown for recreational or medicinal uses offer insects nectar, and all rely on wind to spread pollen. Still, a wide variety of bees showed up in two hemp plots during a trapping survey by entomology student Colton O'Brien of Colorado State University in Fort Collins.

Bees in 23 of the 66 genera known to live in Colorado tumbled into O'Brien's traps, he reported November 11 at

Entomology 2018, a meeting of several entomological societies. O'Brien and his adviser, Arathi Seshadri, think this is the first survey of bees in cannabis fields.

"You walk through fields and you hear buzzing everywhere," O'Brien said.

Bees need pollen to feed their young, and during the trap survey in August and early September 2016, not many other flowers were blooming. Hardly anything is known about the nutritional qualities of hemp pollen for larval bees. Yet commercial hemp plots may end up as food sources for pollinators in stressful times, O'Brien said. Honeybee health has faltered in recent years, and conservationists worry about the fates of the many less-studied wild bees. O'Brien urged scientists developing pest-fighting



Cannabis depends on wind for pollination, yet bees raid male flowers in hemp fields to grab pollen for baby food.

strategies for hemp to be mindful of bee health.

Pest management techniques for hemp are still a work in progress. There are even questions about which insects are truly pests, said Whitney Cranshaw, an entomologist also at Colorado State. New potential menaces have arrived since the early 20th century, when farmers were growing hemp for fiber and other uses. Anti-drug legislation eventually made growing any cannabis illegal until recently. ■

LIFE & EVOLUTION

Mosquitoes surf high above Africa

Scientists don't yet know if air currents help spread disease

BY SUSAN MILIUS

Adult female mosquitoes could be surfing air currents high above the West African Sahel. This traffic might be troubling news for efforts to control malaria.

Traps attached to balloons flown over villages in Mali caught nearly 3,000 mosquitoes at heights of 40 to 290 meters above the ground, where winds might blow the insects long distances. That sample, collected in multiple all-night sessions over three years, was roughly 80 percent adult female, the mosquito life stage that transmits diseases.

Some of the collected species are capable of spreading malaria, said medical entomologist Tovi Lehmann in his preview of trap data, reported November 14 at Entomology 2018, a meeting of several entomological societies. But Lehmann,

of the National Institutes of Health in Rockville, Md., doesn't know yet whether the females were carrying the malaria parasite when they were caught.

There's been debate about what, if anything, such windborne mosquitoes might contribute to Africa's patterns of malaria and high death tolls from the disease. "Mosquitoes are generally thought to have short dispersal distances," said veterinary entomologist Christopher Sanders of the Pirbright Institute in England, who was not involved in the balloon project.

Researchers tethered balloons with sticky net traps attached to the line for sampling. The traps picked up a total of about 460,000 individual insects of many kinds.

The majority of captured female mosquitoes were already carrying eggs; the insects must have had a blood meal, needed for those eggs to develop.

Finding females carrying eggs was "a really novel result," said Luigi Sedda of Lancaster University in England, who works in medical geography but was not part of the project. He speculates

that these mosquito travelers might be particularly worrisome in areas with an eradication or control program in place.

Among the trapped mosquitoes, researchers found representatives of at least three notorious mosquito genera. Out of 21 species of *Anopheles* known in the region, representatives of at least seven were bobbing along in air currents. That included *An. coluzzii*, a major malaria-spreading species in Africa.

The trap results might be relevant for diseases besides malaria. The *Aedes* mosquito genus includes carriers of West Nile virus and other worrisome pathogens. So far, results show that at least 12 species of the 15 known in the area had gone airborne. So had at least 16 of the 21 local *Culex* species, which include carriers of Rift Valley fever virus.

For now, it's unknown how much, if at all, these surfing mosquitoes contribute to disease spread. "We don't know where and how long these mosquitoes have traveled," Sedda said. "We don't know their capacity to create new breeding sites, or if they get damaged in strong winds." ■

BODY & BRAIN

Youngest kindergartners more likely to get ADHD diagnosis

Children who turn 5 just before starting kindergarten are much more likely to be diagnosed with attention-deficit/hyperactivity disorder than their oldest classmates. The finding bolsters concerns that the common neurodevelopmental disorder may be overdiagnosed.

"We think ... it's the relative age and the relative immaturity of the August-born children in any given class that increases the likelihood that they're diagnosed," says Anupam Jena, a physician and economist at Harvard Medical School.

Jena and colleagues analyzed insurance claims data for over 407,000 kids born from 2007 to 2009. In U.S. states that require children be 5 by September 1 to begin kindergarten, kids born in August (usually the youngest in a kindergarten class) were 34 percent more likely to be diagnosed with ADHD than those born nearly a year earlier in September. For August kids, 85.1 per 10,000 were diagnosed with ADHD, compared with 63.6 per 10,000 for the September kids, the team reports in the Nov. 29 *New England Journal of Medicine*.

Many issues, from anxiety to dealing with overcrowded classes, may resemble ADHD, says developmental psychologist Stephen Hinshaw of the University of California, Berkeley, who was not involved with the study. — *Aimee Cunningham*

BODY & BRAIN

Targeted electrical stimulation to the brain may ease depression

Precisely placed zaps to the brain swiftly improved the moods of people with signs of depression. The results, published in the Dec. 17 *Current Biology*, bring scientists closer to understanding the nature of depression and how to treat it.

Neurologist Vikram Rao and neuroscientist Kristin Sellers of the University of California, San Francisco and colleagues studied 25 people who were undergoing treatment for epilepsy that involved electrodes implanted in the brain.

The team stimulated different brain areas with the electrodes and asked the

people about their mood. When a region that lies just behind the eyes, called the lateral orbitofrontal cortex, was stimulated, people who started with signs of moderate or severe depression reported feeling better. People who initially felt pretty good didn't change.

Mood relies on many parts of the brain working together. Because the lateral orbitofrontal cortex has widespread connections in the brain, the region may be especially poised to ease depression. The team plans to test whether stimulation has long-lasting effects. — *Laura Sanders*

LIFE & EVOLUTION

Shape determines how cactus spines stab victims

Scientists have unraveled some of the mechanical mysteries behind the pokes and prods of cacti.

Like porcupine quills, the barbed spines of some cactus species easily puncture their victims but are difficult to remove, scientists report in the Nov. 21 *Proceedings of the Royal Society B*. Smooth spines, however, puncture flesh easily and are removed just as readily.

That variation probably reflects the plants' different ecological needs, says study coauthor Philip Anderson, an evolutionary biomechanist at the University of Illinois at Urbana-Champaign.

The researchers measured the force it took for cactus spines from six species to impale synthetic polymers and butcher meats, and the difficulty in removing spines.



Spines of the jumping cholla (left) hitch a ride on unsuspecting victims that brush up against the cactus. With cuts of meat (right), scientists showed how the spines stay trapped in flesh.

Some spines, such as those of the jumping cholla (*Cylindropuntia fulgida*), are covered in microscopic barbs that made the spines easy to insert but hard to remove from a pork shoulder and a chicken breast. The spines became tangled in the fibrous tissues. *C. fulgida* spines can get so deeply embedded that, as their target pulls away, the spines tear off chunks of cactus that can be dropped to grow again at other places. Help with propagation may be an evolutionary benefit of barbed spines.

But smooth spines, such as those of the golden barrel cactus (*Echinocactus grusonii*), had a tough time implanting in polymers and easily slid in and out of meat. The function of such spines is defensive, aimed at warding away animals, the researchers suggest. — *Jennifer Leman*

GENES & CELLS

Gut bacteria may guard against diabetes that comes with aging

Losing one variety of gut bacteria may lead to type 2 diabetes as people age.

Old mice have less *Akkermansia muciniphila* bacteria than young mice do, researchers report in the Nov. 14 *Science Translational Medicine*. That loss triggers inflammation, which eventually leads cells to ignore signals from the hormone insulin. Such disregard for insulin's message to take in glucose, known as insulin resistance, is a hallmark of type 2 diabetes.

A. muciniphila, or Akk, helps break down dietary fiber into short-chain fatty acids, such as butyrate and acetate. Those fatty acids signal bacteria and human cells to perform certain functions.

Losing Akk led to less butyrate production, Monica Bodogai of the National Institute on Aging in Baltimore and colleagues found. Butyrate loss led to a chain reaction of immune cell dysfunction that ended with mice's cells ignoring insulin.

Treating old mice and elderly rhesus macaques with an antibiotic called enrofloxacin increased the abundance of Akk in the animals' guts and made cells respond to insulin again. Giving old animals butyrate had the same effect, suggesting that there may be multiple ways to head off insulin resistance in older people in the future. — *Tina Hesman Saey*



ELECTRONICS



ENGINEERING



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A satellite view of Earth showing a coastline and surrounding waters. Overlaid on the image is the year '2018' in large yellow font at the top and 'year in' in large yellow font at the bottom. A white rectangular box containing text is positioned in the center-left.

2018

In 2018, we saw just how much power science has to make a real impact.

Science News' top stories of the year include a literal impact — the hidden contours of what appears to be a massive crater created when a meteorite slammed into Greenland long ago. That discovery ranks among our Top 10 partly because it's just cool, but also because it raises the tantalizing prospect of solving a scientific mystery: Did the impact kick the planet into a roughly 1,000-year cold snap, called the Younger Dryas, almost 13,000 years ago?

The mammoths and other species that died out by the end of that period didn't see climate change coming. But we can. That's why human-driven climate change is our top story of the year. The rising tide of attribution studies shows that climbing temperatures are already turning extreme events, such as Hurricane Florence, more extreme. This year's barrage of climate reports gave us a clearer picture of how climate change will affect Earth in the near future — fueling wildfires, sparking heat waves, raising sea levels —and how human actions to curb warming can have an impact.

2018 is also the year a Chinese researcher made the startling claim that he had created the first babies to be born with an edited gene. The ensuing uproar over the controversial birth of twin girls in China, whose genes were allegedly tweaked to reduce their risk of contracting HIV, is sure to have a lasting impact on the future of gene-editing technology.

Two other genetics stories made our Top 10. Genetic genealogy is shaking up the field of forensics, ID'ing suspects in cold cases while raising privacy issues. And in a lab experiment, a gene drive — a genetic tool designed to be inherited by 100 percent of offspring — wiped out a population of mosquitoes. That feat ushers in the enticing but perilous possibility of both eliminating certain diseases and deliberately driving a species to extinction.

Other stories rounding out our Top 10 examine issues close to home (a surge in vaping among teenagers and efforts to combat it) and very far away (tracing a high-energy neutrino back to its source in a distant galaxy). We'll be watching these stories to see what happens in 2019 and beyond. — *Macon Morehouse, News Director*

year in

Hurricane Florence, seen here bearing down on the southeastern United States on September 12, dumped up to 91 centimeters of rain in some places, making it the wettest storm on record to hit the Carolinas.

review

Half a degree stole the climate spotlight

By Carolyn Gramling

1 The grim reality of climate change grabbed center stage in 2018.

This is the year we learned that the 2015 Paris Agreement on global warming won't be enough to forestall significant impacts of climate change. And a new field of research explicitly attributed some extreme weather events to human-caused climate change. This one-two punch made it clear that climate change isn't just something to worry about in the coming decades. It's already here.

This looming problem was apparent three years ago when nearly all of the world's nations agreed to cut greenhouse gas emissions to limit global warming to no more than 2 degrees Celsius over preindustrial times by 2100 (*SN*: 1/9/16, p. 6). That pact was hard-won, but even then, some scientists sounded a note of caution: That target wouldn't be stringent enough to prevent major changes.

So the United Nations took an unprecedented step. It commissioned the Intergovernmental Panel on Climate Change to examine how the world might fare if global warming were limited to 1.5 degrees instead of 2 degrees. That report, released in October, confirmed that half a degree can indeed make a world of difference (*SN*: 10/27/18, p. 7). A half degree less warming means less sea level rise, fewer species lost due to vanished habitats and fewer life-threatening heat, drought and precipitation extremes (*SN*: 6/9/18, p. 6).

There's little time to reverse course. The IPCC report notes that the planet's average temperature has already increased by nearly 1 degree since preindustrial times, and that rise is contributing to extinctions, lower crop yields and more

frequent wildfires. At the end of 2017, three attribution studies for the first time determined that certain extreme events, including an extended marine heat wave in the Pacific Ocean known as "the Blob," would not have happened without human-induced climate change (*SN*: 1/20/18, p. 6).

This year, researchers reported that the 2017 Atlantic hurricane season got a boost from warm waters in the tropical Atlantic, fueled by climate change (*SN Online*: 9/28/18). And a team of scientists determined that climate change was the engine behind September's intense rainfall from Hurricane Florence in the Mid-Atlantic region of the United States (*SN Online*: 9/13/18).

A report released November 23 by hundreds of U.S. climate scientists from 13 federal agencies put a price tag on many of the effects for the United States (*SN Online*: 11/28/18). The report predicts the country's economy will shrink by as much as 10 percent by 2100 if global warming continues on its current trajectory.

Climate simulations suggest that Earth will reach the 1.5 degree threshold within a decade. And even if countries were to agree to limit warming to that level, the planet would almost certainly surpass it before the warming reversed, due to the realities of how quickly emissions can be reduced. Passing that target will probably lead to some irreversible changes, such as melted glaciers and species losses. To overshoot the mark by only a small amount, or not at all, requires reducing emissions by about 45 percent relative to 2010 levels by the year 2030. The planet would then be able to reach net zero, when the amount of carbon released to the atmosphere is balanced by the amount removed, by around 2050, the IPCC report notes.

To bring warming back down below the 1.5 degree target by the end of the century, the world will need negative emissions technologies to remove large amounts of carbon dioxide from the atmosphere. Such technologies that limit or even reverse



To limit global warming, communities need to embrace alternatives to fossil fuels, like these solar panels that power 400 homes in South Burlington, Vt. (left), and deploy negative emissions technologies. In Iceland, Reykjavik Energy has a pilot project to directly capture carbon dioxide from the air at a geothermal power plant (right).

FROM LEFT: ROBERT NICKELBERG/ALAMY; MELANIE STETSON-FREEMAN / THE CHRISTIAN SCIENCE MONITOR/ASSOCIATED PRESS

warming are less pie-in-the-sky than they sound, says Stephen Pacala, an ecologist at Princeton University. “Although there is a lot of doom and gloom available on the progress of humanity, there isn’t on the technological side.” Pacala chaired a National Academies of Sciences, Engineering and Medicine committee that released a report in October that analyzed the viability of current and emerging negative emissions technologies as well as encouraged large-scale investments in them.

Some simple negative emissions practices already in use include planting forests to soak up atmospheric carbon, or growing plants for biofuels and then storing underground the CO₂ from the burning of those fuels. But current efforts have drawbacks. Planting sufficient forests or biofuel crops “would have a large land footprint,” says economist and IPCC coauthor Sabine Fuss of the Mercator Research Institute on Global Commons and Climate Change in Berlin. And that could impact future food availability and biodiversity.

Other negative emissions technologies in development could become game changers, Pacala says. Direct air capture, in which CO₂ is removed directly from the atmosphere and converted into synthetic fuel, is a proven technology. But so far, the high cost of direct air capture remains a barrier to commercial-scale development. The National Academies report says that nations should subsidize start-ups to drive competition in this area — after all, that’s what worked for wind and solar power, Pacala notes. Other proposed negative emissions technologies, such as converting atmospheric CO₂ into a stable mineral form (*SN*: 9/15/18, p. 9), show some promise but require large-scale financial investment in their basic science to make them viable, the report states.




Reducing demand for resource-intensive products will also be important to reach the 1.5 degree target, Fuss says. Cities need to move away from fossil fuels, and individuals can do their part by, for example, traveling less (*SN*: 6/9/18, p. 5), eating less meat (*SN*: 7/7/18, p. 10) and installing more energy-efficient appliances. Data show that, given the right incentives, people are willing to make such lifestyle changes, says IPCC report coauthor Linda Steg, an environmental psychologist at the University of Groningen in the Netherlands. And those incentives aren’t necessarily financial or based on self-interest, she adds. “People are also motivated by protecting the interests of others, or by the quality of the environment.”

Holding warming to 1.5 degrees “is not impossible,” says Natalie Mahowald, a climate scientist at Cornell University and an IPCC report coauthor. But “it really requires ambitious efforts, and the sooner the better. We have to start cutting emissions now.”

Political will to act varies country by country, but scientists have done what they can to convey the urgency and the scope of the climate change problem, says IPCC report coauthor Heleen de Coninck, an environmental scientist at Radboud University in Nijmegen, Netherlands. Nations “have it in their hands, and they know what they are working with,” de Coninck says. “Now it’s up to them.” ■

Less is more

Capping global warming at 1.5 degrees Celsius above preindustrial levels rather than 2 degrees can soften climate impacts. SOURCE: IPCC 2018

	1.5 degrees	2 degrees
		
Global average sea level rise by 2100	48 centimeters	56 centimeters
Increase in ocean acidity by 2100	9%	24%
Probability of an ice-free Arctic Ocean in the summer for any given year	3%	16%
		
Increase in the annual maximum daily temperature	1.7 degrees	2.6 degrees
Proportion of global population facing at least one severe heat wave every five years	14%	37%
Global population exposed to severe drought	132.5 million	194.5 million
		
Global population exposed to flooding in coastal areas by 2095	60 million per year	72 million per year
Proportion of species losing >50% of range that has a climate they can tolerate	6% Invertebrates 4% Vertebrates	18% Invertebrates 8% Vertebrates



Claim of first gene-edited babies sounded alarms

By Tina Hesman Saey

2 A Chinese scientist surprised the world in late November by claiming he had created the first gene-edited babies, who at the time of the announcement were a few weeks old. Scientists and ethicists quickly responded with outrage.

In an interview with the Associated Press and in a video posted November 25, Jiankui He announced that twin girls with a gene altered to reduce the risk of contracting HIV “came crying into this world as healthy as any other babies.”

Many researchers and ethicists say implanting gene-edited embryos to create babies is premature and exposes the children to unnecessary health risks. Critics also fear the creation of “designer babies,” children edited to enhance their intelligence, athleticism or other traits.

Facing his peers on November 28 in Hong Kong at the second International Summit on Human Genome Editing, He explained his research. He also revealed that another woman participating in a gene-editing trial is in the early stages of pregnancy (*SN Online*: 11/28/18).

He said his group used the gene-editing tool CRISPR/Cas9 to disable the *CCR5* gene in the fertilized eggs that produced the babies, “Lulu” and “Nana” (not their real names). *CCR5* encodes a protein that allows the most common version of the HIV virus to enter cells. Some people naturally have

versions of the gene that help protect against HIV infection.

The girls’ parents were one of seven couples recruited from an HIV patient group to take part in what was called an HIV vaccine development project. The twins’ father has HIV; their mother does not.

He claimed that his experiments to disable *CCR5* might help susceptible children, especially in the developing world, avoid HIV infection. “I truly believe this is not only just for this case, but for millions of children that need this protection since an HIV vaccine is not available.... I feel proud.”

But scientists say there was almost no chance the girls would have been infected with HIV at birth since their mother doesn’t carry the virus. And there are easier and safer ways to avoid infection after birth.

Researchers who saw He’s presentation were not convinced that he presented enough evidence to verify that the editing was successful and didn’t damage other genes. Previous CRISPR/Cas9 research has indicated that some cells in embryos may be incompletely edited or escape editing entirely, creating a “mosaic” embryo (*SN*: 9/2/17, p. 6).

In this case, incomplete editing might leave the children as vulnerable to HIV infection as if their DNA had never been altered. Lulu’s edited copies of *CCR5* supposedly mimic the natural variants that give people HIV resistance. Whether the version of the gene He claims Nana carries confers resistance to HIV is not known. Previous claims of successful gene editing in human embryos in lab dishes also have been met with skepticism (*SN Online*: 8/8/18).

Until now, scientists around the world have abided by a

consensus that creating babies with edited embryos goes too far, because safety and ethical issues haven't been resolved. "I assume you're very well aware of this redline," Wensheng Wei of Peking University in Beijing said after He's presentation. "Why did you choose to cross this line? And ... why did you choose to do all these clinical studies in secret?" He did not answer the questions.

Gene editing may sometimes damage other important genes, which could lead to health problems such as cancer later in life. And taking a gene out of commission has risks: People with missing or defective *CCR5* genes are more susceptible to serious complications from West Nile virus infections.

Even if the girls don't end up with any health problems as a result of He's genetic tinkering, the experiment is still bad

science, says Julian Savulescu, a bioethicist at the University of Oxford. "I liken it to Russian roulette. You can pull the trigger and not kill, but that doesn't mean what you did was right."

Within days of He's announcement, China's Ministry of Science and Technology suspended work by He and his team at Southern University of Science and Technology in Shenzhen, China, stating that He's actions "violated China's relevant laws and regulations." Authorities are investigating further.

Organizers of the summit called the work "irresponsible" and expressed doubt over whether the edits happened at all. But they released a statement agreeing that it's time to set standards for future clinical trials that would produce gene-edited babies to correct diseases. ■

Scientific scuttlebutt

Here's our short list of discoveries reported in 2018 that could shake up science, if they hold up. — *Cassie Martin*

Starlight, star bright

The first stars in the universe flickered on by about 180 million years after the Big Bang, radio observations suggest (*SN: 3/31/18, p. 6*). Unexpectedly strong signals, picked up by a table-sized antenna in the Australian outback, hint at the earliest twinklers and what would be a new phenomenon in the early universe: hydrogen particles interacting with dark matter, the mysterious substance that makes up most of the matter in the universe.



Detecting the signature of the first stars required a radio antenna (shown), located in Western Australia, far from artificial sources of radio waves.

Not so standard

Dangling from a helium balloon high above Antarctica, the ANITA detector spied two odd signals that hint at the existence of new subatomic particles. Such extremely energetic particles, if they exist, could upend the standard model, the theory that describes the elementary particles that make up matter (*SN: 10/27/18, p. 8*). Some physicists caution that the signals could have come from something more mundane, such as spacefaring particles called cosmic rays.

Alzheimer's goes viral

Two studies add support for a connection between Alzheimer's disease and herpesvirus (*SN: 7/21/18, p. 10*). One group of researchers found more DNA from strains of the common virus in brains of Alzheimer's patients versus healthy people; a second group says that amyloid-beta plaques in the brain, a hallmark of the disease, might be a protective reaction to pathogens like herpesvirus. But the connection, if any, remains unclear, and scientists emphasize that Alzheimer's is not contagious.

Superconductor suspect

A new hydrogen-rich compound may solve a big problem with superconductors — the materials have to be in a deep

freeze to function. Two experiments found lanthanum-hydrogen compounds transmitted electricity without resistance when squeezed between two diamonds at temperatures higher than seen before (*SN: 10/13/18, p. 6*). That would be a big improvement, researchers say, but the compounds haven't yet been shown to expel magnetic fields as a true superconductor would.

Bird breath

Are white speckles in the chest cavity of a 120-million-year-old bird fossil traces of a respiratory system similar to that of modern birds (*SN: 11/10/18, p. 12*)? If so, the fossil, found in China, could be the first to preserve lungs of a bird. Some paleontologists aren't convinced, partly because it's so rare for delicate lung tissue to survive fossilization.

Exomoon expectations

The Hubble Space Telescope bolstered evidence of the first known moon outside of our solar system (*SN: 10/27/18, p. 14*). The researchers are cautiously optimistic. A dip in starlight observed earlier by the Kepler space telescope suggested the existence of a Neptune-sized moon orbiting a gas exoplanet 8,000 light-years away (*SN: 12/23/17 & 1/6/18, p. 23*). Hubble spotted the same dip and saw the planet passing in front of its star earlier than expected, suggesting something was tugging on the planet. A moon, perhaps?

Crime solvers embraced genetic genealogy

By Tina Hesman Saey

3 Every week, Ellen Greytak checks DNA profiles in a genealogy database. She's not searching for long-lost relatives. She's out to find family members of unknown assailants in rape and murder cases.

Greytak is director of bioinformatics at Parabon NanoLabs in Reston, Va. Since May, the company has used genetic genealogy, a forensic technique for tracking down suspects through their family trees, to help close more than a dozen cases nationwide.

In 2018, criminal investigators in the United States embraced the tool, solving decades-old cold cases and some fresh crimes. But this new type of DNA-based detective work has raised questions about genetic privacy and police procedures.

More than 12 million Americans have jumped on the consumer genetic testing bandwagon, sending spit samples to companies like 23andMe or AncestryDNA to learn about health risks and to explore family origins (*SN*: 6/23/18, p. 26). People who've had their DNA tested and want to find relatives tested by a different company can upload their results to a public database called GEDMatch.

Now GEDMatch is being used to locate rape and murder suspects. In April, Sacramento police arrested Joseph James DeAngelo as a suspect in the Golden State Killer case (*SN Online*: 4/29/18). DeAngelo, a former police officer, is accused of committing about 50 rapes and 12 murders from 1974 to 1986.

Police found DNA matches in GEDMatch to multiple third cousins of DeAngelo. Building out the suspect's family tree eventually led investigators to DeAngelo. A few weeks after DeAngelo's arrest, Parabon identified William Earl Talbott II as a suspect in a 1987 double murder of a young Canadian couple in Snohomish County, Wash. (*SN*: 6/23/18, p. 11). Since then, suspects in 16 other cases have been arrested after genetic genealogy searches.

"Today, if you're a criminal and you've left your DNA at the crime scene, you may as well turn yourself in now. We will catch you," Mark Lindquist said at a June 22 news conference. The Pierce County, Wash., prosecutor was announcing the arrest of Gary Hartman for the 1986 killing of 12-year-old Michella Welch.

About 60 percent of Americans of mainly European heritage can be identified through their relatives' DNA in genealogy databases (*SN Online*: 10/12/18). Soon GEDMatch may be big enough for U.S. investigators to figure out the source of almost

any anonymous DNA sample. To reach that milestone, 3 million people would need to upload data to the site, scientists calculate. About 1.5 million to 2 million people have already done so.

Legal and privacy experts worry that this new sleuthing tool allows police to rummage in people's genetic closets without probable cause (*SN Online*: 6/7/18). Police used to be limited to searching law enforcement databases, which include data from people arrested for or convicted of crimes, for direct matches to crime scene DNA. But the older type of DNA fingerprints used in those searches is good for finding only very close family members: a parent, child or sibling.

Genetic genealogy reaches further, analyzing DNA left at a crime scene (found in blood or semen, for example) for the same types of genetic markers that companies such as 23andMe and AncestryDNA use to determine customers' ethnicity and help them find relatives. GEDMatch's terms spell out that the database can be used to identify perpetrators of violent crimes (defined as homicide or sexual assault) or to identify remains of the deceased.

Police are unlikely to find a direct match in the database, says the site's cofounder Curtis Rogers. "Serial killers tend not to put their DNA on GEDMatch," he says. Instead, police may find hundreds to thousands of distant relatives who share some piece of DNA with the suspect. To narrow the search, genealogists typically need a match to a third cousin or closer relative on both sides of the family.

Innocent people looking for long-lost family may be surprised to find

that putting their DNA on a public website opens them and their relatives to police scrutiny, says Andrea Roth, a professor of law at the University of California, Berkeley Law.

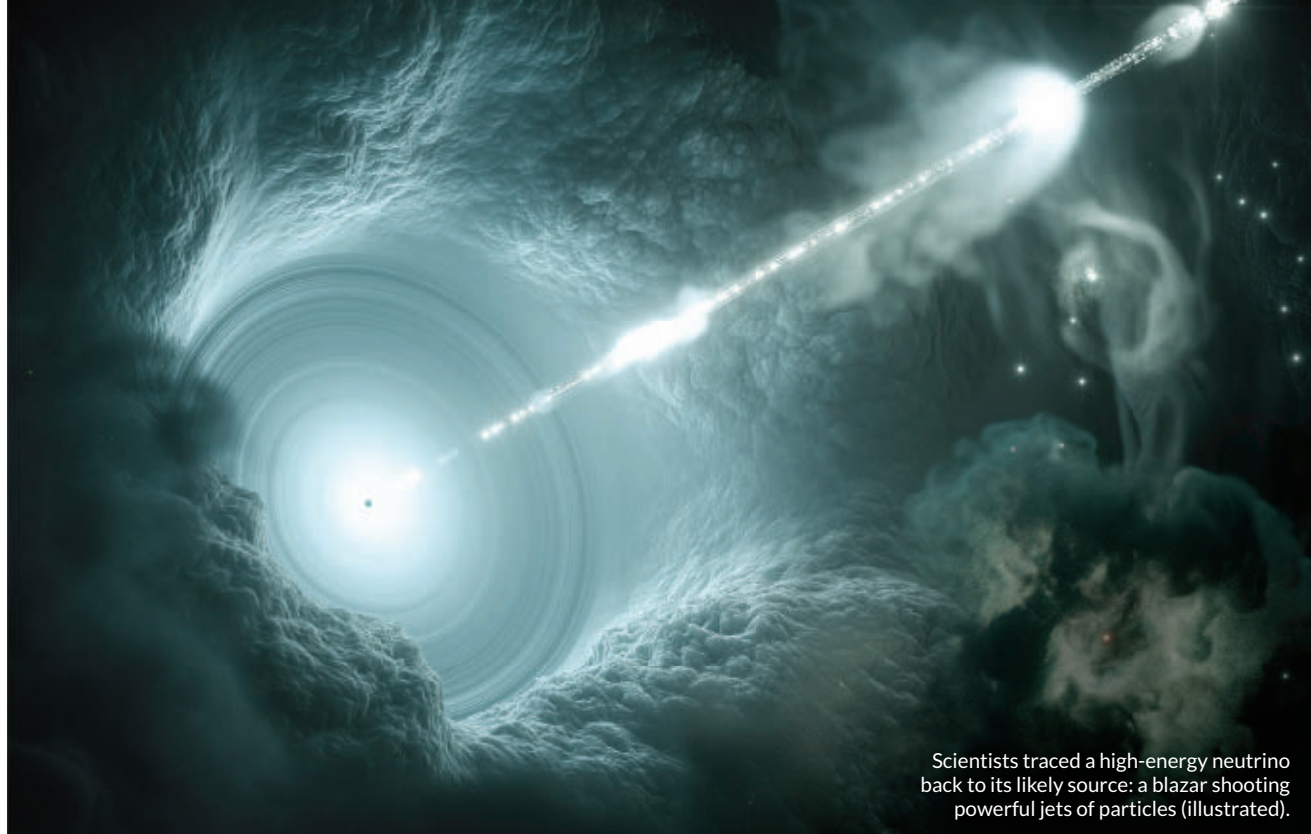
She and other critics charge that genetic genealogy searches put too many people under police scrutiny and should be regulated like law enforcement databases. For instance, California allows police to do family searches of law enforcement databases only as a last resort for the most serious crimes and limits what material can be used. Roth would go a step further: People whose DNA is collected as part of a genetic genealogy investigation and are not linked to the crime must have their data wiped from police databases.

But DNA relatives of a suspect aren't being investigated; they are akin to eyewitnesses who might give police clues about who to look for, says Margaret Press, cofounder of the DNA Doe Project, which aims to identify human remains. The relatives offer a lead, similar to a shoe print or a fingerprint.

And follow-up investigations would include collecting new DNA samples to match against crime scene DNA. Even with a direct DNA match, police still need to build a case to show the person could have committed the crime, Greytak says. "We're just helping them get there." ■



Sacramento County Sheriff Scott Jones (left) discusses the April arrest of Joseph James DeAngelo (photo) in Sacramento, Calif.



Scientists traced a high-energy neutrino back to its likely source: a blazar shooting powerful jets of particles (illustrated).

Neutrino discovery ushered in a new era of astronomy

By Emily Conover

4 Mysterious particles called neutrinos constantly barrel down on Earth from space. No one has known where, exactly, the highest-energy neutrinos come from. This year, scientists finally put a finger on one likely source: a brilliant cosmic beacon called a blazar. The discovery could kick-start a new field of astronomy that combines information gleaned from neutrinos and light.

It began with one high-energy neutrino spotted on September 22, 2017, by the IceCube observatory, a giant particle detector with thousands of sensors buried deep in the ice at the South Pole. Alerted by IceCube, astronomers soon spotted a flare from a blazar about 4 billion light-years away. The neutrino had come from the same area of the sky. With that matchup in time and space between the neutrino and the blazar's light, scientists in 2018 pegged the blazar as the particle's probable source (*SN: 8/4/18, p. 6*).

"People have been hoping for this kind of discovery for decades," says astrophysicist Meg Urry of Yale University.

Blazars are active regions at the centers of galaxies that spew jets of high-energy matter and light toward Earth. Both the Earth-orbiting Fermi Gamma-ray Space Telescope and the Major Atmospheric Gamma Imaging Cherenkov, or MAGIC, telescopes in the Canary Islands reported that the blazar was violently flaring up in gamma rays, a type of high-energy light, at about the same time the neutrino was detected.

"People have been hoping for this kind of discovery for decades."

MEG URRY

After combing through old data, IceCube researchers found evidence of even more neutrinos from near the blazar's location in the sky. With those extra neutrinos, the researchers were finally convinced that the blazar birthed neutrinos.

Not only did the detection hint at the source of at least some high-energy spacefaring particles, it also taught physicists a few things about blazars. Scientists weren't sure what kinds of particles blazars emit, but the detection reveals that the jets contain protons. That's because scientists know that any neutrino from a blazar would have to be produced in combination with protons.

The discovery, scientists say, could invigorate a nascent field, dubbed multimessenger neutrino astronomy, to reveal secrets of the cosmos, whether from blazars or other sources. Now, says astrophysicist Kohta Murase of Penn State, "we can use neutrinos as very important probes" to learn more about the objects that spit them out. For example, researchers might spot neutrinos from a collision of two neutron stars, like the one detected by the Advanced Laser Interferometer Gravitational-Wave Observatory, LIGO, in 2017 (*SN: 11/11/17, p. 6*). IceCube didn't see any neutrinos from that event, but astrophysicists are hopeful that future neutron star smashups will produce a neutrino bounty.

Before scientists are fully confident that blazars can blast out high-energy neutrinos, researchers need to spot more of the wily particles, Murase says. To improve detection, an upgrade to IceCube will make the detector 10 times bigger in volume and should be ready by the mid-2020s, says Francis Halzen, leader of IceCube and an astrophysicist at the University of Wisconsin–Madison. If all goes well, the tiny particles may soon be revealing secrets from new corners of the cosmos. ■

Crater renewed debate over an ancient climate mystery

By Carolyn Gramling

5 For three years, a team of scientists kept a big secret: They had discovered a giant crater-shaped depression buried beneath about a kilometer of ice in northwestern Greenland. In November, the researchers revealed their find to the world.

They hadn't set out to find a crater. But in 2015, glaciologists studying ice-penetrating radar images of Greenland's ice sheet, part of an annual survey by NASA's Operation IceBridge mission, noticed an oddly rounded shape right at the northern edge of Hiawatha Glacier. If the 31-kilometer-wide depression is confirmed to be the remnant of a meteorite impact — and the team has produced a wealth of evidence suggesting that it is (*SN*: 12/8/18, p. 6) — the discovery is exciting in and of itself. It's rare to find a new crater, let alone one on land that has retained its perfect bowl shape.

"This is just a straight-up exciting discovery that starts with this wonderful element of serendipity," says team member Joseph MacGregor, a glaciologist with Operation IceBridge.

But the crater — let's call it that, for the sake of discussion — may have also reignited a debate over a controversial hypothesis about a mysterious cold snap known as the Younger Dryas. This cold period began abruptly about 12,800 years ago and ended just as abruptly about 11,700 years ago. For more than a decade, a small group of researchers, unconnected with the group behind the new discovery, has suggested that a cosmic impact triggered the cooling (*SN*: 7/7/18, p. 18).

Proponents of the Younger Dryas impact hypothesis say that the remnants of a comet exploded in Earth's atmosphere and that the airbursts sparked wildfires across North America. Soot and other particles from the fires blocked out the sun, causing the cold snap, which has been blamed for everything from the extinction of the mammoths to the disappearance of a group of people known as the Clovis.

Most scientists reject that an impact was responsible, refuting the idea that there were vast wildfires at the time or that the Clovis people even disappeared. Another big objection: the lack of a smoking gun, a crater dating to the onset of the Younger Dryas.

The "mammoth in the room," therefore, is whether the Greenland crater might be that smoking gun. But a large, recent impact would be extremely unlikely, given the rarity of such impacts on Earth, particularly on land, says planetary scientist Clark Chapman of the Southwest Research Institute in Boulder, Colo., who was not involved with the discovery.

Indeed, one sticking point is that there are no direct dates for the newly discovered crater, because it is still buried beneath all that ice. The radar data offer only tantalizing clues to the age, suggesting that the crater is between 2.6 million and 11,700 years old.

That's a huge time range, but the proponents of the hypothesis are convinced that this crater is what they've been waiting for. "I think it's transformational in terms of convincing a lot of skeptics," says James Kennett, a geologist at the University of California, Santa Barbara.

There's another big sticking point when it comes to linking this crater to the impact hypothesis: Instead of a fragment of a comet, the discoverers think the Hiawatha impactor was an iron meteorite. That determination is based on measurements of platinum and other elements in glacial outwash, sediments carried by meltwater from beneath the ice. An iron meteorite impact would probably not produce the kinds of explosive airbursts that could ignite continent-scale wildfires, says Michail Petaev, a geochemist at Harvard University.

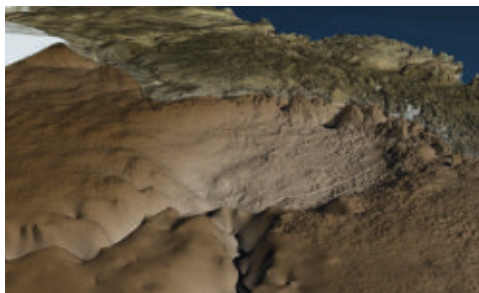
Petaev and colleagues previously found a hint that an iron meteorite might have smacked into Greenland about 13,000 years ago. In 2013, his group examined Greenland ice cores and found a strange platinum anomaly dating to right before the Younger Dryas. The ratio of platinum to iridium measured in the ice cores points to an iron meteorite, the team reported.

Despite the platinum data, the impact hypothesis proponents hold firmly to the idea that the Hiawatha impactor was a comet. Because little is known about comet compositions, Kennett says, a comet might well have been the source for the platinum found in the glacial outwash and the ice cores. But Petaev maintains that the observed platinum ratios just wouldn't occur in a comet, which is made of the primitive stuff of the universe. Instead, he says, those ratios require the cycles of melting and recrystallizing that form iron meteorites, the ancient cores of asteroids or planets.

Glaciologist Kurt Kjær of the University of Copenhagen, who led the team that identified the crater, and his colleagues don't want to weigh in on the Younger Dryas debate. "We can't prove it," Kjær says. "But we can certainly not disprove it."

Instead, the crater's discoverers are planning to collect more sediments from the glacial outwash, and perhaps even drill directly into the crater to retrieve sediment cores that can be dated. And there may be other craters lurking beneath Greenland's ice, or even Antarctica's — perhaps more easily identifiable once you know what to look for, says MacGregor.

Asked whether the team has actually identified any other round shapes of interest, he pauses. Then MacGregor says, cryptically, "stay tuned." ■



Ice-penetrating radar revealed a possible crater under a Greenland glacier. This topographic map strips away the ice to show the 31-kilometer-wide crater.

AI gets a liberal arts education

In 2018, artificial intelligence took on new tasks, with these smarty-pants algorithms acing everything from disease diagnosis to crater counting. — *Maria Temming*

Coming to a clinic near you

In April, the U.S. Food and Drug Administration permitted marketing of the first artificial intelligence that diagnoses health problems at primary care clinics without specialist supervision (*SN*: 3/31/18, p. 15). The program, which inspects eye images for signs of diabetes-related vision loss, could be a boon for people in remote or low-resource areas where ophthalmologists are scarce. Other eye-inspecting AI programs are learning to recognize everything from age-related vision loss to heart problems.

Moon mapping

One artificial intelligence is a celestial cartographer after Galileo's own heart. The algorithm studied a third of the moon's surface to learn what craters look like (*SN Online*: 3/15/18). When playing crater "I Spy" with a different third of the lunar landscape, the AI found 92 percent of previously discovered craters and spotted about 6,000 pockmarks that humans had missed. If focused on rocky planets and icy moons, this program could give new insight into the solar system's history.

Ear to the ground

Artificial intelligence that predicts where earthquake aftershocks will hit could help people in high-risk areas better prepare for these dangerous seismic shake-ups. A program that studied characteristics of over 130,000 earthquakes and their aftershocks learned to predict aftershock locations much more accurately than traditional techniques (*SN Online*: 8/29/18).

Megafauna paparazzi

Automated camera traps, which snap photos of animals in their natural habitats, can help researchers and conservationists track animal behavior. But these wildlife-watching systems take more photos than any human has

time to review. Enter a master naturalist artificial intelligence that learned to identify wildlife by studying 1.4 million hand-labeled images collected by the Snapshot Serengeti citizen science project. This algorithm, described in June in the *Proceedings of the National Academy of Sciences*, labels the number, species and activity of animals in each new picture.

Savvy navigator

Designing artificial intelligence to mimic the activity in specific regions of the brain could help scientists better understand how our minds work. An AI programmed with virtual versions of specialized brain cells called grid cells found shortcuts through a virtual maze better than an AI without the mapping cells (*SN*: 6/9/18, p. 14). The grid cell-equipped AI's nimble navigation suggests that grid cells in mammal brains do more than give animals an internal coordinate system. The nerve cells may also help us map the shortest route to our destination.

Competing companies join forces

A new artificial intelligence lets competing drug companies share information without revealing secrets (*SN Online*: 10/18/18). This secure setup using a novel

cryptography system may encourage drug companies to pool their resources, creating larger libraries of training data to beget smarter AI. Programmers have used the system to train an AI that predicts which drugs will interact with which proteins in the human body to develop new medical treatments. AI could also use this system to analyze confidential hospital health records to devise patient treatment plans and make prognoses.

Say what?

Humans are naturally good at ignoring background babble to focus on what a single person is saying. Computers, not so much. But now, an artificial intelligence analyzes both audio and visual cues, like lip movements, to pick out what individual speakers are saying in noisy videos (*SN*: 7/7/18, p. 16). Such keen-eared AI could write more accurate captions and power virtual assistants that better understand voice commands in loud settings.

Seeing is not believing

Of course, smarter artificial intelligence isn't always good news. One AI that raised eyebrows in 2018 generates realistic fake video footage by making the subject of one video mirror the motions and expressions of someone else in a different clip (*SN*: 9/15/18, p. 12). In the wrong hands, this AI could be a powerful tool for spreading misinformation (*SN*: 8/4/18, p. 22).



A computer program can manipulate a video so that its subject mirrors the movements of someone else in another video. In this case, video frames of Russian President Vladimir Putin are altered to match those of former President Barack Obama.



We nudged closer to the Mosquito Terminator

By Susan Milius

6 For the first time, humans have built a set of pushy, destructive genes that infiltrated small populations of mosquitoes and drove them to extinction.

But before dancing sleeveless in the streets, let's be clear. This extermination occurred in a lab in mosquito populations with less of the crazy genetic diversity that an extinction scheme would face in the wild. The new gene drive, constructed to speed the spread of a damaging genetic tweak to virtually all offspring, is a long way from practical use. Yet this test and other news from 2018 feed one of humankind's most persistent dreams: wiping mosquitoes off the face of the Earth.

For the lab-based annihilation, medical geneticist Andrea Crisanti and colleagues at Imperial College London focused on one of the main malaria-spreading mosquitoes, *Anopheles gambiae*. The mosquitoes thrive in much of sub-Saharan Africa, where more than 400,000 people a year die from malaria, about 90 percent of the global total of malaria deaths.

To crash the lab population, the researchers put together genes for a molecular copy-and-paste tool called a CRISPR/Cas9 gene drive. The gene drive, which in this case targeted a mosquito gene called *doublesex*, is a pushy cheat. It copies itself into any normal *doublesex* gene it encounters, so that all eggs and sperm will carry the gene drive into the next generations. Female progeny with two altered *doublesex* genes develop more like males and, to people's delight, can't bite or reproduce.

In the test, researchers set up two enclosures, each mixing 150 males carrying the saboteur genes into a group of 450 normal mosquitoes, males and females. Extinction occurred in eight generations in one of the enclosures and in 12 in the other (*SN*: 10/27/18, p. 6).

This is the first time that a gene drive has forced a mosquito population to breed itself down to zero, says Omar Akbari of the University of California, San Diego, who has worked on other gene drives. However, he warns, "I believe resistance will be an issue in larger, diverse populations." More variety in mosquito genes means more chances of some genetic quirk arising that counters the attacking gene drive.

Researchers used a gene drive to exterminate two small lab populations of *Anopheles gambiae* mosquitoes this year.

But what if a gene drive could monkey-wrench a wild population, or maybe a whole species, all the way to extinction? Should people release such a thing? To make sense of this question, we humans will have to stop talking about "mosquitoes" as if they're all alike. The more than 3,000 species vary considerably in what they bite and what ecosystem chores they do.

The big, iridescent adults of *Toxorhynchites rutilus*, for instance, can't even drink blood. And snowmelt mosquitoes (*Ochlerotatus communis*) are pollinators of the blunt-leaved orchid (*Platanthera obtusata*), ecologist Ryo Okubo of the University of Washington in Seattle said at the 2018 meeting of the Society for Integrative and Comparative Biology.

Estimating what difference it would make ecologically if a whole mosquito species disappeared has stirred up plenty of speculation but not much data. "I got pretty fed up with the hand-waving," says insect ecologist Tilly Collins of Imperial College London. So she and colleagues dug through existing literature to see what eats *An. gambiae* and whether other mosquitoes would flourish should their competitor vanish.

So far, extermination of this particular mosquito doesn't look like an ecological catastrophe, Collins says. Prey information is far from perfect, but diets suggest that other kinds of mosquitoes could compensate for the loss. The species doesn't seem to be any great prize anyway. "As adults, they are small, not juicy, and hard to catch," she says. The little larvae, built like aquatic caterpillars with bulging "shoulders" just behind their heads, live mostly in small, temporary spots of water.

The closest the researchers came to finding a predator that might depend heavily on this particular mosquito was the little East African jumping spider *Evarcha culicivora*. It catches *An. gambiae* for about a third of its diet and likes the females fattened with a human blood meal. Yet even this connoisseur "will readily consume" an alternative mosquito species, the researchers noted in July in *Medical and Veterinary Entomology*.

Collins also thinks about the alternatives to using genetically engineered pests as pest controls. Her personal hunch is that saddling mosquitoes with gene drives to take down their own species is "likely to have fewer ecological risks than broad-spectrum use of pesticides that also kill other species and the beneficial insects."

Gene drives aren't the only choice for weaponizing live mosquitoes against their own kind. To pick just one example, a test this year using drones to spread radiation-sterilized male mosquitoes in Brazil improved the chances that the old radiation approach will be turned against an *Aedes* mosquito that can spread Zika, yellow fever and chikungunya.

Old ideas, oddly enough, may turn out to be an advantage for antimosquito technologies in this era of white-hot genetic innovation. Coaxing the various kinds of gene drives to work is hard enough, but getting citizens to sign off on their use may be even harder. ■

Researchers sent mixed messages about drinking

By Rachel Ehrenberg

7 For people who enjoy an occasional cocktail, 2018 was a sobering year. Headlines delivered the news with stone-cold certainty: Alcohol — in any amount — is bad for your health. “The safest level of drinking is none,” a group of scientists concluded.

That finding, along with another one reported this year, seemed to contradict the reassuring notion that an occasional drink might be good for you (*SN*: 9/5/15, p. 10). But the two studies were met with a flurry of criticism. While drinking in excess is undoubtedly unhealthy, a finding confirmed by this year’s research, the studies and the headlines focused on the risks of a single drink per day. And that’s a risk the analyses weren’t designed to address.

“These studies clearly show that alcohol is a huge health problem,” says Stanford University epidemiologist John Ioannidis, who was not involved in the studies. “But the emphasis was placed on no amount of alcohol being safe, and that’s wrong.”

Both studies were meta-analyses. They combined data from numerous observational studies that tracked what large numbers of people drank over time and compared rates of disease or death in those populations. For the first study, a team from the University of Cambridge combined 83 studies that looked for links between drinking and the risk of death or cardiovascular disease in nearly 600,000 people in 19 countries.

People who had more than about seven drinks per week (one drink is 12 ounces of beer, five ounces of wine or 1.5 ounces of distilled spirits) had a lower life expectancy and a higher risk of stroke, heart failure, fatal aneurysm and other problems than lighter drinkers. The more booze imbibed, the greater the risk of earlier death, the team reported in the April 14 *Lancet*.

The second study — with the dramatic conclusion that

anything more than abstinence is risky — looked at nearly 700 studies including millions of people. The team, led by researchers at the University of Washington in Seattle, tried to get a snapshot of the world’s health if no one drank alcohol. The team considered 23 health problems caused or exacerbated by drinking, including tuberculosis, car accidents, diabetes and various cancers.

In a world of teetotalers, there would have been 2.8 million fewer deaths in 2016 alone, the team reported in the Sept. 22 *Lancet*.

Few took issue with this broad-brush conclusion. But the results didn’t support the notion that no amount of alcohol is safe. In fact, a figure in the study showed that an increased risk of death begins somewhere slightly above one drink per day.

Study coauthor Emmanuela Gakidou, an expert in health metrics, acknowledges that the risks for light to moderate drinkers are small. In a given year, 914 per 100,000 people who drink no alcohol will die from one of the health conditions examined in the study. If all those people had one drink per day in that year, an extra four, for a total of 918, would die.

“Saying to yourself, having a glass of wine presents a small risk, but I enjoy it — OK, that’s fine,” Gakidou says. “But I would like people to move away from thinking drinking is good for you.”

The controversy over these studies highlights the challenges of studying the interaction of diet and human health, Ioannidis says. “Observational studies are in a very tough position to give us an answer to questions like, is one drink bad or beneficial.” There are too many confounding factors, such as the different lifestyles, health and backgrounds of the people in the studies. “When trying to study small risks, it is very difficult to get all of these factors out of the way,” he says.

Because observational studies merely observe, they can’t establish cause and effect. And meta-analyses in particular, in which many studies are combined and statistically analyzed, can appear to lend weight to a broad conclusion, even when it’s not justified (*SN Online*: 4/23/18).

“The emphasis was placed on no amount of alcohol being safe, and that’s wrong.”

JOHN IOANNIDIS



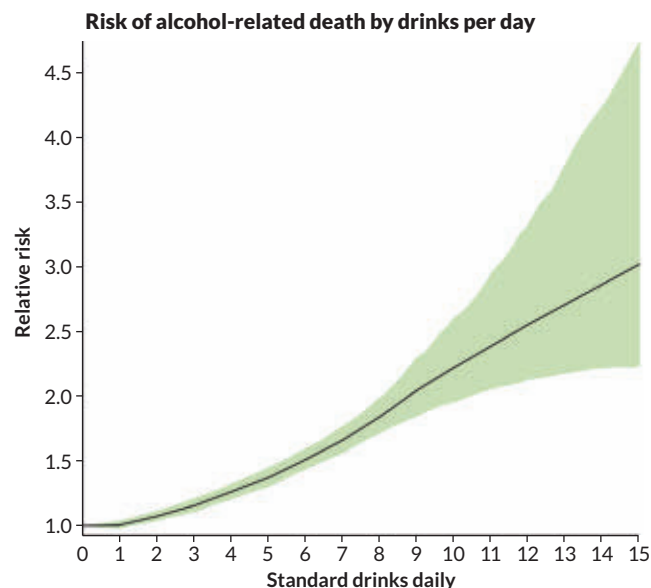
In the case of alcohol, focusing on the dangers of one drink per day isn't just flawed, it "runs the risk of diminishing attention to problem drinking," says Elliot Tapper, a physician at the University of Michigan Medical School in Ann Arbor.

Alcohol in excess can be toxic to the liver, and excessive drinking appears to be a growing problem, especially among young adults. From 2009 to 2016, U.S. deaths from alcohol-related cirrhosis, a scarring of the liver, went up on average 10.5 percent each year among those ages 25 to 34. White, Native American and Hispanic men experienced the most fatalities, Tapper and a colleague reported in July in *BMJ*.

As for drinking in moderation, the only way to find out if it is beneficial or harmful is with a randomized controlled trial in which two comparable groups of people are given different interventions, such as drink vs. no drink. Such a study was under way, but the National Institutes of Health canceled it in June after learning that the researchers secretly conferred with and solicited funding from beer and liquor executives when planning the study.

Until a randomized controlled trial is done, Tapper says, "use a dose of common sense when considering how much to drink." ■

One and done In a 2018 study claiming that no amount of drinking is safe, risk was very close for people who had no drinks and those who had one drink per day. From there, risk for alcohol-attributable deaths rose with increasing consumption. SOURCE: M.G. GRISWOLD ET AL/LANCET 2018



E-cigs caught fire among teens

On November 15, Scott Gottlieb, commissioner of the U.S. Food and Drug Administration, announced new sales restrictions on certain e-cigarette flavors preferred by teens. The move was a response to a worrying rise in vaping among adolescents in the last year.

"E-cigs have become an almost ubiquitous and dangerous trend among teens," he warned, calling it an "epidemic" in a September speech.

His claim is no exaggeration.

In 2018, 20.8 percent of high schoolers surveyed said they had used e-cigarettes at least once in the last 30 days, up from 11.7 percent in 2017. That is a 78 percent jump in e-cig use, based on data from the National Youth Tobacco Survey (*SN Online*: 11/16/18).

That spike may be due to use of the top-selling e-cigarette brand, Juul. One of a new

class of e-cigarettes called pod-mods, a Juul vaporizes a prefilled pod of flavored liquid that contains a higher concentration of nicotine than other e-cigs. The palm-sized device resembles a USB flash drive and can be used discreetly, as it doesn't produce much vapor. A survey of 437 California high school students found that teens are more likely to become regular users of Juuls than of other e-cigs (*SN Online*: 10/23/18). Teens already have their own term for vaping: juuling.

A person who inhales all of the nicotine in a 5 percent nicotine Juul pod (a 3 percent version is also available) takes in about the same amount as a smoker would get from 26 to 40 cigarettes, says toxicologist Gideon St. Helen of the University of California, San Francisco. A pod may last about a day for a heavy user, he says.

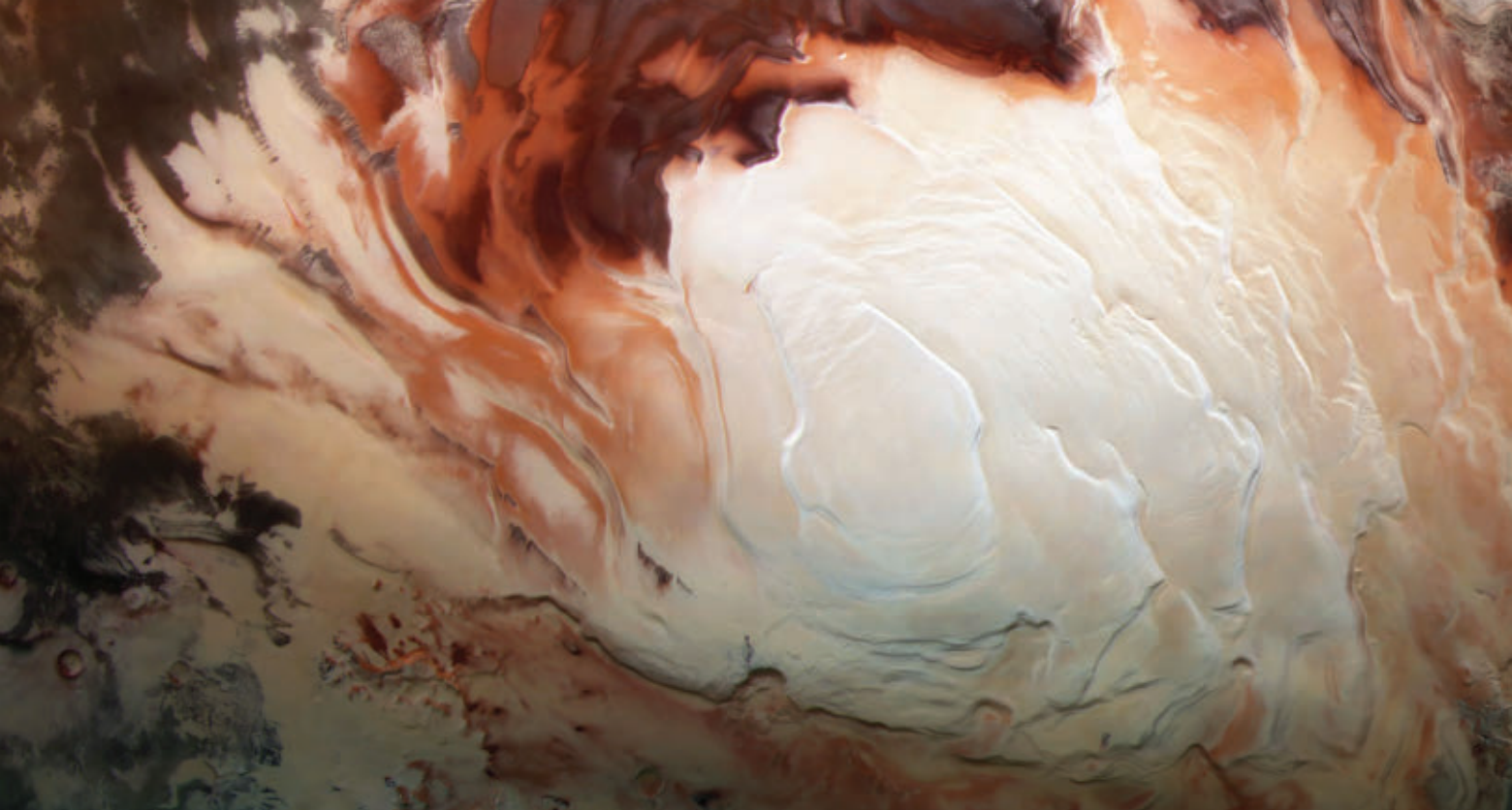
Juul's high dose of nicotine alarms public health officials. But use of any e-cigarette or vaping product containing the addictive chemical puts youth at

risk. Adolescents and young adults are more likely to become addicted than older adults. Nicotine also harms brain development — ongoing until around age 25 — affecting mood and impulse control. Other health concerns, which apply regardless of age, include toxic vapors and lung problems (*SN*: 7/11/15, p. 18).

The idea that e-cigarettes are a lesser evil than traditional cigarettes because they don't release cancer-causing tar is irrelevant when it comes to teens, researchers say.

"The majority of young people who are using vapes never wanted to use cigarettes to begin with," says Bonnie Halpern-Felsher, a developmental psychologist at Stanford University School of Medicine. The correct comparison, she says, is "vapes vs. nothing."

The medical community is playing catch-up on vaping, says Anne Thorndike, an internist at Massachusetts General Hospital in Boston. But the message for teens who vape is clear, she says. "If you continue using, you will become dependent on nicotine." — *Aimee Cunningham*



A buried lake on Mars excited and baffled scientists

By Lisa Grossman

8 Headlines touting the discovery of water on Mars — again! — are a long-standing punchline among planetary scientists. But a discovery this year was something very different.

Unlike previous claims of water-bearing rocks or ephemeral streaks of brine, researchers reported in the Aug. 3 *Science* that they had found a wide lake of standing liquid near the Red Planet's south pole, buried beneath 1.5 kilometers of ice (*SN*: 8/18/18, p. 6). The purported polar pool, spotted by an orbiting satellite, is the largest volume of liquid water ever claimed to currently exist on Mars, and has probably been around for a long time. Both of those features raise hopes that life could survive on Mars today.

But months after the announcement, the discovery remains controversial. First, it's not clear how that water could remain liquid when the temperature at that icy depth should be about -68° Celsius. Even salts dissolved in the water would have a hard time melting ice that cold. "This is the main objection that has been raised," says one of the lake's discoverers, planetary scientist Roberto Orosei of the National Institute for Astrophysics in Bologna, Italy.

The other concern is that a second Mars orbiter, which should be able to detect such lakes, has seen nothing so far.

Orosei, however, thinks he has the answer to both puzzles: If Mars' south polar ice cap has a texture like Styrofoam, he says, that could both insulate the lake and befuddle the other orbiter.

Orosei and colleagues spotted the lake after years of analyzing data from the European Space Agency's Mars Express orbiter, which aims radar at the planet to see below its surface. As radar waves bounce off an interface between two materials, the brightness of the reflection can tell scientists what those materials are. Orosei's group found a bright triangular reflection measuring about 20 kilometers across at Mars' south pole. A lake of liquid water beneath the ice is the most likely explanation, Orosei says.

NASA's Mars Reconnaissance Orbiter, which has also observed the south pole with radar, has seen no sign of the lake. "It's a big mystery," says Toronto-based planetary scientist Isaac Smith of the Planetary Science Institute, who works on the NASA mission. "We'd love to figure it out."

Tiny pockets of air in the polar ice sheet might explain the conflicting radar results, Orosei suspects. If the ice is riddled with holes, they may scatter the Mars Reconnaissance Orbiter's short-wavelength radar, like light filtering through a cloud. That scattering would hide the lake from the short-wavelength radar's view. But Mars Express' longer-wavelength radar could pass through the ice cleanly allowing it to reach and reflect off the lake.

The air in those holes would also help insulate lower layers of ice and raise the temperature there, or hold in heat from the planet's interior more efficiently, similar to the way a Styrofoam cup keeps coffee hot.

"This is just a conjecture at the moment," Orosei cautions.

Smith thinks porous, Styrofoam-like ice sounds plausible, but hard to explain. On Earth, ice normally packs tightly and

Layers of ice near Mars' south pole, shown here in a 2012 composite image from the European Space Agency's Mars Express orbiter, may conceal a lake far below the surface.

becomes denser as it grows thicker. It's hard to see how such a thick slab of ice on Mars would not do the same. Other orbital measurements suggest that Mars' ice is even denser than regular water ice, which doesn't leave much room for air holes.

But Mars' south polar ice behaves differently than earthly ice in other ways too, Smith says. It doesn't flow the way you would expect from tightly packed glaciers. Porous ice might explain why it flows differently, and more dust and other impurities in the ice could make up for the difference in density.

"It would be a big surprise," Smith says. "But Mars is a unique place."

If the ice is porous, there should be more insulated lakes hidden beneath the ice cap, Orosei says. The Mars Express team may have seen some hints of such lakes already, although it's too early to be sure.

Finding additional lakes would be great news for the possibility of life there. If life took root in the past, it could still hang on in these long-lived subglacial lakes, like life does in similar lakes in Antarctica (*SN*: 9/20/14, p. 10).

"This means you would have a sort of Noah's ark for life to exist today, if it ever developed on early Mars," Orosei says. "The chances of finding extant life today would be much greater." ■

Paralysis became less permanent with electricity

By Laurel Hamers

9 The spinal cord can make a comeback. Intensive rehabilitation paired with electric stimulation of the spinal cord allowed six paralyzed people to walk or take steps years after their injuries, three small studies published this year showed.

"There's a capacity here of human spinal circuitry to be able to regain significant motor control and function," says Susan Harkema, a neuroengineer at the University of Louisville in Kentucky who led one of the studies, published in September in the *New England Journal of Medicine*. "That's really exciting and really important."

Nearly 1.5 million people in the United States have some degree of paralysis from a spinal cord injury. For many of these people, rehabilitation focuses on learning to live with their newly limited mobility.

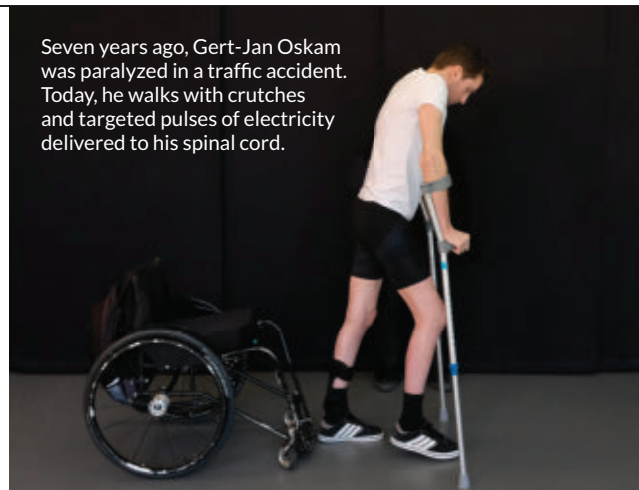
In all three studies, patients were implanted with a small device that zaps the spinal cord. Over months of training sessions, the stimulators sent electrical signals to the patients' spinal cord. At the same time, researchers guided the participants through physical therapy routines.

Eventually, some patients could take a few steps with no support, though most needed crutches, walkers or aid from harnesses that held them up.

Harkema's study, and one by another team published in September in *Nature Medicine*, included people whose neural connections to the lower extremities didn't work at all. The third study, published in October in *Nature*, showed similar improvements in people who were paralyzed but had some working connections (*SN*: 11/24/18, p. 6).

Because people with quadriplegia consistently rate regaining use of their hands as more important than being able to walk, neuroengineer Chet Moritz is trying to restore hand movement. His group at the University of Washington in Seattle is stimulating

Seven years ago, Gert-Jan Oskam was paralyzed in a traffic accident. Today, he walks with crutches and targeted pulses of electricity delivered to his spinal cord.



the spinal cord through the skin (rather than via an implanted stimulator). The researchers reported improvements in finger dexterity and grip strength in one patient in the June *IEEE Transactions on Neural Systems and Rehabilitation Engineering*.

So far, the gains have been limited to a very small number of people who spent months going to rehab sessions several times a week. Still, this year's advances show that, in some cases, stimulation works. Now, scientists need to figure out why. "One possible explanation... is that the stimulator acts like a hearing aid or an amplifier for the spinal cord below the injury," Moritz says. "It could make the cord listen better to the signals coming from the brain."

The electric pulses may also be helping to rebuild weakened neural connections — some patients were ultimately able to move voluntarily without stimulation.

That might mean that patients who begin treatment soon after an injury, before muscles and nerves have a chance to atrophy, could see even bigger improvements, says Grégoire Courtine, a neuroengineer at the Swiss Federal Institute of Technology in Lausanne and lead author of the October study in *Nature*.

But scientists have a lot more work to do, Harkema says. "Who can recover? How much? How far? What type of stimulation is best? All of those questions are unanswered." ■

1.5
million
Estimate of people in the United States who have some level of paralysis from a spinal cord injury

Human smarts got a surprisingly early start

By Bruce Bower

10 Archaeological discoveries reported this year broadened the scope of what scientists know about Stone Age ingenuity. These finds move the roots of innovative behavior ever closer to the origins of the human genus, *Homo*.

Example No. 1 came from Kenya's Olorgesailie Basin, where fickle rainfall apparently led to a wave of ancient tool and trading advances (*SN*: 4/14/18, p. 8). Frequent climate swings in East Africa probably stimulated the creation of new types of stone tools and the formation of trading networks by about 320,000 years ago, said a team led by paleoanthropologist Rick Potts of the Smithsonian Institution in Washington, D.C. Soil analyses point to shifts from dry to rainy conditions every few years or decades at Olorgesailie around that time, the researchers noted in *Science* in March.

Potts has argued since the 1990s that humans and our direct ancestors evolved to deal with frequent environmental shifts, making human evolution a story of "survival of the versatile." That's still a controversial idea, but the Olorgesailie finds support Potts' scenario.

No *Homo* fossils have been found at the Kenyan location, leaving the toolmakers' evolutionary ID unknown. But the timing is right for the Olorgesailie folk to have been *Homo sapiens* (*SN*: 12/23/17, p. 24).

If they were, Olorgesailie groups heralded later Stone Age artistic innovations by humans elsewhere. A crosshatched

design on a rock found in South Africa was made by humans around 73,000 years ago, making it the oldest known drawing, another team reported this year (*SN*: 10/13/18, p. 6).

Meanwhile, in a cave on the Southeast Asian island of Borneo, researchers uncovered the oldest known painted figure, depicting a horned animal, which dates to at least 40,000 years ago (*SN*: 12/8/18, p. 8). Even Neandertals got in on the act, creating abstract rock art in Spanish caves at least 64,800 years ago, one study suggests (*SN*: 3/17/18, p. 6). Once portrayed as humans' brutish cousins, Neandertal artistry implies that the hominids were humans' mental equals.

Another report this year suggested that Stone Age ingenuity took a surprising turn long before those early artists or the Olorgesailie crowd made their marks. Archaeologists discovered the oldest signs of a *Homo* presence way outside of Africa, nearly 7,000 kilometers away in China. Humanlike populations, perhaps *Homo erectus*, reached central China about 2.1 million years ago, Zhaoyu Zhu of the Chinese Academy of Sciences in Guangzhou and colleagues reported in *Nature* in July (*SN*: 8/4/18, p. 7). That's about 250,000 years before what was previously the oldest outside-of-Africa evidence, in western Asia.

Even if early *Homo* populations simply followed migrating herds of prey across Asia without planning to travel far, those intrepid hunters would have had to adjust on the fly to novel habitats and climates along the way. That neat trick foreshadowed Olorgesailie people's innovative aptitude by more than 1.7 million years.

When naming the earliest species in the human genus, scientists have emphasized hands designed for toolmaking (*H. habilis*) and upright gaits (*H. erectus*). Based on the latest archaeological findings, a better title for those inventive pioneers may be *Homo versatilis*. ■

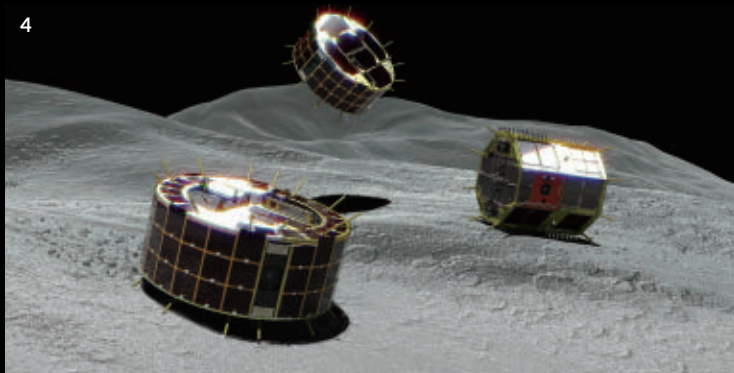


Red horizontal and vertical lines painted on a Spanish cave's walls may date to at least 64,800 years ago. *Homo sapiens* had not yet reached Europe, so researchers propose Neandertals created the art.

A year of launches and farewells in space

Several new space probes got their starts in 2018, while some sang swan songs. — *Lisa Grossman*

Hello



This year saw the launch of several new spacecraft (clockwise from top): the TESS exoplanet-hunting telescope (illustrated); the InSight lander, which took this photo from the surface of Mars on November 26; MASCOT and the MINERVA-II twins, which explored asteroid Ryugu (illustrated); and the Parker Solar Probe, shown under construction in a clean room.

1. TESS is on the lookout for planets

There's a new planet hunter in town. The Transiting Exoplanet Survey Satellite, or TESS, launched April 18 to search the nearest, brightest stars in the sky for signs of orbiting planets. TESS has already spotted at least two new worlds, one of which may be saturated with water (*SN Online*: 9/18/18).

2. Parker Solar Probe aims for the sun

The Parker Solar Probe launched August 12 on an Icarus-esque journey to the sun (*SN*: 7/21/18, p. 12). The craft made its first close flyby of our nearest star November 5 and began sending data back to Earth in December. Over the next seven years, Parker, built to withstand searing heat (*SN*: 9/15/18, p. 16), will swoop ever closer to the sun, eventually coming to within about 6 million kilometers of the solar surface and directly sampling the sun's wispy corona.

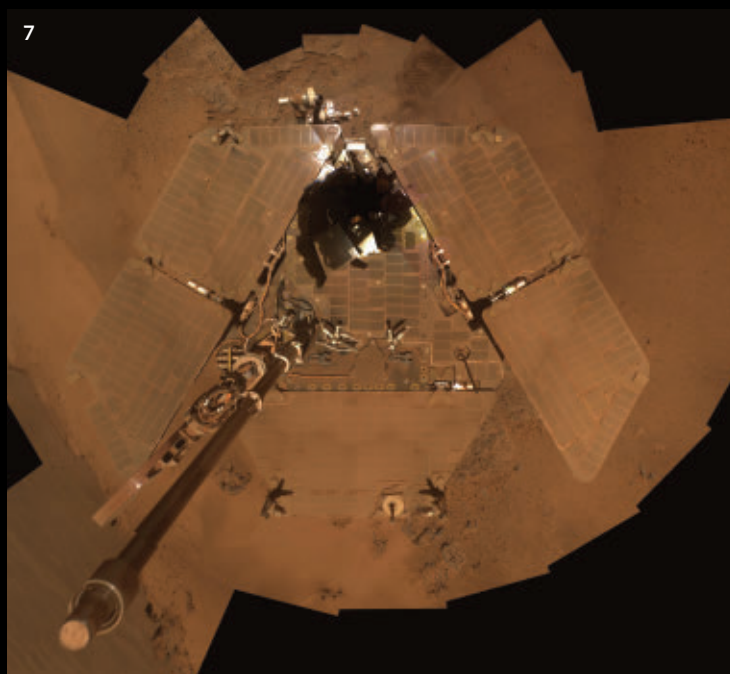
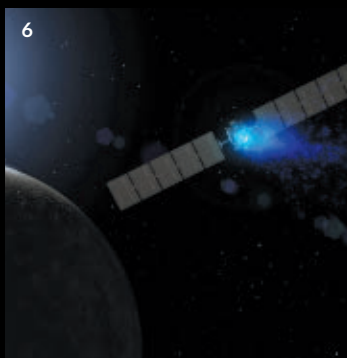
3. InSight touched down on Mars

NASA's latest Mars lander, which reached its target November 26, will explore the whole planet while sitting perfectly still. With little more than a seismometer, a heat probe and time, InSight will listen for "Marsquakes" to figure out what Mars is like on the inside (*SN*: 5/26/18, p. 13).

4. MASCOT and MINERVA-II hop to Ryugu

A trio of robots became the first to land on an asteroid (*SN Online*: 9/24/18). Japan's twin MINERVA-II rovers and Germany's MASCOT lander traveled to the asteroid Ryugu aboard Japan's Hayabusa2 spacecraft. The MINERVA-II robots landed September 21 and hopped around, taking otherworldly pictures and measurements of the asteroid's surface. MASCOT landed October 3. Designed to live for only about 16 hours, MASCOT managed to show that Ryugu has almost no magnetic field, providing insight into the asteroid's interior, mission scientists announced. Next year, Hayabusa2 will grab an asteroid sample, and return it to Earth in 2020.

Good-bye



5. End of the line for Kepler

The Kepler space telescope ran out of fuel just before November (*SN Online*: 10/30/18). The planet-hunting telescope was launched in 2009 to seek planets orbiting other stars. It succeeded spectacularly — discovering thousands of new worlds, some of which may have the right conditions for life, and showing that planets outnumber stars in the Milky Way.

6. Dusk for Dawn

Two days after Kepler's demise, NASA announced that Dawn had sent its final message (*SN Online*: 11/1/18). The spacecraft was the first to orbit two alien places, first the asteroid Vesta and then the dwarf planet Ceres. The probe showed that the two worlds had remarkably different histories, even though they both live in the asteroid belt between Mars and Jupiter. Out of fuel, Dawn will silently orbit Ceres for decades, if not longer.

7. Missed Opportunity

The veteran Mars rover Opportunity fell victim to a dust storm this spring, and mission managers fear it has roved its last. The storm started May 30 and eventually covered the whole planet. The dust blocked so much of the sun that Opportunity's solar panels couldn't charge, and the rover put itself to sleep in June (*SN Online*: 6/13/18). The dust cleared in August, but Opportunity has yet to phone home (*SN Online*: 8/31/18). The rover set records that will be hard to beat: After landing in 2004 for a mission that was supposed to last roughly 93 Earth days (90 Martian days), Opportunity roamed for more than 14 Earth years across more than 45 kilometers.

8. Cassini keeps on giving

True, we said our tearful good-bye to Cassini in 2017 (*SN*: 12/23/17, p. 31). But this year, planetary scientists analyzed some of the last data that the spacecraft took of Saturn, including measurements of "ring rain," a surprisingly complex cocktail of chemicals that falls from the planet's rings onto its atmosphere (*SN Online*: 10/4/18). More analyses of Cassini's data are sure to come.

We said farewell to two spacecraft in 2018: the Kepler exoplanet hunter (illustrated) and the Dawn asteroid explorer (illustrated). The Opportunity Mars rover took this selfie of its own dust-covered solar panels (middle) but is still silent after sitting out a months-long dust storm. Cassini (illustrated) plunged into Saturn last year, but the data the spacecraft collected continues to surprise.



U.S. college students have called out sexual harassment (a 2017 protest at Boston University, shown). 2018 saw institutions take action.

Science's #MeToo moment

By Kyle Plantz

Science is catching up to Hollywood in coming to terms with its own #MeToo moment. In the last year or so, several high-profile scientists left their posts after investigations of sexual harassment allegations, including geneticist Francisco Ayala, cancer biologist Inder Verma and astrophysicist Christian Ott. But getting rid of the “bad actors” isn’t enough, according to a report released in June by the National Academies of Sciences, Engineering and Medicine (*SN Online*: 6/22/18). The report, along with the rise of #MeToo in science, has begun to spur institutional changes.

The problem is widespread in the United States, according to the report. Of nearly 18,000 female undergraduate and graduate students surveyed at the University of Texas System, 20 percent of the science students, 27 percent of the engineering students and 47 percent of the medical students said they had experienced sexual harassment from faculty or staff.

“We recognize that we need to change the culture and environment that is allowing sexual harassment to continue,” Victor Dzau, president of the National Academy of Medicine, said in Washington, D.C., in November at a workshop on best practices for preventing sexual harassment.

As of October, the National Science Foundation requires institutions to report confirmed cases of harassment by researchers who are receiving NSF funding. Failure to do so could result in the removal of scientists from a project or termination of funding. The Food and Drug Administration and the National Institutes of Health, however, have been under fire for not amending policies quickly enough or going far enough to punish abusers who receive government funding.

“There are a lot of individuals in academia and scientists specifically that are eager for change and don’t really see why it’s taking so long,” says Kate Clancy, an anthropologist at the University of Illinois at Urbana-Champaign and a coauthor of the National Academies report.

To guide institutions on adopting new and effective policies, more research is needed on how best to prevent harassment in science, says U.S. Rep. Eddie Bernice Johnson, D-Texas. “When we begin to study and acknowledge what harassment

means in these different environments, across all professions and certainly all scientific areas, we are more likely to address it,” she says. “I don’t think we have the luxury of thinking that it will just go away.” Johnson introduced a bill in Congress in October to provide \$17.4 million in federal funding to study the factors and consequences of sexual harassment in science, technology, engineering and math.

That funding, if the bill is enacted, could aid the kind of research that Clancy is doing. In 2014, she and colleagues reported that out of a sample of about 500 female scientists, 71 percent said they had been sexually harassed during field research and 26 percent said they had been sexually assaulted. Isolating environments and other factors can make field research ripe for sexual misconduct when rules and policies aren’t expressed or enforced, Clancy and colleagues noted.

Follow-up research published in 2017 indicates that embracing codes of conduct, enforcing consequences for perpetrators and providing protection for targets and bystanders who report an incident could help deter sexual harassment and keep more women in the sciences. Clancy is now working on other studies about sexual harassment in science, including an investigation of the rate of sexual harassment among female undergraduate physics majors.

Other researchers are looking at how atypical work settings can lead to sexual harassment and ways to better inform intervention techniques and bystander training. Reshma Jaggi, director of the Center for Bioethics and Social Sciences in Medicine at the University of Michigan in Ann Arbor, is studying the experiences of people in health care who work odd hours, such as nurses who work the night shift when fewer people are around.

“Efforts like these are essential to developing evidence with which we ground our intervention strategies,” Jaggi says.

One common intervention approach at universities and other institutions is sexual harassment training, though not many studies have tested the effectiveness of such training. An analysis of 15 studies including more than 6,000 college students across the United States found that bystander training — in which people learn how to intervene when witnessing an incident — may be effective, researchers reported online September 27 in the *Journal of Youth and Adolescence*. Although the number of bystander interventions varied widely among students, those who participated in training intervened in two more incidences on average compared with untrained students.

“I think this is an incredibly important moment in history,” Jaggi says. “The #MeToo movement has opened up an incredible awareness that I hope will lead to meaningful change in the sciences.” ■

71
percent
Proportion of female scientists who said they had been sexually harassed during field research

What's next?

By Kate Travis

FUTURE DISCIPLINES are devoted to predicting the future. Trained forecasters use data, trends, human behavior and more to predict what lies ahead.

Exactly no one at *Science News* is a quantitative forecaster or futurist. But we do hear what scientists are buzzing about at meetings, on social media and while reporting stories. So when we asked our writers to predict the big science stories of 2019, each person brought well-informed insights, with a dash of optimism (and sometimes pessimism), to the task. Here's what they had to say.

Mark your calendars

This first set feels a bit like cheating: Some already scheduled happenings will no doubt lead to big findings.

The Parker Solar Probe, which launched in August, will fly close to the sun in April and in September to yield never-before-seen details about our star.

Meanwhile, the Advanced Laser Interferometer Gravitational-Wave Observatory, LIGO, starts its third observing run in February. With upgrades, LIGO may detect many more black hole mergers than it saw in past runs, astronomy writer Lisa Grossman says.

And our moon will get a lot of traffic, she adds. China expects to land the first sample-return mission on the moon since 1976. India will head to the moon's south pole. And the Israeli company SpaceIL will send its own spacecraft.

Grossman and physics writer Emily Conover also put their money on 2019 as the year we finally get a glimpse of a black hole — if the Event Horizon Telescope captures Sagittarius A*, the supermassive black hole at the center of our galaxy.

Here come the data

Climate change will continue to be a big story. As earth and climate writer Carolyn Gramling noted in our top story of 2018 (see Page 18), the last year has

brought studies connecting climate change with extreme events such as Hurricane Florence and Asia's 2016 heat wave. These climate attribution studies will become more common, she predicts.

To slow climate change and limit global warming to 1.5 degrees Celsius over pre-industrial levels will require technology that can remove large amounts of carbon dioxide from the air. "I'm predicting that research on this will kick into high gear," Gramling says. "Or maybe I'm just hoping."

This is us

Bruce Bower, who covers behavioral sciences and human evolution, went meta with his main prediction. "Scientific focus will intensify on what it means to be human, and how evolution produced us," he says. When did the current set of human characteristics emerge? How about the mental capacity of modern people? Did interbreeding with other *Homo* species play a role? "Anthropologists, archaeologists and geneticists will all weigh in," Bower says.

Our brains are one thing that makes us human, and neuroscience writer Laura Sanders predicts that in 2019, scientists will finally figure out the purpose of the claustrum. This paper-thin sheet covers the insular cortex, a brain structure involved in emotional processing. The claustrum was once theorized to be the seat of human consciousness. "This is one of the most mysterious parts of the human brain," Sanders says.

Every year has a flu season, and the most recent, 2017–2018, was harsh, causing 80,000 U.S. deaths and sending some 900,000 people to the hospital. Biomedical writer Aimee Cunningham wonders if we'll see ramped-up production of cell-based vaccines, which are reportedly 20 percent more effective than widely used vaccines grown in chicken eggs.

We hope we're wrong

On to our gloomy predictions. Technology writer Maria Temming predicts that there will be more accidents involving self-driving cars in 2019 — because there will be more self-driving cars on the road



In 2019, data from the Event Horizon Telescope could reveal an image of Sagittarius A*, the supermassive black hole at the center of our galaxy (Milky Way center shown).

from companies such as Waymo and General Motors. New safety standards may or may not require driverless vehicles to have steering wheels, mirrors or pedals. A hands-off setup would make it difficult — or impossible — for a person to take control if something goes wrong.

Life sciences writer Susan Milius worries about the fungus *Batrachochytrium salamandrivorans*, which is attacking salamanders in Europe, spread from Asia via the pet trade. "I dread the morning I turn on my computer and see notification that this newly emerging pathogen has reached North America," which is particularly rich in salamander diversity, she says. "Maybe I will be luckily wrong for another year."

The regulatory balance

Regulatory agencies will keep busy in 2019. Staff writer Laurel Hamers has her eye on per- and polyfluoroalkyl substances, or PFAS, chemicals used in nonstick coatings and firefighting foams that have become persistent contaminants of U.S. water sources (SN: 11/24/18, p. 18). "It's a topic area to watch, both research-wise and regulations-wise," Hamers says.

Regulatory groups have their eye on the gene-editing technology CRISPR/Cas9 as well. In 2018, the European Union set stringent rules on gene-edited crops. Will other countries follow? And what will be the fallout of the explosive announcement that gene-edited babies were born in China (see Page 20)? Molecular biology writer Tina Hesman Saey wants to know. ■

BOOKSHELF

Science News' favorite books of 2018

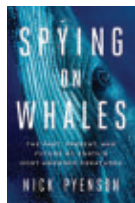
From tales about whales to enthralling scientific histories and the memoir of a frustrated astrophysicist, 2018 was a banner year for science books. Here are *Science News'* picks for the titles that should be on any science lover's bookshelf. Find detailed reviews of many of these books at bit.ly/SN_books2018

**The Truth About Animals**

Lucy Cooke

A zoologist debunks myths about bats, pandas, Adélie penguins and many other misunderstood creatures,

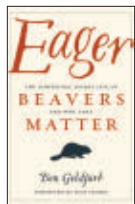
recounting surprising stories from the animal kingdom (SN: 4/14/18, p. 26). Basic Books, \$28

**Spying On Whales**

Nick Pyenson

In this captivating look at whales, a paleontologist dives into the animals' past, exploring how some of Earth's most

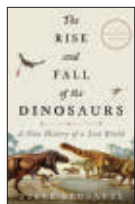
intelligent species came to be, and their uncertain future (SN: 7/7/18, p. 29). Viking, \$27

**Eager**

Ben Goldfarb

Some people see beavers as pests. But a science writer explains how the dam-building rodents are actually vital ecosystem

engineers that can create or expand habitats that benefit the entire wildlife community (SN: 8/4/18, p. 28). Chelsea Green Publishing, \$24.95

**The Rise and Fall of the Dinosaurs**

Steve Brusatte

In this memoir, a paleontologist blends experiences from his career with evolutionary

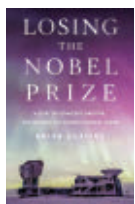
science to take readers on an engrossing journey through time, from the beginnings of the dinosaurs to their ultimate extinction. William Morrow, \$29.99

**The Big Ones**

Lucy Jones

A seismologist examines past catastrophic natural disasters, including volcanic eruptions, earthquakes and floods,

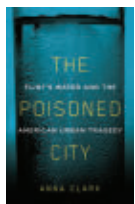
and their impact on culture, politics and society (SN: 3/31/18, p. 26). With the past as a guide, the author warns readers to be prepared for when the next disaster strikes. Doubleday, \$26.95

**Losing the Nobel Prize**

Brian Keating

An astrophysicist's dream of winning a Nobel Prize turned to dust after a promising experiment failed to find

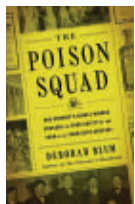
the first definitive evidence of cosmic inflation. The experience revealed how the prize can hamper scientific progress (SN: 4/14/18, p. 27). W.W. Norton & Co., \$27.95

**The Poisoned City**

Anna Clark

Weaving together history, science and reporting, a journalist explores the public health crisis that began in Flint, Mich.,

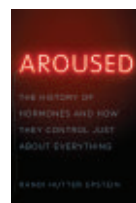
when lead started leaching into residents' drinking water (SN: 7/21/18, p. 28). Metropolitan Books, \$30

**The Poison Squad**

Deborah Blum

A Pulitzer Prize-winning journalist tells the story of a government chemist at the turn of the 20th century and his mission to make food safe in the United States.

Penguin Press, \$28

**Aroused**

Randi Hutter Epstein

The history of endocrinology makes for a strange and fascinating read, from the scientists who

discovered the effects of hormones to the people whose lives have been irrevocably changed by these powerful substances (SN: 7/7/18, p. 28). W.W. Norton & Co., \$26.95

**Nine Pints**

Rose George

Blood, the feared as well as revered substance that flows throughout the human body, has a rich historical and scientific past (SN: 10/27/18, p. 28).

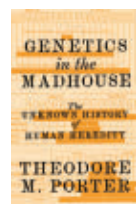
Metropolitan Books, \$30

**She Has Her Mother's Laugh**

Carl Zimmer

This comprehensive history recounts how researchers have come to understand genetic

inheritance. Looking to the future, the author considers risks of gene manipulation (SN: 6/9/18, p. 29). Dutton, \$30

**Genetics in the Madhouse**

Theodore M. Porter

Using archival records, a science historian traces the origins of the study of human heredity to insane asylums in the 1800s (SN: 7/7/18, p. 29). Princeton Univ., \$35

**The Tangled Tree**

David Quammen

In chronicling the lives of researchers who made important advances in molecular biology and genetics, this book shows

how recent findings shake up our understanding of evolution and the tree of life. Simon & Schuster, \$30

The Society's Top 10 moments of 2018



1 Regeneron Science Talent Search
Benjamin “Benjy” Firester of New York City won the top award of \$250,000 in March in Washington, D.C., at the Regeneron Science Talent Search 2018, a competition for high school seniors. He developed a mathematical model that uses disease data to predict how weather patterns could spread spores of the late blight fungus, which caused the Irish Potato Famine.

2 National Leadership Council
In April, Society for Science & the Public unveiled a new National Leadership Council made up of 20 alumni from the Society’s three science competitions. The council will advise the Society on key opportunities to help foster lifelong connections among the alumni community.

3 Advocates
In May, the Society named 50 Advocates — educators and scientists — who will work to find opportunities for underrepresented students to participate in science research competitions, inspiring the students to engage in science, technology, engineering and mathematics, or STEM, fields.

4 Intel International Science and Engineering Fair
Nearly 1,800 young scientists selected from 420 affiliated fairs in 81 countries, regions and territories competed in Pittsburgh in May at the Intel International Science and Engineering Fair 2018 — an international pre-college competition. Oliver Nicholls of Sydney won the first-place prize of \$75,000 for designing and building a prototype of an autonomous robotic window cleaner.

5 STEM Action & Research Grants
The Society was proud to award \$100,000 to 24 middle school science teachers to purchase much-needed equipment and \$30,000 to seven innovative organizations supporting community-based STEM projects through our STEM Action & Research Grants Program.

6 Climate Change Chronicles
In September, *Science News for Students* launched a 10-month series called Climate Change Chronicles. The daily online magazine for middle school students, parents and educators is looking at how climate change is already impacting Earth, the new science behind those changes and what a warmer future may mean for the planet’s species.

7 SN 10: Scientists to Watch
For the fourth year, *Science News* highlighted 10 early- and mid-career scientists who are poised to solve some of the most important questions facing science and society. This year’s SN 10, announced in September, were Shahzeen Attari, Emily Balskus, Ibrahim Cissé, Christopher Hamilton, Paula Jofré, Lisa Manning, Joaquín Rodríguez-López, Anshumali Shrivastava, Douglas Stanford and Jenny Tung.

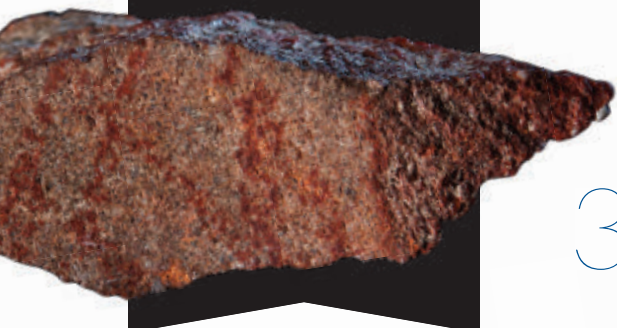
8 Science News in High Schools
Science News in High Schools, a program that provides educators with access to *Science News*, is available in more than 4,300 schools during the 2018–2019 school year. The program supports more than 15,000 educators, with a potential reach of 4.1 million students.

9 Broadcom MASTERS
Georgia Hutchinson of Woodside, Calif., won the \$25,000 Samueli Foundation Prize during the Broadcom MASTERS, a STEM competition for middle school students. She won the award in October in Washington, D.C., for her project on developing more efficient and cost-effective solar panels.

10 New Board Members
Nobel Prize-winning scientist W.E. Moerner (shown above, right), MacArthur Fellow Dianne K. Newman and San Francisco 49ers co-owner Gideon Yu joined the Society’s Board of Trustees in 2018.

Online favorites of 2018

More than 11 million people visited the *Science News* website this year. Check out this recap of the most-read stories of 2018, and the most popular stories published this year on each of our blogs.



Top stories

- 1 **Male birth control pill passes a safety test**
Men who took a prototype once-daily contraceptive pill for about a month saw their testosterone and other reproductive hormones safely plummet to levels known to halt sperm development, a small study found (*SN Online*: 3/21/18).
- 2 **The brain may clean out Alzheimer's plaques during sleep**
A provocative theory that sleep deprivation can cause the brain's garbage disposal to short-circuit, leading to Alzheimer's disease, is getting renewed attention (*SN Online*: 7/15/18).
- 3 **This South African cave stone may bear the world's oldest drawing**
At more than 70,000 years old, red lines crosshatched onto a rock (shown at left) found in a South African cave may be the oldest known drawing, some archaeologists contend (*SN Online*: 9/12/18).
- 4 **What I actually learned about my family after trying 5 DNA ancestry tests**
Interested in unraveling your DNA to learn more about your family history? *Science News* writer Tina Hesman Saey took DNA ancestry tests offered by several consumer genetic testing companies and shared the good, the bad and the confusing (*SN Online*: 6/13/18).
- 5 **Wombats are the only animals whose poop is a cube. Here's how they do it**
The stout marsupials native to Australia can thank their elastic intestines for their distinctive cubelike feces. Wombats' cuboid nuggets mark their territory, but the stackable scat can even be rolled like dice, one scientist found (see Page 4).

Top blog posts

CONTEXT | TOM SIEGFRIED

In honor of his centennial, the Top 10 Feynman quotations

Physicist and Nobel laureate Richard Feynman was a curious character who made many quotable observations on science and life (*SN Online*: 5/11/18).

SCIENCE TICKER | SCIENCE NEWS STAFF

Here's the key ingredient that lets a centipede's bite take down prey

A so-called "spooky toxin" helps tropical centipedes overpower large prey. Insight into how the venom affects lab mice may lead to a treatment for people who receive painful bites from these leggy creatures (*SN Online*: 1/22/18).

GROWTH CURVE | LAURA SANDERS

A new study eases fears of a link between autism and prenatal ultrasounds

The increasing number of ultrasound scans that women receive during pregnancy are not associated with rising rates of autism diagnoses, scientists found (*SN Online*: 2/21/18).

WILD THINGS | SARAH ZIELINSKI

How a deep-sea geology trip led researchers to a doomed octopus nursery

A recently discovered colony of purple octopuses chose the wrong brooding spot on a rocky outcrop. They will probably die because of the warm, low-oxygen water seeping from the rock (*SN Online*: 5/15/18).

SCICURIOSUS | BETHANY BROOKSHIRE

To regulate fecal transplants, FDA has to first answer a serious question: What is poop?

Fecal transplants are promising treatments for some illnesses, but putting effective regulations in place is proving to be a tricky business (*SN Online*: 5/18/18).

SCIENCE & THE PUBLIC | SCIENCE NEWS STAFF

Forget Pi Day. We should be celebrating Tau Day

Replacing the mathematical constant pi with the constant tau could make certain math subjects easier for students to learn (*SN Online*: 3/14/18).

Join the conversation

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Y Yale

YGS Young Global Scholars

Yale Young Global Scholars (YYGS) is a summer academic enrichment and leadership program that brings together students from around the world for two-week sessions on Yale's campus in New Haven. Last year, over 50% of YYGS participants were international, and we admitted students from all 50 U.S. states! View our website for all session offerings, including social science and humanities sessions, and YYGS-Beijing: Asia in the 21st Century, which is administered by Yale Center Beijing and takes place in Beijing, China.



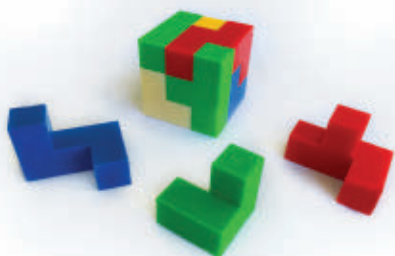
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Here are all of the impact craters known to survive on Earth

When it comes to impact craters, Earth is the pauper of the solar system. Even with a recent, still-to-be-confirmed crater discovery under Greenland's ice (see Page 24), there are fewer than 200 known impact craters on the planet. Mars, for comparison, has hundreds of thousands.

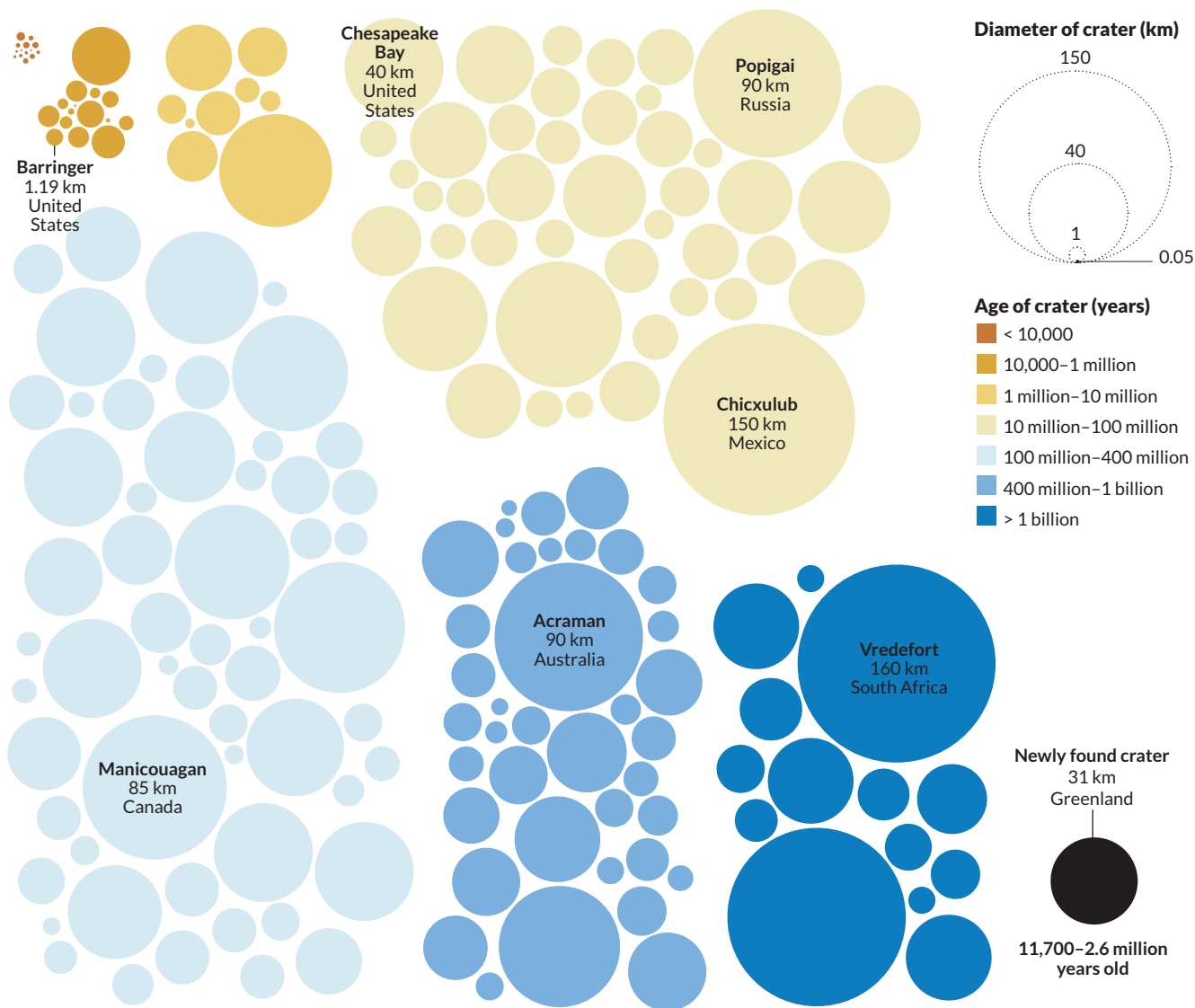
Produced by falling space rocks, most impact craters on Earth have been wiped away over time by wind, rain, shifting ice and the crawl of tectonic plates. The circles below show the rough sizes, from rim to rim, and ages of the 190 confirmed survivors recorded in the Earth Impact Database, maintained by the University of New Brunswick in Canada — plus the ice-covered newcomer.

Studying such features could offer clues about the history of Earth, including the evolution of life itself. Researchers have tried to link various craters to the five known mass extinctions, for example. But only the space rock that cre-

ated Chicxulub, hidden under Mexico's Yucatán Peninsula and the Gulf of Mexico, is widely accepted as causing a major die-off. That space rock left a crater 150 kilometers wide and may have done in the dinosaurs and many other creatures about 66 million years ago (*SN*: 2/4/17, p. 16).

It's too early to put a precise date on the 31-kilometer-wide crater recently found in Greenland. Scientists think it probably formed from 2.6 million to 11,700 years ago, but narrowing down that estimate could be tricky. Like many of Earth's impact craters, the Greenland crater is not exposed at the surface; it's buried under nearly a kilometer of ice. Try drilling through that to get a good sample.

More impact craters may yet be found. A study in 2015 estimated that as many as 350 craters between 0.25 and 6 kilometers in diameter remain undiscovered on Earth (*SN*: 7/25/15, p. 5). — *Emily DeMarco*



» GEOLOGIC ROAD TRIP OF THE MONTH

CATARACT FALLS

Massive amounts of water pour over rocky alcoves at Cataract Falls, the largest waterfall by volume in Indiana. Located about 7 miles southwest of Cloverdale in Owen County, the two-tiered cataract is in one of the most beautiful recreation areas in Indiana and is a remnant of the last ice age in the Martinsville Hills region. As Mill Creek flows under the covered bridge and over Upper Cataract Falls, the gentle valley changes into a picturesque gorge.

The dramatic cascades at Cataract Falls are the result of meltwater erosion on a glacial lake plain. During the Illinoian Stage of glaciation, thick ice sheets flowed from Canada and stagnated north of the recreation site. As the ice melted, large quantities of meltwater flooded the creek and ponded to form Glacial Lake Quincy. An extensive lake plain developed, and fine-grained silt and clay covered about 40 square miles in northeastern Owen, southeastern Putnam, and western Morgan Counties. When the climate cooled and the ice sheet resumed its retreat northward, Glacial Lake Quincy drained and Mill Creek began to cut across the lake plain, eroding the fine-grained lake sediments to reveal two bedrock ridges below.

More than 100 feet of rock strata is exposed in the waterfalls and gorge at Cataract Falls, providing an excellent stratigraphic column of two Middle Mississippian-age formations. Below the remnants of an old dam at Upper Cataract Falls, Mill Creek cascades over thin beds of the Ste. Genevieve Limestone. At low water levels, large chert nodules of the Indian Creek Beds are exposed directly below the dam. After a few small drops in elevation, water flows over thick-bedded oolitic limestone before



Water cascades over the Ste. Genevieve Limestone at Upper Cataract Falls.

plunging about 20 feet over Upper Cataract Falls. The overhang and base of the falls are composed of massive fine-grained calcareous sandstone, which spalls into the plunge pool below. Mill Creek flows about 0.8 mile northwest through the Ste. Genevieve-walled canyon before falling 18 feet at Lower Cataract Falls. The Lost River Chert Bed marks the lip of the U-shaped falls, and the St. Louis Limestone makes up the waterfall base and extensive canyon walls downstream. The contact between the two formations is about 8 feet below the lip of Lower Cataract Falls. Overall, Mill Creek drops more than 80 feet in a 1-mile span. You can explore the canyon and falls on an easy 0.8-mile trail that connects the observation deck at Upper Cataract Falls to Lower Cataract Falls on the western side of Mill Creek.



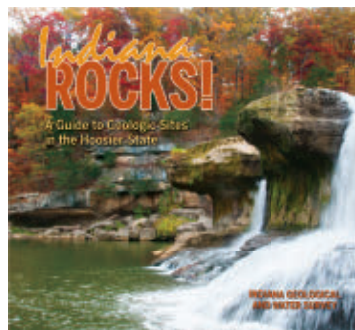
Below Lower Cataract Falls, Mill Creek intersects a preglacial valley, and there is a noticeable widening of the valley. From here, the creek flows northwest to Cagles Mill Lake within the Lieber State Recreation Area.
—Courtesy of Steven Higgs, Natural Bloomington

EXCERPT FROM

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