Bones From Rosetta Stone Revolt | The Closest Look Yet at the Sun

ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ DECEMBER 21, 2019 & JANUARY 4, 2020

Robert Wood Johnson Foundation

Health is Where We Live, Learn, Work, and Play

Health is much more than simply not being sick. It is shaped by every aspect of our lives. But for too many of us, the prospects for good health are limited by where we live, how much money we make, or discrimination we face.

We all benefit when everyone has an honest chance at access to living-wage jobs, fair pay, good schools, affordable housing, safe neighborhoods, and quality medical care. This is health equity—when we all have the basics to live a healthier life.

That is why it is so important to create communities where people and organizations from all walks of life can work together to build a Culture of Health that helps everyone get and stay healthier.

Seeking Innovators From Every Field to Boost Health and Equity

Building a Culture of Health that benefits everyone is like assembling a quilt. It requires many hands working together. No individual, organization, or government program can alter the course of America's health alone. We must all work together.

Sometimes that means stepping out of your comfort zone and partnering with communities, individuals, or groups that you have not worked beside before. It also means broadening your perspectives regarding health, learning from one another, and finding effective ways to collaborate with others.

At RWJF, we focus on four broad areas of well-being:

- Making sure every child in America has the opportunity to grow up as healthy as possible—socially, emotionally, and physically.
- Strengthening the ways in which community health systems work together to meet the needs of the people they serve.
- Helping all communities be as healthy as possible by creating strong collaborations.
- Developing a wide network of diverse leaders dedicated to driving positive change together.

At RWJF, we want to highlight—and learn from—the growing number of bright spots in communities across the country, creating conditions for healthier living.

Our goal is to help families and communities find ways to make the healthy choice the easy choice, and keep well-being front and center for generations to come.

Learn more at **www.rwjf.org**.
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ScienceNews

2019 Year in Review

20 TOP 10 STORIES: The first-ever picture of a black hole was the easy top pick, followed by stories on new and reemerging health risks, a wake-up call on climate change, a claim of quantum supremacy and more.

PLUS: New views of asteroids, exoplanets and Mars; fossils that reveal faces, tumors, tricked-out toes and other treasures; discoveries that are big if true; and our writers' watch list for 2020

News

Departments

COVER Biodiversity losses, measles outbreaks and CRISPR in patient studies are some of this year's biggest stories. *Gwen Keraval*

FROM TOP: EVENT HORIZON TELESCOPE COLLABORATION; IBM RESEARCH; RILEY GRAHAM

Our take on this year's big science newsmakers

Readers often tell us that they prize the magazine for keeping them up to speed on science in the broadest sense. We work hard to meet that expectation, with reporters reading scientific journals, traveling to scope out presentations and poster sessions at key research meetings, and talking with many, many scientists to find out what's new and what's next.

In the daily swirl of news, it's easy to lose sight of what we build in a year — a body of work including almost 1,000 original articles, plus columns, reviews, data visualizations, original photography and illustrations, all created to explain the scientific enterprise and provide context on its impact. So it's a pleasure to be able to pause, look back and consider the signal achievements and events of 2019 for this special issue.

This time around, we quickly agreed that the Event Horizon Telescope team's first-ever image of a black hole was the most significant advance of the year (Page 20). It was also among the most delightful; who wouldn't want to glimpse one of these mysterious beasts? And we weren't alone in our fascination. Our stories about the April 10 unveiling of that image generated the most traffic ever in a single day to our website. And our work was honored with a Folio "Eddie" award and as a finalist in breaking news coverage by the Online News Association.

Our year-end review also includes a look at "interesting if true" news — findings that generated a lot of buzz but are not yet a sure thing. I would love to learn that I can detect magnetic fields just like migratory birds do (Page 36), but I'm not ready to relinquish Google Maps. Then there's our perennially popular roundup of great science books of the year (Page 38). And our reporters give us a peek into their notebooks to see what trends they'll be watching in 2020 (Page 37). Another black hole image? Bring it on.

As always, we provide a concise, accurate and lively update on the news, including the first reports from the Parker Solar Probe's pioneering mission to the sun, and a study finding that DNA screening probably won't work if your goal is to have taller, smarter "designer babies."

We'll take a break in publishing the magazine over the holidays, but you can always stay up to date online at sciencenews.org. One of our big achievements of 2019 was rebuilding the *Science News* and *Science News for Students* websites. They are now much faster and easier to use, whether you're reading on a desktop computer, a tablet or your phone. They also make the most of visual storytelling, such as this issue's mesmerizing "fingerprints" that whiskey leaves behind (Page 44), and the videos of associate digital editor Helen Thompson. One of my favorites shows wee insect larvae leaping 36 times their body length, set to "Also sprach Zarathustra." I guarantee that will put a smile on your face.

Thank you for making it possible for us to do our work; subscriptions are a key source of funding for our nonprofit enterprise, and we put every dollar to good use. We look forward to exploring the next year in science together.
— Nancy Shute, Editor in Chief

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SSP

Excerpt from the December 20, 1969 issue of *Science News*

50 YEARS AGO

Seeking the places where the elements are made

One of the outstanding questions in astrophysics is whether all [variants of naturally occurring elements] have been present from the beginning of the universe.... If the nuclear manufacture was not accomplished in some big bang ... then it must take place in smaller cataclysms.... A good candidate ... is an exploding star, or supernova.

UPDATE: The Big Bang created the universe's lighter elements, including the hydrogen and helium that formed the first stars. Nuclear fusion within stars creates heavier elements up to about iron, which are spewed out when these stars explode as supernovas. The merging of two neutron stars, first witnessed from Earth in 2017, revealed that many variants of elements heavier than iron are made in such smashups (*SN: 11/11/17, p. 6*). There may be other sources, too. Some physicists think certain rare, fast-spinning supernovas may be powerful enough (*SN: 6/8/19, p. 10*).

Camera traps snapped photographic evidence that silver-backed chevrotains, which were feared to be extinct, still live in Vietnam.

THE SCIENCE LIFE

Silver-backed chevrotains have been 'rediscovered'

Amid the dry, thorny underbrush of a coastal Vietnamese forest, a silver-backed chevrotain stepped into view of a camera trap — and back into the scientific record after almost three decades.

No bigger than a toy poodle, the deerlike ungulate had only ever been studied from three dead specimens obtained from the region in 1907 and a fourth in 1990. Scientists feared the animal might have gone extinct due to hunting and habitat loss.

But local residents knew better, and in late 2017 directed researchers to forest areas where the silver-backed chevrotain (*Tragulus versicolor*) might be living. Cameras triggered by motion or heat then snapped the first photographic evidence that the elusive animal still exists, researchers reported November 11 in *Nature Ecology & Evolution*.

"We were really excited" by the find, says An Nguyen, a biologist at the Leibniz Institute for Zoo and Wildlife Research in Berlin. The region's forests are home to many mammals found nowhere else, but an increase in animal snares and encroaching human development in recent decades have threatened that diversity.

"Indiscriminate snaring has taken a tremendous toll on mammal communities across Vietnam," says Andrew Tilker, a biologist at the Leibniz Institute. Snaring has left "a lot more forest than animals to inhabit [that forest] in Vietnam," he says.

But a species lost to science is not necessarily extinct. In late 2017, the researchers asked people in towns and villages near the southeast city of Nha Trang about the animal: "Had they seen chevrotains with silver backs? How many? Where?" Nguyen recalls. People referred to the silver-backed chevrotain and its more common cousin, the lesser chevrotain (*T. kanchil*), by the same name, "cheo cheo." Still, many people reported seeing the distinctive silver-haired animal.

The team set up cameras at three spots in the forest where silver-backed chevrotains had been seen. When the researchers collected the cameras five months later, they had their first images of the animal.

After adding dozens more camera traps, the team ended up with a total of 1,881 images that documented 208 separate daytime visits, mostly by one chevrotain but sometimes by pairs. It's unclear how many individuals were photographed, or whether they are part of a larger population.

The villagers weren't surprised that the animals had been spotted. "They see them all the time," Nguyen says, though everyone interviewed said the animals' numbers have declined in recent years.

The research "emphasizes the critical value of integrating local ecological knowledge into biodiversity conservation efforts," says Patricia Fifita, an environmental anthropologist at the University of Hawaii at Manoa who was not involved in the study.

Tilker agrees that the villagers' help was crucial to the researchers' success. "Local people often have a vast reservoir of ecological knowledge," he says.

Without more research, the future of the silver-backed chevrotain is unclear. If the species exists only in this part of Vietnam, it could be highly threatened, Tilker says. "Right now it's just a question mark."

— *Jonathan Lambert*

SOUTHERN INST. OF ECOLOGY, GLOBAL WILDLIFE CONSERVATION, LEIBNIZ INST. FOR ZOO AND WILDLIFE RESEARCH, NCNP

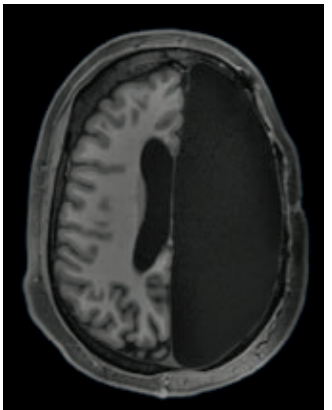
REINTRODUCING

Arrokoth, aka Ultima Thule

The solar system body called Ultima Thule, visited in January 2019 by NASA's New Horizons mission, has a new name: Arrokoth.

The word means "sky" in the language of the Powhatan, a Native American tribe indigenous to Maryland. The state is home to New Horizons mission control at the Johns Hopkins University Applied Physics Lab in Laurel. NASA announced the new name November 12, with the consent of Powhatan tribal elders and the International Astronomical Union.

Arrokoth (pronounced AR-uh-koth), a two-lobed body in the Kuiper Belt (see Page 32), has been through a few names already. Its official designation had been 2014 MU69. In March 2018, the New Horizons team nicknamed it Ultima Thule, a Latin phrase that signifies a place beyond the known world. But that moniker was criticized because it had been used by the Nazis as the name of the mythical homeland of the Aryan race. With Arrokoth, "we wanted to honor Maryland as our mission epicenter," says Alan Stern, mission head and a planetary scientist at the Southwest Research Institute in Boulder, Colo. — *Christopher Crockett*



In some people with half a brain (seen in this MRI image), certain neural links appear to be stronger than links in people with a whole brain.

RETHINK

Partial brains have strong neural links

Half of a brain can do a full-time job.

Scientists studied six adults who, as children, had half their brains removed to treat epilepsy. Despite the surgery's severity, many such people keep or recover language and thinking skills. In a new study in the Nov. 19 *Cell Reports*, researchers at Caltech and their colleagues found one way brains may compensate and bounce back.

As the six participants rested in an MRI scanner, the researchers measured blood flow in seven brain regions that handle jobs such as vision, attention and movement. Blood flow served as a proxy for brain activity. When activity in one brain region changes in lockstep with another, it implies that the regions are working together and sharing information.

In all six participants, the seven brain systems seemed to be working normally, and connections were even stronger than in six people with whole brains. Having stronger-than-normal links might help explain how postsurgery brains compensate for missing parts, the researchers suspect. Understanding how the brain reorganizes itself after a big change could lead to new approaches to speed recovery from common brain injuries. — *Laura Sanders*

FROM TOP: CALTECH BRAIN IMAGING CENTER; IBM RESEARCH

TEASER

AI sleuths out a new Nazca line in Peru

Artificial intelligence is putting on its Indiana Jones hat.

An AI trained to recognize Nazca lines, ancient designs in the desert plains of Peru, has discovered a new geoglyph etched into the earth: a faint humanoid figure a few meters across.

The figure joins a collection of over 2,700 known Nazca lines, depicting animals, plants, fantastical beings and geometric patterns. These glyphs can be difficult to spot, as they're often obscured by roads and other landscape markings. Having AI scour large sets of aerial photos, maps and other data could uncover more glyphs that archaeologists have overlooked.

Using AI that searches satellite and drone images, scientists uncovered a previously unknown Nazca line depicting a humanoid figure in Peru (top, with a sketch overlaid in the bottom photograph).

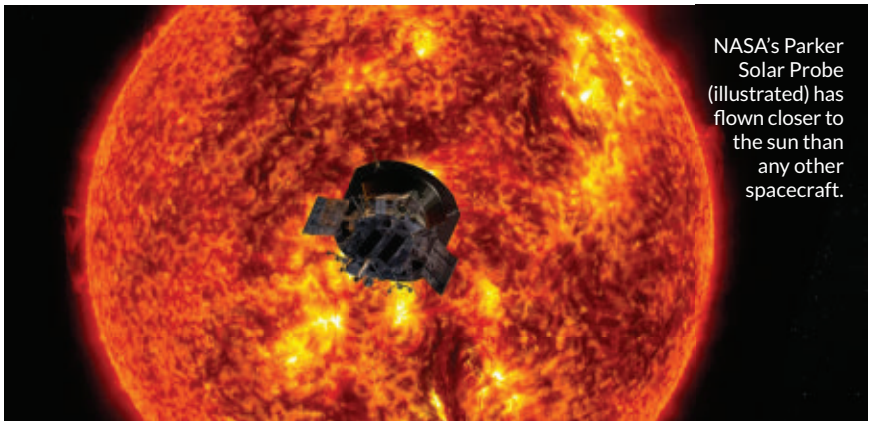
Researchers at IBM and Yamagata University in Japan taught an AI to recognize Nazca lines by showing it drone and satellite images of known glyphs. The AI identified over 500 possible new geoglyphs over a five-kilometer stretch of terrain. Aerial images and in-person visits to the site confirmed the presence of the humanoid figure, which is near a well-known hummingbird-like Nazca design (*SN: 8/3/19, p. 7*).

Previously, the Yamagata researchers had found over 100 other glyphs using aerial images and fieldwork, the team said November 15 in a news release. Expanding the database of Nazca lines may offer new insight into why people created these markings thousands of years ago (*SN: 1/12/13, p. 9*), and how to best preserve them. — *Maria Temming*

ATOM & COSMOS

Parker probe reveals solar surprises

NASA spacecraft reports back from its first trips to the sun



NASA's Parker Solar Probe (illustrated) has flown closer to the sun than any other spacecraft.

BY CHRISTOPHER CROCKETT

Rogue plasma waves. Kinked magnetic fields. Showers of charged particles. These are just some of the things NASA's Parker Solar Probe witnessed during its first two close encounters with the sun.

Parker is on a nearly seven-year mission to repeatedly soar near the sun and gather intel (*SN: 7/21/18, p. 12*). By flying the craft through the plasma emanating from the sun, researchers hope to solve such puzzles as why the sun's atmosphere is millions of degrees Celsius hotter than its surface and what powers the solar wind, the stream of charged particles that blows through the solar system.

Scientists aren't ready to answer those questions. But data from the probe's first two orbits, published online December 4 in four papers in *Nature*, offer a peek at what's to come as Parker moves closer to the sun over the next several years.

"We're exploring a brand-new region," says mission scientist Russell Howard, a solar physicist at the U.S. Naval Research Laboratory in Washington, D.C. "Questions we would have formulated a year ago are just going to be blown away by the things that we're actually seeing."

Launched in 2018, Parker is currently on an elliptical orbit that brings it near the sun about every five months. With its latest rendezvous September 1, the probe has now completed three trips. Each time, Parker flew within about 24 million kilometers of the sun's surface — about twice as close as Mercury ever gets.

Parker is already serving up plenty of surprises from its first two trips. For example, Parker got whacked by intense waves of plasma. Every so often, the speed of the plasma flowing away from the sun would jump by nearly 500,000 kilometers per hour — nearly doubling in speed — for up to a couple of minutes.

Each of these rogue waves was accompanied by a sudden reversal of the magnetic field around the probe. Scientists think they are seeing S-shaped ripples in the magnetic field, as if something near the sun's surface grabbed a magnetic field line and snapped it like a whip.

Astrophysicist Yannis Zouganelis of the European Space Astronomy Centre in Madrid, who is not involved with the mission, says he is not surprised by the ripples. The sun's magnetic field jiggles in response to fluid churning in the sun, he says. "What is surprising is that we see them very frequently and very strong."

During the first encounter alone, Parker saw about 800 plasma waves over 11 days. "That's a very concrete thing we can try to connect to," says mission scientist Justin Kasper, a physicist at the University of Michigan in Ann Arbor. "What is the sun giving off 800 times in 11 days?"

Plasma at Parker's distance above the sun also whips around faster than expected. Scientists expected to clock lateral speeds of a few kilometers per second as the escaping plasma gets twirled into space by the sun's rotation. Instead, speeds were as high as 50 km/s.

Those high speeds might force a rethink of how the sun, and all stars, evolve. As stellar winds spiral away, they carry rotational energy from the star, gradually putting the brakes on rotation. A faster wind spiral may mean stars spin down faster than thought, Kasper says.

"This is really amazing, if true," says Zouganelis, who cautions that these data need to be confirmed at lower altitudes.

While Parker was busy raising questions, it also may have solved a mystery: the origin of the "slow" solar wind. The flood of particles from the sun is a blend of two flows, one moving as much as twice as fast as the other. Scientists knew the fast component originates near the sun's poles through funnellike openings in the magnetic field known as coronal holes. Now, Parker's data suggest that the slow wind flows from small coronal holes near the sun's equator.

The spacecraft also recorded small bursts of energetic particles, mostly protons, coming from the sun. These might provide the seeds for more voluminous particle tsunamis sometimes carried aloft as part of the solar wind, says mission scientist David McComas, a solar physicist at Princeton University. These smaller bursts were not seen by other spacecraft orbiting farther out.

"We know that energetic particles come from the sun, but we seem to be seeing many more near the sun," says Philippa Browning, a solar physicist at the University of Manchester in England who is not involved with the mission. "Particle acceleration might be much more common than perhaps we thought."

On each of Parker's next 18 orbits, the probe will inch a little closer to the sun. Then in its last three orbits, starting in 2024, Parker will fly within just 6 million kilometers of the sun's surface. ■

JHUAPL, NASA

GENES & CELLS

‘Designer baby’ tests don’t deliver

DNA doesn’t reliably predict complex traits in offspring

BY TINA HESMAN SAEY

Picking embryos based on genetics might not give prospective parents the “designer baby” they’re after.

DNA predictions of height or IQ might help would-be parents select an embryo that would grow into a child who is, at most, only about three centimeters taller or about three IQ points smarter than an average embryo from the couple, scientists report in the Nov. 27 *Cell*. Offspring predicted by their DNA to be the tallest among siblings were actually the tallest in only seven of 28 real families.

Even if it were ethical to select embryos based on genetic propensity for height or intelligence, “the impact of doing so is likely to be modest — so modest that it’s not likely to be practically worth it,” says Amit Khera, a physician and geneticist at the Center for Genomics Medicine at Massachusetts General Hospital in Boston who was not involved in the study.

For years, couples have used genetic diagnosis to screen out embryos carrying a disease-causing DNA variant. The procedure, called preimplantation genetic diagnosis, involves creating embryos through in vitro fertilization. Clinic staff remove a single cell from the embryo and test for variants in single genes that cause cystic fibrosis, Tay-Sachs or other life-threatening diseases.

But many diseases such as diabetes and heart disease, as well as traits like height and intelligence, are caused in part by tiny effects of variants in hundreds or thousands of genes. Scientists can boil down these effects into one “polygenic” score. Khera was involved, for example, in compiling 6 million genetic variants into a risk score for a heart attack.

Advances in this area have sparked debate about whether people should be allowed to use polygenic scores to select embryos. Some people say that selecting for “enhancements” or other nonmedical traits smacks of eugenics, the practice of breeding humans toward some desired outcome. The term is often associated with racism, genocide and forced sterilization campaigns. The study’s findings bring a dose of reality to the discussions.

“We wanted to use these numbers or these methods to make the debate more quantitative, more evidence-based,” says Shai Carmi, a statistical geneticist at the Hebrew University of Jerusalem.

Carmi and colleagues used genetic data, originally collected for studies of longevity and schizophrenia, to look at what might happen in embryo selection. Some people in the longevity study were real-world spouses, so the researchers simulated genetic profiles for the couples’ hypothetical offspring. The researchers also created virtual couples by pairing unrelated people and simulating the genetic makeup of their embryos. Polygenic scores predicting height or IQ were then calculated for the embryos.

Among 10 embryos, the one that the genetic scores suggested would be tallest was predicted to be only three centimeters taller than the average height predicted for all 10 embryos. And the highest intelligence polygenic score predicted the resulting child would be three IQ points smarter than the average for all 10 embryos. With only five embryos to choose from (more realistic based on numbers of embryos generated in fertility studies), the gains drop to about 2.5 centimeters and 2.5 IQ points.

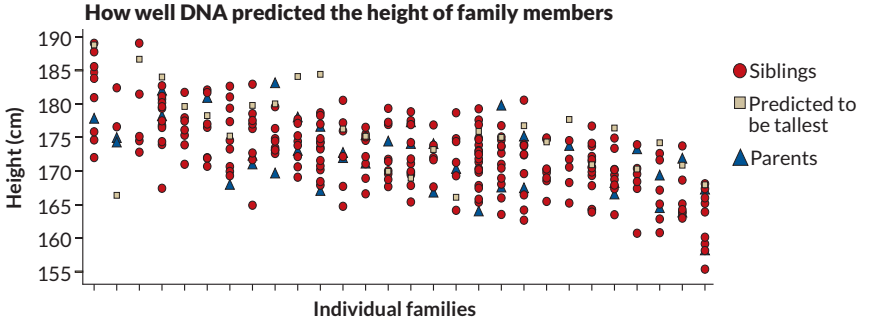
Carmi and colleagues also looked at 28 real families, each with up to 20 adult children. In those large families, the child predicted by genetic score to be the tallest was actually the tallest in a quarter of the families. In fact, the child predicted to be the tallest was actually about three centimeters shorter on average than the family’s tallest child.

The study “does add more data,” says Susanne Haga, a human geneticist at Duke University School of Medicine. There’s too much variability in these complex traits to accurately predict an outcome just by looking at DNA. “There’s still a great deal of variability that’s not accounted for by the genes they were analyzing or simulating in their polygenic score. Therefore, you’re still going to see a wide distribution of height or IQ points.”

Differences in diet, lifestyle, exposure to pollution, culture, undiscovered genetic variants and other unknown factors can also influence how complex traits develop, Haga says. “We still have a ways to go to understand the genetic mechanisms behind these traits, and the fact that the environment plays such a critical role cannot be discounted.”

Human geneticist Nicholas Katsanis of the Ann & Robert H. Lurie Children’s Hospital of Chicago worries the study’s findings could be misunderstood or misrepresented to promote embryo selection for nonmedical traits. “The fundamental question should not be asked in the first place, because the idea that we’re going to do genetic screening for anything other than medically actionable items is the definition of eugenics,” Katsanis says. “That we’re even contemplating this is disturbing.” ■

Measuring up Scientists compiled genetic scores that predicted the height of each member of 28 large families (each column is one family). In adulthood, children whose DNA predicted they’d be tallest (beige squares) often were several centimeters shorter than one or more sibling (red circles).



E. KARAVANI *ET AL*/*CELL* 2019

HUMANS & SOCIETY

Mummies' tattoos come to light

Infrared imagery reveals body markings on ancient Egyptians

BY BRUCE BOWER

Modern technology is illuminating tattoos on mummified ancient Egyptians that until now had gone unnoticed.

Infrared photography helped identify tattoos on seven mummified individuals dating to at least 3,000 years ago at a site called Deir el-Medina, archaeologist Anne Austin of the University of Missouri–St. Louis reported November 22 at the annual meeting of the American Schools of Oriental Research.

Previously, tattoos had been found on only six mummies — five female and one male — in over more than a century of research at ancient Egyptian sites. But infrared photos, which capture wavelengths of light invisible to the naked eye, are transforming what's known about tattooing in ancient Egypt, Austin said.

"It's quite magical to be working in an ancient tomb and suddenly see tattoos on a mummified person using infrared photography," said Austin, who participated in the research while working at the French Institute of Oriental Archaeology in Cairo.

Tattoo design and placement vary greatly on the 13 known Egyptian mummies with tattoos.

A female found in 1891 bore the first known ancient Egyptian tattoo. More recently, archaeologist Renée Friedman of the University of Oxford used infrared imaging to reveal tattoos on a male and a female mummy at the British Museum in London. Those two people lived in Egypt shortly before the rise of the first pharaoh, about 5,100 years ago.

Only tattooed females have been identified at Deir el-Medina. Discoveries there challenge an old idea that tattoos on women connoted fertility or sexuality. Deir el-Medina tattoos appear to be more closely associated with women's roles as healers or priestesses, Austin said.

In the most striking case, infrared photos revealed at least 30 tattoos on various parts of a female mummy. Cross-shaped patterns on her arms don't occur on any of the other dozen tattooed mummies, Austin said. Several other of the mummy's tattoos look like hieroglyphs used in ancient Egyptian writing. The extent and range of the woman's body markings suggest that she may have been a religious practitioner of some kind, Austin speculated.

Another Deir el-Medina woman had a neck tattoo depicting a human eye — an ancient Egyptian symbol associated with protection — as well as tattoos of a seated baboon on each side of her neck.

Finding tattoos on additional mummies from Egypt may help clarify how these markings were used. "Everything about the new tattoo discoveries is surprising because so little is known about this ancient Egyptian practice," said Egyptologist Kerry Muhlestein of Brigham Young University in Provo, Utah. ■

MEETING NOTES

Ancient bones linked to Rosetta Stone revolt

Excavated remains of a warrior slain about 2,200 years ago provide physical evidence of an uprising described on the Rosetta Stone. "Most likely, the warrior we found was a casualty of the ancient Egyptian revolt," archaeologist Robert Littman said November 22.

A team led by Littman, of the University of Hawaii at Manoa, and anthropological archaeologist Jay Silverstein of the University of Tyumen in Russia unearthed the man's skeleton at the ancient city of Thmouis in the Nile Delta.

The Rosetta Stone, carved in 196 B.C., is famous for bearing an official message in three scripts, including one in ancient Greek that enabled scholars to decipher Egyptian hieroglyphs. That message describes a military victory of Ptolemy V, a pharaoh from a Greek dynasty, against a native Egyptian revolt that lasted from about 206 to 186. Thmouis was in a region where battles in that revolt occurred.

The warrior's body had been thrown on the ground and covered with dirt soon after death, with no sign of a burial. Healed and unhealed injuries likely resulted from combat years earlier as well as near the time of death, Littman said. Near the skeleton, researchers found a burned arrowhead and ballista balls, stones that were hurled by catapults.

Littman suspects the warrior died at the time of the revolt. Coins excavated just above his remains date to between 180 and 170. Coins found just below the man date to 205 or earlier. It's unclear whether Thmouis residents sided with the rebels or the pharaoh, Littman said. — *Bruce Bower*

Rock from Jordan may be oldest known chess piece

A palm-sized, rectangular sandstone object at an Early Islamic trading outpost in what's now southern Jordan appears to be the oldest known chess piece.

The roughly 1,300-year-old piece of rock with two horn-like projections on top resembles rooks, or castles, found at other Islamic sites in the region. But those other rooks are a century or more younger, archaeologist John Oleson of the University of Victoria in Canada said November 21.

Written accounts indicate that chess originated in India at least 1,400 years ago, Oleson said. Merchants and diplomats probably carried the game westward. The suspected chess piece, excavated at Humayma, located on what was once a major trade route, dates to between 680 and 749.

Rooks from southwestern Asia in the shape of two-horse chariots date to as early as the late 700s. The two-pronged shape of Early Islamic rooks may have been meant to represent such chariots, Oleson said. — *Bruce Bower*

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BODY & BRAIN

Stents aren't always necessary

Some heart patients can be treated with medications alone

BY AIMEE CUNNINGHAM

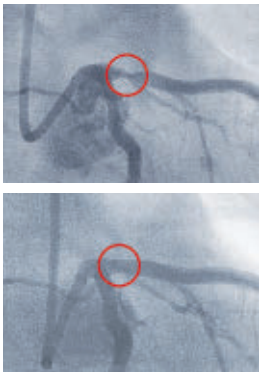
In their heyday, stents and bypass surgery were the go-to treatment for patients newly diagnosed with heart disease. That began to change about a decade ago, after data emerged suggesting these procedures were no better than medications alone for patients whose heart-related symptoms weren't considered an emergency. Now a large study has tipped the scales further, reporting that statins, aspirin and other drugs together protect these patients just as well as stents or bypass surgery against heart attacks and death.

The key to managing patients who have stable ischemic heart disease "is medicines, medicines, medicines," says Michael Gavin, a cardiologist at Beth Israel Deaconess Medical Center in Boston who was not involved in the study. "That's what's going to stop you from having a heart attack."

Going the medications route requires that patients stay committed. That means seeing the doctor regularly, keeping up with medications and exercise, and eating a healthy diet. "You can't say, 'I don't want the stent,' and then not do all those things, and get a good result," says cardiologist Gina Lundberg of Emory University School of Medicine in Atlanta, who also was not involved in the study.

The federally funded study, called ISCHEMIA, is the largest clinical trial to examine whether drugs alone reduce death or heart attacks in a certain group of patients. These patients have heart disease primarily due to coronary arteries narrowed by plaque, but with pain or other symptoms that are manageable. Some participants received just medications during the trial. Others took drugs and had either a stent placed in an artery to keep it open or bypass surgery to divert blood flow around a blockage. Both procedures have risks, such as bleeding or the formation of blood clots that can block an artery again.

The study measured how well patients did in terms of heart attacks, hospitalization for worsening heart health or death. Drugs alone produced similar results to invasive procedures plus drugs in terms of rates of death during the study period and the chance of a heart attack. The results, unveiled November 16 in Dallas at the American Heart Association scientific sessions, reinforce the findings of two trials from about a decade ago, but extend them to patients with stable symptoms but with moderate to extensive coronary disease.



In a coronary angioplasty, doctors insert a balloon at the tip of a catheter into a blocked artery (top X-ray) to open the vessel (bottom).

When it came to quality of life, patients who had an invasive procedure plus drugs reported more symptom improvements in the first year following the procedure than those on drugs alone. The difference was most pronounced for someone with daily or weekly chest pain: While 20 percent on drugs alone were pain-free after a year, that was true for 50 percent who'd had drugs plus an invasive procedure, says Judith Hochman, a cardiologist at the New York University Grossman School of Medicine and one of the lead researchers of the trial.

"What patients care about really is, 'Is this treatment going to make me live longer or feel better? Preferably both,'" Hochman says. For the invasive treatment, "we didn't see that it would prolong life over the time period we studied, about five years." But for those who had chest pain, called angina, at the start of the study, the invasive strategy plus medications was superior, she says.

That makes sense, Gavin says, because there tends to be a connection between pain and artery blockage. "If you fix that blockage, symptoms more than likely will get better," he says. But "the area that's going to cause the heart attack is just as likely to be hiding out somewhere else within your coronary arteries as it is to occur where the stent is.... The medicines are what's going to treat everything."

The study included nearly 5,200 participants in 37 countries with moderate to extensive coronary artery disease. That could mean patients had narrowing or blockages in any or even all of the three major arteries that supply blood to the heart. These patients experienced chest pain only when the heart had to work harder. The results do not apply to people who have chest pain at rest or while sleeping, or chest pain that arises suddenly or with very little exertion. Patients with this unstable ischemic heart disease are in immediate danger of a heart attack and need invasive treatment.

Women made up only 23 percent of study participants. "We definitely have to put an asterisk by the information as it applies to women," says Lundberg. "I wouldn't say the study doesn't count; it just might not be the final answer."

Heart disease can look different in men and women. Artery plaques — made of cholesterol, cells and other substances — tend to rupture in men, causing a blockage at the site that can lead to a heart attack. In women, plaques contribute to heart attacks in a few different ways, such as through erosion, in which small pieces of plaque break off and flow away, producing clots farther down the vessel. Women are more likely than men to have heart disease that doesn't arise from a blockage at all but from a condition called microvascular dysfunction, in which the small blood vessels that feed the heart don't function properly.

Treatment for stable heart disease has been moving toward medications alone in the United States. The new work will continue the push in that direction, Gavin says. "It's a nice trial to have when talking to patients in terms of reassuring them" about pursuing medical therapy alone. ■

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TEXAS TECH UNIVERSITY

DANNY REIBLE WAS UNANIMOUSLY SELECTED AS THE 2020 RECIPIENT OF THE GORDON MASKEW FAIR AWARD

Texas Tech University's Danny Reible, the Donovan Maddox Distinguished Engineering Chair, Horn Professor and professor of civil, environmental and construction engineering and chemical engineering in the Edward E. Whitacre Jr. College of Engineering, was unanimously selected as the 2020 recipient of the Gordon Maskew Fair Award from the American Academy of Environmental Engineers and Scientists® (AAEES).

"I'm highly appreciative and highly honored to receive the Gordon Maskew Fair Award, especially given the fact that many of the past recipients have been colleagues who I admire and respect. I'm happy to join their ranks."

INFLUENCE INNOVATION INSPIRATION **IMPACT**

DANNY REIBLE
Donovan Maddox Distinguished Engineering Chair, Horn Professor, Professor of Chemical Engineering, Professor of Civil, Environmental, and Construction Engineering

ATOM & COSMOS

Neutrinos linked to cosmic puzzle

Study hints the particles could explain why matter abounds

BY EMILY CONOVER

Neutrinos could help answer a really big question: why anything exists at all.

A new result reaffirms earlier hints that the tiny subatomic particles behave differently than their antimatter counterparts, antineutrinos, physicists with the neutrino experiment T2K report. If confirmed, the particles' divergence could help reveal how the universe avoided becoming an empty wasteland.

T2K scientists declined to comment on the results, described in a paper posted online October 9 at arXiv.org, as the work had not yet been peer reviewed.

In the newborn cosmos, matter and antimatter existed in equal measure. Since matter and antimatter destroy each other when they get together, that should have left the cosmos filled with nothing but energy. Yet today, matter is abundant while antimatter is much less common.

Each type of matter particle has an antimatter mirror image with the opposite electric charge. Typically, matter and antimatter behave similarly, but the two can sometimes diverge, an effect known as a CP violation (for "charge parity"). If neutrinos violate CP today, theories suggest, the universe's first moments might have been beset by an additional source of CP violation that would explain how matter prevailed.

T2K researchers sent beams of neutrinos or antineutrinos on a nearly 300-kilometer trek across Japan to an underground detector at the Kamioka Observatory in Hida. There was reason for the long journey: As they travel, neutrinos can oscillate, morphing between three particle types — electron neutrinos, muon neutrinos and tau neutrinos. The same goes for antineutrinos.

T2K's beams initially consist of muon neutrinos or muon antineutrinos. The researchers counted how often the particles converted into electron neutrinos or electron antineutrinos. Collected over nearly a decade, the data suggest that neutrinos oscillated more than expected, while antineutrinos oscillated less than expected — a sign of CP violation.

The result continues a "slow buildup" of evidence for CP violation in neutrinos, says neutrino physicist Jonathan Link of Virginia Tech in Blacksburg. Previous T2K results showed signs of CP violation (*SN: 9/2/17, p. 15*). The new results constrain the amount of CP violation better than ever before, though scientists still can't say whether CP violation occurs. ■

MATH & TECHNOLOGY

Data of the future may ride light waves

Tiny switches offer a path toward more efficient electronics

BY MARIA TEMMING

Microscopic switches that route light signals between computer chips like tiny traffic conductors could help make faster, more efficient electronics.

Light can carry information more easily than the electric current used in traditional circuitry, because light zips through materials without interacting with its surroundings as much as electrons do. But mechanical switches designed to manipulate data-carrying light waves have run slowly and required impractically high electric voltages.

Now, newly designed switches redirect light in less than a millionth of a second using just about one volt of electricity — comparable to what this kind of switch would need to work in ordinary electronics, researchers report in the Nov. 15 *Science*.

Each switch comprises an ultrathin gold disk suspended above a silicon plate. Applying a small voltage across the switch forces the disk to curve upward or bow downward. The disk's orientation controls whether light flowing through a nearby wirelike structure called a waveguide continues uninterrupted or gets rerouted to another waveguide.

Many interconnected switches choreographing the travel of various light signals between different electronic components could allow a computer to perform sophisticated operations.

The switches redirect light in tens of nanoseconds, compared with the microseconds-long switching times of similar devices. Such high speeds are possible because the gold disk is more lightweight and easier to manipulate than the bulky components in other light switches, says study coauthor Christian Haffner, a nanophotonics researcher at the National Institute of Standards and Technology in Gaithersburg, Md. "It's like [driving] a sports car compared with a truck."

Physicist Leonardo Midolo of the University of Copenhagen says he is impressed with the design, which requires only about a tenth as much electricity as other light switch designs. But currently, a light beam retains only about 60 percent of its original strength when taking a detour. If each switch washes out almost 40 percent of the original light, it only takes a few switches for that information to be almost completely unreadable, Midolo says. "This is definitely something that could be improved." ■

Using an ultrathin gold disk, a tiny switch catches light waves (blue pulses) traveling down a wirelike structure called a waveguide (flowing top right to bottom left) and transfers that light to another waveguide.

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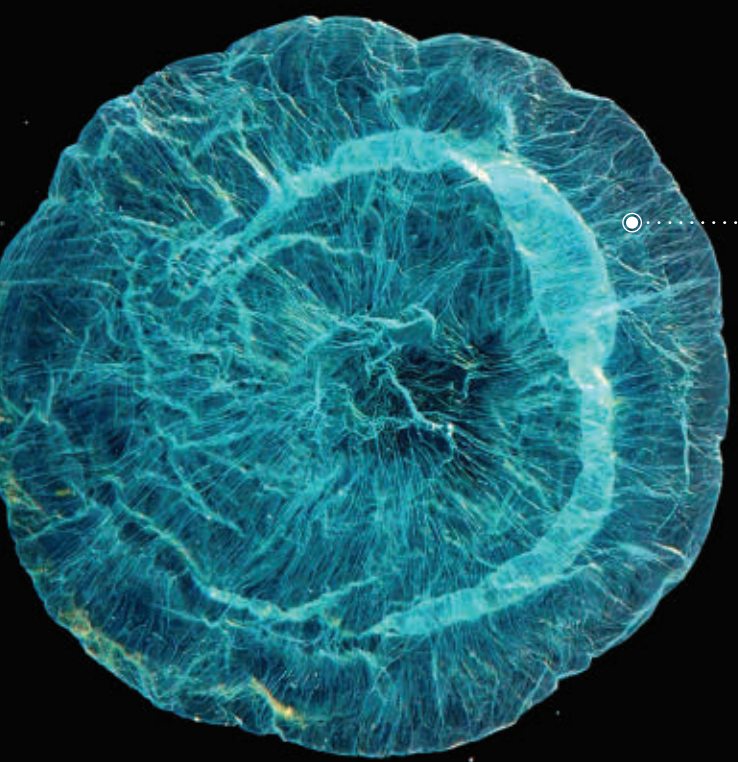

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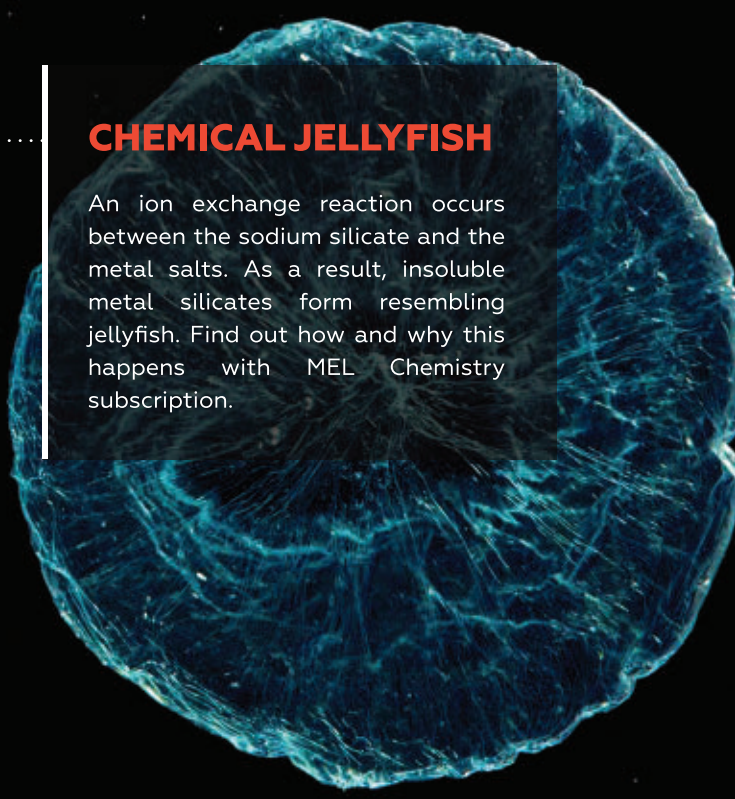

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LIFE & EVOLUTION

Molecular switch can alter an ant's job

Dialing up one protein transforms a warrior into a forager

BY JAKE BUEHLER

When it comes to career paths, workers among carpenter ants split into castes: Some tackle defense, others forage for the colony. But these roles aren't predestined by DNA. An ant's career trajectory is influenced by other factors early in life.

Now, a study reveals one possible way those factors play out. A protein called CoREST acts like a molecular switch in Florida carpenter ants (*Camponotus floridanus*), researchers report online November 12 in *Molecular Cell*. With a toggle of the switch, workers set to be soldiers can be reprogrammed to forage.

Brawny warrior ants called majors and smaller foragers called minors share nearly identical sets of DNA. So researchers have looked for epigenetic influences, chemical tags on DNA and associated proteins that can manipulate how genes are read, to explain the different behaviors.

"And that's what we found," says Shelley Berger, a molecular biologist at the University of Pennsylvania Perelman School of Medicine.

The finding highlights that these highly specialized social insects show substantial flexibility and responsiveness to the environment, says Beryl Jones, an evolutionary biologist at Princeton University. "This is likely another important facet of the great success of social insects."

Among carpenter ants, workers called minors (left) forage for food while majors (right) defend the nest.

RILEY GRAHAM

Berger and colleagues had previously shown that trichostatin A, a chemical that helps unwind tightly packed DNA, can alter majors. But it wasn't clear which genes trichostatin A affected, or how far into development ants could change jobs.

In the new study, Berger's group injected trichostatin A into the brains of worker ants either zero, five or 10 days after ants emerged as adults from their pupal stage. Injections reprogrammed majors up to five days into adulthood, but not if administered later.

When the team analyzed gene activity, reprogrammed majors made more CoREST protein than majors not injected with trichostatin A. CoREST represses enzymes that break down juvenile hormone, which is normally elevated in minors but not in majors, the team found. Boosting CoREST made the warriors more like minors — with less enzyme production and more juvenile hormone.

"People have wondered about the mechanisms underlying [ant] caste development and division of labor for so long," says Daniel Kronauer, a biologist at Rockefeller University in New York City, "and it feels like we're finally on the verge of understanding them." ■

ATOM & COSMOS

Galaxies low on dark matter found

Scientists can't yet explain how the star systems formed

BY CHRISTOPHER CROCKETT

A smattering of small galaxies appear to be missing a whole lot of dark matter.

Most mass in a typical galaxy is invisible. This dark matter seems to be an indispensable galaxy ingredient — it's the scaffolding that attracts normal matter — yet reveals itself only as an extra gravitational tug on gas and stars.

Scientists have now found 19 dwarf galaxies, all tinier than the Milky Way, that defy this common wisdom. The finding, reported November 25 in *Nature Astronomy*, more than quintuples the known population of dark matter rebels.

"We are not sure why and how these galaxies form," says astrophysicist Qi Guo of the Chinese Academy of Sciences in Beijing. Typical dwarf galaxies concentrate dark matter far more than their larger cousins, she says. The smaller size leads to weaker gravity, which has trouble holding on to tenuous clouds of gas, shifting the balance of mass away from normal matter and toward dark matter.

In 2016, researchers identified two galaxies that seemed low on dark matter. Then, two more oddballs turned up.

Guo's group wondered if there were more. Using data from the Arecibo radio telescope in Puerto Rico, the team estimated the masses of 324 dwarf galaxies. Nineteen, or about 6 percent, have less dark matter than expected.

Five of the 19 galaxies are in or near other groups of galaxies, so perhaps the neighbors siphoned off dark matter, the team says. The remaining 14 are far from other galaxies. Either these oddballs were born different, or some internal machinations such as exploding stars upset the allotment of dark and normal matter.

Astrophysicist James Bullock of the University of California, Irvine says it may not be a case of missing dark matter. Instead, maybe these dwarf galaxies have clung to their normal matter — or even stolen some — and so have too much of that matter. Either way, he says, "this is telling us something about the diversity of galaxy formation.... Exactly what that's telling us, that's the trick." ■

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EARTH & ENVIRONMENT

‘Eternal ice’ loss threatens herders

Interviews document climate change in Mongolia

BY CAROLYN GRAMLING

Reindeer in Mongolia (shown here in 2017) rely on “eternal ice” patches to cool themselves during summer.

MYAGMAR NANSALMAA

Patches of long-frozen snowpack and ice in the Mongolian steppes are rapidly vanishing — with potentially dire consequences for the reindeer and herders who rely on the ice.

About 30 families, members of the Tsaatan people, live within a remote part of northern Mongolia called the Ulaan Taiga Special Protected Area. Through interviews with some of these families, researchers have created a recorded history of the region’s frozen resources to gain new insight into how quickly the ice is vanishing.

During summer, the Tsaatan bring reindeer herds to a tundra valley region called Mengebulag, where large patches of snow and ice have persisted, regardless of season, for decades, perhaps longer. The people call these patches “eternal ice,” or *munkh mus*.

The ice is an important source of freshwater for families, and reindeer lie on the ice to cool themselves and seek respite from biting insects, says archaeologist William Taylor of the University of Colorado Boulder and the Max Planck Institute for the Science of Human History in Jena, Germany. Without the ice, the herders told researchers, the animals are more vulnerable to parasite-borne illnesses and heat stress.

Taylor and colleagues recount these people’s ethnographic history, increasingly recognized as an important part of documenting ongoing climate change, in a study published November 20 in *PLOS ONE*. “These folks are immediately experiencing the consequences [of climate change], because of the way their livelihood is tied to the animals, and tied to the water,” Taylor says.

Mongolia is one of the driest countries in the world, but “mountains provide these unique microenvironments, where the seasonal precipitation is banked up in the form of snowpack,” Taylor says. That has allowed people to live and herd animals throughout the country.

But many of the ice patches appear to be shrinking, or even vanishing, Taylor and colleagues have noted on repeat visits to the region. To learn more about where and when the ice began to vanish, the team interviewed, in Mongolian, members of three families who have visited the ice patches year after year. Loss of ice patches appears to have accelerated in the last decade, the families reported; many long-standing patches melted away completely during the summers of 2016, 2017 and 2018.

“The really troubling stories were the ones where the families took us to where patches used to be,” Taylor says. Now these spots are just barren rock faces. “The term *munkh mus* — it’s a term of respect,” he adds. “They don’t use ‘eternal’ lightly in the Mongolian language. And the loss is, in many ways, felt as a tragic one.”

The study doesn’t analyze how the loss of ice patches is related to rising temperatures. But summer temperatures in Mongolia in 2001 were already 1.5 degrees Celsius higher than the country’s 20th century average, according to a United Nations climate change report.

Using locations given by the families as well as satellite data from 2016 and 2017, the researchers visited 11 existing ice patches and two sites that in 2016 were covered in ice that is now gone. Those surveys, by horseback, yielded wooden artifacts, once buried by the ice, that Taylor says represent clues to the history of reindeer herding in the region. For instance, a long, cylindrical wooden stick may have been a “scaring stick,” an object herders still use to control the behavior of wild reindeer, the herders told researchers. Lines of such sticks, placed upright in the snow, can trigger the animals’ instincts to shy away from a location.

Carbon-14 dating suggests that the uncovered artifacts were used in the 1960s or 1970s, the team reports. Melting ice patches may have previously exposed many other, perhaps older, organic artifacts that have already degraded away. “After those are gone, it’s impossible to backtrack and extrapolate what may have been lost,” Taylor says.

Since the early 2000s, similar finds have begun emerging from melting ice in Norway, North America and the Alps, says Lars Holger Pilø, a glacial archaeologist with the Glacier Archaeology Program in Oppland, Norway. Scientists are racing to collect oral histories and artifacts from these sites. “Many of the finds are in organic materials that are not preserved elsewhere, but which have survived hundreds or thousands of years inside the ice like in a time machine,” Pilø says.

Taylor’s group is the first to do such glacial archaeology in Mongolia, Pilø says. “They are doing really important work.” The ethnographic information “adds meat to the bone, so to speak. It makes it easier to understand why finds are made in ice patches and glaciers, and how the finds should be interpreted.” ■

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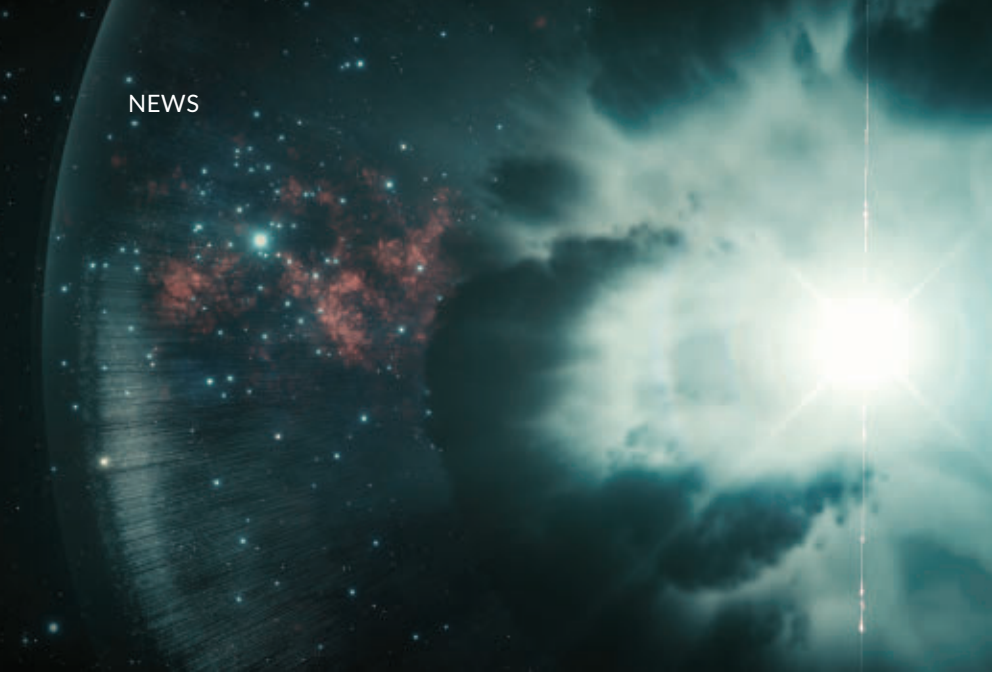

Fast electrons trapped in magnetic fields rev up light from a long gamma-ray burst (one illustrated).

ATOM & COSMOS

Cosmic explosion sets energy record

Long gamma-ray burst's light packs 1 trillion electron volts

BY CHRISTOPHER CROCKETT

Two eruptions of gamma rays from exploding stars in far-off galaxies have pelted Earth with the highest-energy photons yet detected from one of these explosions. The shower of light particles reveals how so-called long gamma-ray bursts — among the most powerful explosions in the universe — produce such energetic photons.

"This is the Rosetta Stone of gamma-ray bursts," says astrophysicist Tsvi Piran of the Hebrew University of Jerusalem, who was not involved with this research.

Long gamma-ray bursts, or GRBs, mark the death of a massive star as it explodes and leaves behind a neutron star or a black hole. (Short GRBs, on the other hand, appear to accompany collisions between neutron stars. See Page 36.) Until now, the most energetic photons radiating from a long GRB typically maxed out at a few million electron volts of energy, or roughly a million times more energetic than the photons our eyes can detect.

That record has been smashed. In July 2018 the HESS observatory, about 100 kilometers southwest of the Namibian capital of Windhoek, recorded photons from a GRB with between 100 billion and 440 billion electron volts, 10 hours after the initial burst. Six months later, in January 2019, the twin MAGIC telescopes on the Canary Island of La Palma saw a different burst and captured photons with a whopping 1 trillion electron volts of energy. The previous record holder from a GRB was a single photon with 94 billion electron volts, detected in 2013. The new findings appear in three papers published in the Nov. 21 *Nature*.

> "This is the Rosetta Stone of gamma-ray bursts."
> **TSVI PIRAN**

"There were theories predicting that there should be [very-high-energy photons] from GRBs, but things were very uncertain," says Razmik Mirzoyan, an astrophysicist at the Max Planck Institute for Physics in Munich who led the study of the 2019 burst.

These theories offered differing explanations for how magnetic fields, electrons and ambient light interact within the debris from a stellar explosion to produce gamma rays. To test these ideas, several teams have been hunting for very-high-energy gamma rays for years, Mirzoyan says. "We were trying for 15 years, but never succeeding."

The researchers' newfound success reveals a tale of how GRB photons get so much vigor. Shock waves from the explosion accelerate electrons to nearly the speed of light and generate magnetic fields. The electrons whip around the magnetic field lines and emit relatively low-energy photons. These photons, along with other photons passing by from other galaxies, subsequently get a power boost by ricocheting off and stealing energy from these speedy electrons. It's this last step, known as inverse Compton scattering, that gives some GRB photons their extreme energies.

"This basic theory came out more than 20 years ago, but there was no proof," Piran says. "It's so wonderful that they got it."

The discovery was helped by the relative proximity of the two blasts. The light from the 2018 burst took about 6 billion years to reach Earth; the 2019 explosion needed roughly 4.5 billion years. While that puts both bursts far beyond our galactic neighborhood, they were much closer than typical GRBs.

The extreme photons revealed a couple of tidbits about GRBs. For inverse Compton scattering to work, the low-energy photons need a good chance of running into electrons. "This tells you that you have a very dense medium" around the explosion, says astrophysicist Edna Ruiz-Velasco of the Max Planck Institute for Nuclear Physics in Heidelberg, Germany, who studied the 2018 burst.

It also appears that astronomers have been underselling just how much oomph a GRB can pack. GRBs emit light across the entire electromagnetic spectrum — from radio waves to gamma rays — and the 2019 burst pumped as much energy into its extreme gamma-ray photons as it did into its more numerous X-rays, Mirzoyan says. That bumps up the overall energy for GRBs — already comparable to the entire energy output of the sun over its lifetime — by about one-third, he says. ■

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The year in

19 review

Science is good at measuring progress — and where we fall short. *Science News*' Top 10 stories of the year reflect that duality, from celebrating great achievements to highlighting problems we had hoped to avoid.

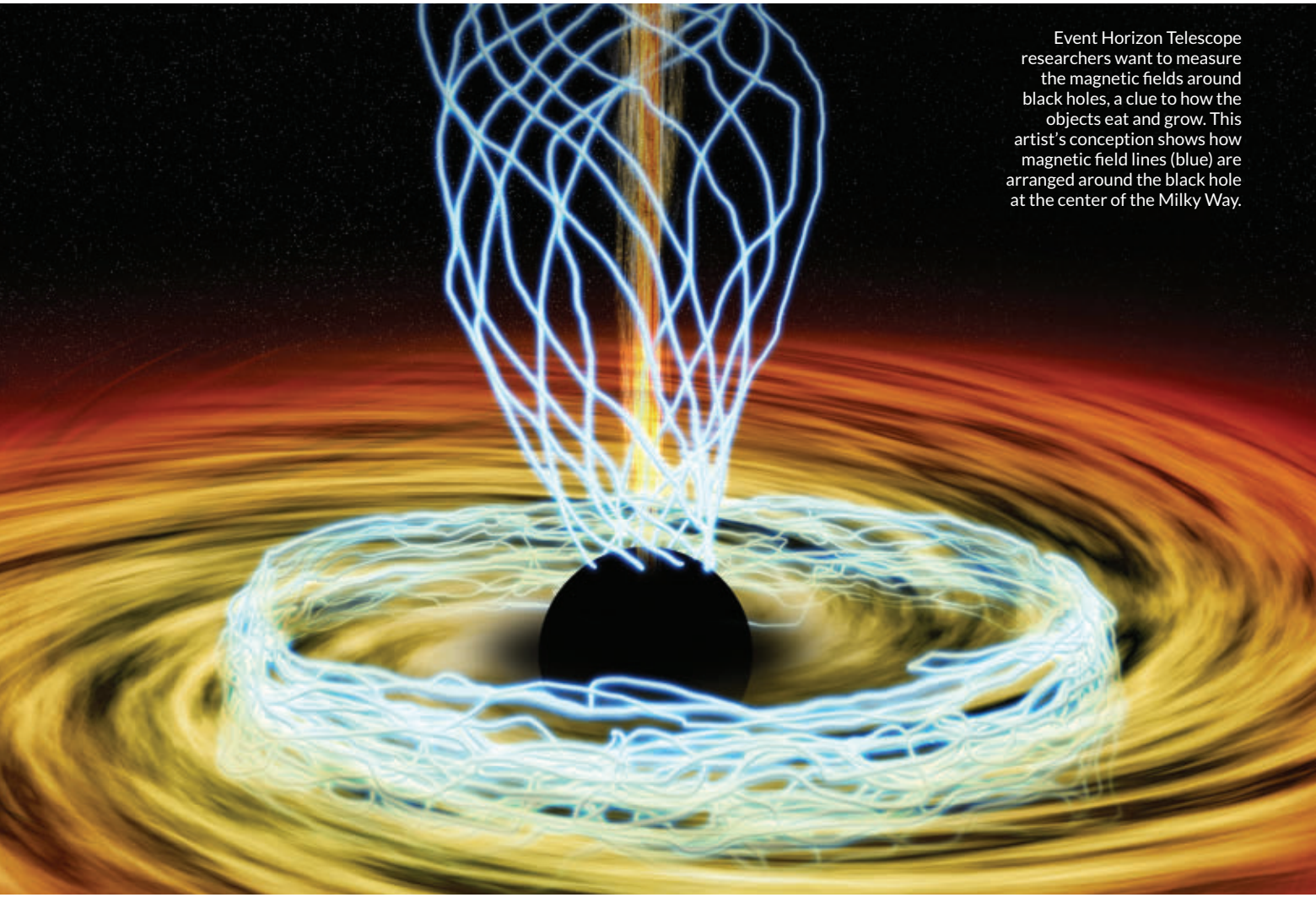
This was the year in which more than a decade of effort by hundreds of scientists who created a globe-spanning "telescope" to see the previously unseeable paid off. The Event Horizon Telescope captured the first image of a black hole (shown at left). That now-iconic picture confirmed a fundamental theory of how our universe works (Einstein, still right) and opened up a new era of exploration, making it our top story of 2019.

That wasn't the year's only big milestone. Just seven years after its development, the gene-editing tool CRISPR/Cas9 moved into human clinical trials in the United States to see if the approach can treat cancer, blood disorders and an inherited form of blindness. And Google claimed quantum supremacy, saying it had created a qubit-based computer that could speedily solve a problem that would take a classical supercomputer thousands of years to do. That announcement provoked immediate pushback, but highlighted the groundwork being laid for the next big leap in quantum computing.

Yet for every advance, there are setbacks. In 2019, several countries officially lost a hard-earned public health achievement — the elimination of measles, defined as a year without continuously spreading infections. The United States racked up its most measles cases since achieving elimination in 2000, but managed to just barely hold on to that status: An aggressive public health campaign ended one outbreak just before its one-year anniversary.

Many other records we never wanted to see were set in 2019; temperatures spiked to all-time highs in hundreds of places in the Northern Hemisphere, leading to deadly heat waves, fires and droughts. Scientists have been warning of looming catastrophes fueled by climate change for years. Perhaps 2019 will be remembered as the year that message finally caught fire with the public. Climate protests, many led by teen activists, spread globally to include millions of people. Only time will tell if the rising tide of people demanding action on climate change will become the turning point we remember in years to come.

— Macon Morehouse, News Director



Event Horizon Telescope researchers want to measure the magnetic fields around black holes, a clue to how the objects eat and grow. This artist's conception shows how magnetic field lines (blue) are arranged around the black hole at the center of the Milky Way.

1 First black hole image made its debut

By Lisa Grossman

Black holes are notoriously bashful beasts. The supermassive monsters that dwell at the centers of galaxies weigh millions to billions of times the mass of the sun and control the fates of everything in their vicinity, including light. Despite such outsize influence over their home galaxies, black holes never show their faces.

Until now. After more than a decade of work, results from the Event Horizon Telescope, or EHT, stunned the world this year with the first direct image of a black hole's event horizon, the region beyond which not even light can escape.

To make this remarkable image, scientists cobbled together a massive "telescope" by connecting seven observatories around the world to create a tool effectively the size of Earth (*SN: 4/27/19, p. 7*). The result: a picture of the round silhouette of a black hole against the ringlike backdrop of its brightly glowing accretion disk, the gas and other material drawn in by the black hole's voracious gravitational appetite.

Almost immediately, that image shored up Einstein's general theory of relativity, weighed in on the best way to measure a black hole's mass (*SN Online: 4/22/19*) and provided evidence that event horizons are real. Now the EHT team is digging into what else the telescope's vast amount of data can reveal, in the hopes of cracking more black hole mysteries.

"This is just the beginning of this kind of new era of observing event horizons," says Kazu Akiyama, an EHT team member and astrophysicist at the MIT Haystack Observatory in Westford, Mass.

The initial black hole snapshot, unveiled in April, focused on a distant galaxy, M87 (*SN: 4/27/19, p. 6*). At roughly 6.5 billion solar masses, M87's black hole is 1,000 times as massive as EHT's other target, the black hole in the center of the Milky Way. That black hole, Sagittarius A*, also known as Sgr A*, weighs about 4 million times the mass of the sun.

Being more massive made M87's giant an easier subject. Gases swirling around that black hole were more sluggish and

PREVIOUS SPREAD: EVENT HORIZON TELESCOPE COLLABORATION; THIS PAGE: M. WEISS/CFA

changed brightness less often and less dramatically than those moving more nimbly around Sgr A*.

"M87 was sitting still for its portrait," says EHT team member Andrew Chael, an astrophysicist at Princeton University. "Sgr A* is like a cheetah running across the frame."

In data collected during a week in April 2017, Sgr A* changed its appearance over the course of a few minutes. So while M87's black hole lent itself to a single still image, "for Sgr A*, we may need to construct a movie," Akiyama says.

The simplest way to make a movie would be to break up one night's observations into segments, make an image from each segment and string them together, says EHT team member Katie Bouman, a data scientist at Caltech. But there's not enough information in even the smallest segment to produce a reliable image. "You reconstruct nonsense," she says.

Instead, the team is working on techniques to fill in gaps and carry information about the black hole's appearance forward in time. "We assume that although the source is evolving, it's not evolving randomly — there is some continuity in how the gas is moving around the black hole," Bouman says. By stitching together a movie that plays smoothly, she and colleagues hope to understand the black hole's structure.

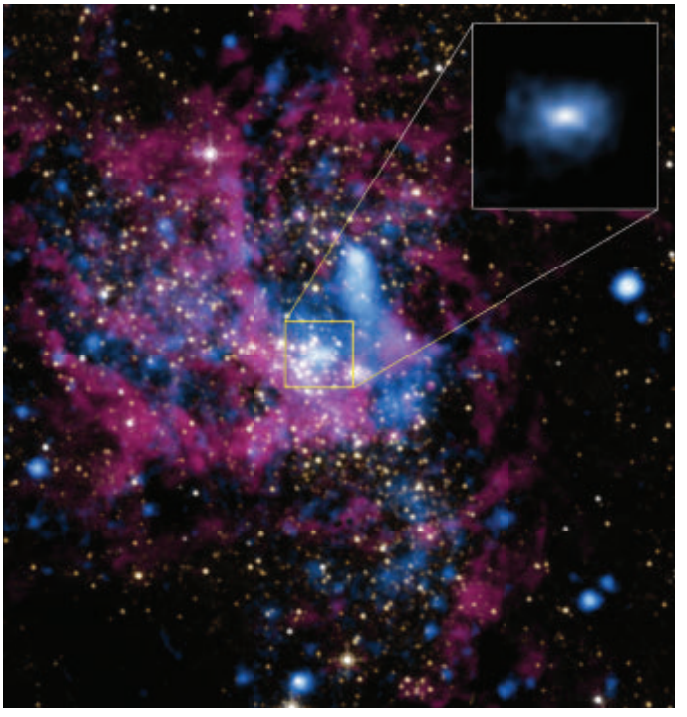
Getting a good look at Sgr A*'s event horizon will give physicists one of the best tests yet of general relativity, says physicist Feryal Özel of the University of Arizona in Tucson. The century-old theory predicts how the mass of a black hole warps spacetime (*SN: 10/17/15, p. 16*). General relativity also makes precise predictions for the size of the bright ring and dark silhouette for black holes of a given mass.

M87's black hole was too far away for astronomers to know precisely its mass before capturing the image. But Sgr A*'s mass is well known, thanks to decades of measurements of stars orbiting the Milky Way's black hole. Capturing Sgr A*'s image would be "a clean test of some of the things we want to look at," Özel says. "The ring and the shadow, it either is the size you expect or it's not.... That's an incredible opportunity for us."

A movie of M87's black hole may be in the works, too. "Our observations provided good evidence that M87 is actually changing [within] the timescale of a week," Akiyama says. Studying how the black hole changes could reveal details of how it rotates, spinning magnetized plasma around it like a dancer's skirt.

Among other treasures waiting in already collected data is the polarization of light emitted from the bright ring of M87's black hole. This measure of the orientation of light waves — wiggling up and down, left and right, or at an angle — lets scientists determine the arrangement of strong magnetic fields near the black hole. Those magnetic fields are thought to control how the black hole accretes matter.

The arrangement "tells you how the black hole eats," says astrophysicist and EHT team member Michael Johnson of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass. Black holes are known for their hearty appetites, but actually "it's extremely difficult to fall into a black hole," he says. An orbiting bit of matter will just keep orbiting forever unless some friction or viscosity in the environment drags it toward the black hole.



The Event Horizon Telescope's next target lurks in the Milky Way's center (shown). The inset zooms in on Sagittarius A*, revealing X-rays (blue) emitted from hot gas captured by the black hole.

X-RAY: NASA, UMASS, D. WANG ET AL.; INFRARED: NASA, STSCI

Physicists think magnetic fields are what make the environment around black holes viscous. In 2015, Johnson and colleagues published EHT observations of the polarization around Sgr A*, which showed tangled magnetic fields close to the black hole and more organized fields farther away. But those observations came from just four telescopes.

"We have this beautiful theory of why black holes can eat, but we've never seen evidence for it," Johnson says. "So if EHT can see these magnetic fields, we might have our first glimpse into this accretion process."

Polarization could also help explain one mysterious feature of M87: It launches a bright, energetic jet that extends light-years into space. Magnetic fields that get twisted around the black hole as it spins are important for launching the jet, physicists think, but the details are murky.

"If we could see this polarization, we might be able to see these processes directly — the magnetic fields and the jet and how they're connected to the black hole," Johnson says.

EHT will fire up again in April 2020, this time with 11 observatories, including Kitt Peak in Arizona and NOEMA in the French Alps. Further in the future, EHT scientists are considering sending a telescope to space. Extending EHT into Earth's orbit would alleviate worries about weather on the ground ruining observations — and would help make even sharper images of even more black holes. ■

2 The fight against measles got intense

By Aimee Cunningham

In 2019, measles sickened more people in the United States than in any year since 1992. As of November 7, there were 1,261 illnesses reported in 31 states. Two outbreaks in New York accounted for the lion's share: more than 75 percent of the cases.

The New York outbreaks, which began in the fall of 2018, ran almost long enough to strip the United States of its measles elimination status, which it achieved in 2000. To receive that designation from the World Health Organization, a country must go a year without the disease spreading continuously in an area within its borders.

There have been U.S. outbreaks since 2000 — most notably, 667 cases in 2014 — but none had threatened to undo elimination (*SN Online: 10/4/19*). The outbreak in New York City ended on September 3. The other New York outbreak, in Rockland and neighboring counties, ended in early October.

"The best way to stop this and other vaccine-preventable diseases from gaining a foothold in the U.S. is to accept vaccines," Robert Redfield, director of the U.S. Centers for Disease Control and Prevention in Atlanta, said in an October 4 statement announcing that the nation was holding on to its elimination status.

Many other countries struggled with measles outbreaks this year (*SN: 6/8/19, p. 22*). As of November 17, Congo had the largest outbreak, with an estimated 250,000 measles cases and more than 5,000 deaths, mostly children under 5. Samoa, with immunization rates as low as 31 percent, was hit hard late in 2019, with more than 3,700 cases and dozens of deaths.

As in previous years, travelers launched the recent U.S. measles outbreaks, bringing the virus into the country and spurring infections in places where immunization rates were lower than 92 to 95 percent, the threshold needed to prevent a measles outbreak (*SN Online: 4/15/19*). This herd immunity protects the unvaccinated, including those who can't be vaccinated, such as infants or people who have weak immune systems.

The first half of 2019 had more reported measles cases globally than in any year since 2006. This baby in the Philippines has the telltale rash.

JAMES GOODSON/CDC

In 1978, the United States embarked on what became a decadeslong effort to eliminate measles, which included an immunization program that requires children be vaccinated to enter school and helps defray the cost of vaccination for eligible children. Yet parents who delay or avoid vaccinating their children — by seeking exemptions for religious or personal beliefs — leave their communities vulnerable. About 90 percent of the U.S. cases in 2019 occurred in people who had not been vaccinated or didn't know if they had been. Doctors are exploring how to find common ground with vaccine-hesitant parents to encourage vaccination (*SN: 6/8/19, p. 16*).

Many people aren't aware of the toll that measles can take, says Yvonne Maldonado, a pediatric infectious disease expert at Stanford University School of Medicine. She has seen children with measles develop pneumonia and encephalitis, a dangerous brain swelling. And measles can wipe out immune memory, raising a person's risk for other infections (*SN: 6/8/19, p. 20*).

Future U.S. outbreaks are likely, says William Moss, an infectious disease epidemiologist at the Johns Hopkins Bloomberg School of Public Health. The United States still has communities where there's a high enough number of susceptible individuals to ignite an outbreak. "We can't let our guard down," he says. "Measles will find its way back." ■

Good news on other infections

This year saw progress against several dangerous infectious diseases.

Tuberculosis The U.S. Food and Drug Administration approved a new antibiotic for use with two other drugs to treat a particularly deadly form of drug-resistant tuberculosis (*SN: 9/14/19, p. 6*).

Ebola In November, European regulators approved an Ebola vaccine that was used during the recent Congo outbreak, which started in August 2018. In a study in patients infected with the virus, conducted amid that outbreak, two therapies proved effective at preventing death (*SN Online: 8/12/19*). (Regeneron Pharmaceuticals, which makes one of the treatments, is a major financial supporter of Society for Science & the Public, which publishes *Science News*.)

Chlamydia The first vaccine candidate against chlamydia, one of the most common sexually transmitted diseases, passed its first test in healthy women (*SN: 9/14/19, p. 6*). Two versions of the vaccine safely produced an immune response, while a placebo had no effect.

Greta Thunberg (at table, second from left) and other young activists filed a complaint with the United Nations in September, arguing that a lack of action on climate change violated their human rights.

KENA BETANCUR/GETTY IMAGES

3 Student activists push for climate action

By Carolyn Gramling

This year was a scorcher. Summer temperatures broke hundreds of all-time records, bringing unprecedented melting to Greenland and helping to fuel wildfires that raged across the Arctic as early as June (*SN Online: 8/2/19*). And a stark report from the Intergovernmental Panel on Climate Change warned of a bleak future for Earth's oceans and frozen regions as the planet heats up (*SN Online: 9/25/19*).

But climate scientists say that's not 2019's only takeaway: This year also saw record-breaking waves of climate activism.

"I've never seen so much protest," says glaciologist Eric Rignot of the University of California, Irvine. He's referring to the climate marches that swept the world and culminated in climate strikes during the September United Nations' Climate Action Summit in New York City. "It's actually a very exciting time."

Many of these strikes were led by students, particularly 16-year-old Swedish climate activist Greta Thunberg. Her #FridaysForFuture movement began in August 2018 as a personal pledge to protest every Friday until the Swedish government speeds up its plan for full carbon neutrality by 2045, which Thunberg has said is not soon enough. She says she will protest until her government agrees to reduce carbon emissions by 15 percent each year, achieving carbon neutrality within just a decade or so.

As word of Thunberg's protests spread via social media, the movement went global; an estimated 1.6 million students in over 120 countries joined a coordinated climate strike on March 15. A second wave of student-led protests coincided with the September Climate Action Summit, with a record-breaking 7.6 million people participating in a global climate strike.

On September 23, Thunberg spoke bluntly to world leaders assembled at the summit. "For more than 30 years, the science has been crystal clear," she said. "Right here, right now is where we draw the line. The world is waking up. And change is coming, whether you like it or not."

This intensity of climate activism "is long overdue, and it's super exciting to see," says Kim Cobb, a climate scientist at Georgia Tech in Atlanta. It's something that climate scientists have "always dreamed about," she says.

Of course, this year's dramatic and record-smashing heat waves likely added urgency to the protests.

From May to August, nearly 400 all-time high temperature records were set in 29 countries in the Northern Hemisphere. Europe baked under two back-to-back heat waves in June and July. Human-caused climate change made that oppressive heat between 10 and 100 times more likely in France, according to a report by the World Weather Attribution Network, an international consortium of climate scientists (*SN Online: 7/2/19*).

Temperatures at Anchorage International Airport in Alaska spiked to an all-time high of 32° Celsius (89.6° Fahrenheit) on July 4. India and Pakistan sweltered under a prolonged, deadly June heat wave that coincided with extreme droughts and water shortages. In Japan, a deadly heat wave swept across the country in late July, sending more than 18,000 people to the hospital in one week.

Globally, July was the hottest month in 140 years of record-keeping, according to the U.S. National Oceanic and Atmospheric Administration.

This year's intense heat — along with wildfires, slow-moving and deadly hurricanes and other extreme climate events — may have helped bring the reality of climate change home to people.

Cobb recounts a recent conversation she overheard in the checkout line at a grocery store in Atlanta: "They were talking about this — the hurricanes, the wildfires, the ocean heat waves, the coral bleaching, the king tides in Miami." Climate change is front and center now, she says. "It's definitely a kitchen-table issue at this point for tens of millions of Americans."

Rignot says he's happy to see that the conversations are moving away from debates about whether human-caused climate change is real and toward efforts to reduce greenhouse gas emissions, as well as strategies for adapting to a warmer world. "I'm personally a bit tired of being the bearer of bad news. The focus on solutions is heartening," he says. "It's common sense, and it's starting to percolate through society."

For their efforts, Thunberg and other teenage climate activists have garnered international recognition and awards. But while receiving the U.N. Environment Programme's Champions of the Earth prize in September, 15-year-old #FridaysForFuture organizer Kallan Benson offered a blistering response. "Awards are for celebrating achievement," she told the U.N. members. "The achievement we seek has not occurred." ■

The maker of Juul, the e-cigarette most popular with teen vapers, announced this fall that it will stop selling pods of many of its flavors, such as mango, cucumber and mint. Tobacco flavors, such as those depicted here, as well as menthol are still available.

4 Dozens of deaths were linked to vaping this year

By Aimee Cunningham

E-cigarettes have enjoyed a reputation of being relatively harmless, at least among the public. But that began to change in 2019, when the first reported lung injuries and deaths linked to vaping provided a stark corrective. As of November 20, a total of 2,290 people from every U.S. state but Alaska, many of whom were young and otherwise healthy, have become sick, according to the U.S. Centers for Disease Control and Prevention. And 47 people, including a 17-year-old, have died.

Federal health officials have announced a potential culprit: vitamin E acetate (*SN Online: 11/8/19*), added mainly as a thickening agent in vaping products containing THC, or tetrahydrocannabinol, the compound in marijuana that produces the high. Vapers should avoid THC, officials say, but the investigation is ongoing, and the illnesses may be due to more than one vaping ingredient.

Whatever the final word on this type of lung injury, dubbed EVALI for "e-cigarette, or vaping, product use associated lung injury," it won't be the end of the story on the dangers of e-cigarettes. An ever-rising tide of U.S. teens are vaping, and their experiences will reveal the long-term effects of e-cigarette use.

"While of course these lung injuries related to vaping are very serious, it really is just the tip of the iceberg," says Susan Walley, a pediatrician at the University of Alabama at Birmingham School of Medicine. "The millions of kids who are using e-cigarettes now ... what's going to happen to all those kids in 10 years?"

The association of EVALI cases with THC may bring a false sense of security to those who vape nicotine. But even if it's not tied to these lung injuries, nicotine is addicting a whole generation of adolescent e-cigarette users, putting them at risk for a wide range of harms, health officials say.

Studies suggest that the chemicals inhaled while vaping affect the brain, the heart and the lungs. Nicotine alters teens' brain development, increasing the risk of addiction to other drugs (*SN: 3/7/15, p. 12*). Exposure to the chemicals in e-cigarettes impairs the function of the cells that line blood vessels, which could boost the risk of cardiovascular disease. And teens who vape are at higher risk of chronic respiratory symptoms than their nonvaping peers. It will take time to uncover how vaping affects long-term health; e-cigarettes have been on the market in the United States for only about a decade, and the technology has changed rapidly.

Meanwhile, the pace at which teens — drawn in by fruit and candy flavors and then hooked on nicotine — are becoming e-cigarette users hasn't slowed. The National Youth Tobacco Survey found that 27.5 percent of U.S. high school students reported in 2019 using e-cigarettes in the last 30 days, up from 20.8 percent in 2018. More alarmingly, another youth survey reported this year revealed that nearly 12 percent of high school seniors and 7 percent of sophomores use nicotine vapes daily, suggesting addiction (*SN Online: 9/18/19*).

Nicotine in the pods used with Juul, the top-selling brand of e-cigarettes, is formulated to be less harsh than what's found in most combustible cigarettes. "It's not painful to inhale," says primary care pediatrician Susanne Tanski of the Dartmouth Geisel School of Medicine in Hanover, N.H. Young people "are taking these large hits of nicotine," she says, and more of these teens report that they're highly addicted, even waking up at night to vape.

A person who inhales the full amount of nicotine contained in a 5 percent nicotine Juul pod gets what a smoker would take in from a pack and a half to two packs of cigarettes (*SN: 12/22/18 & 1/5/19, p. 28*). The device's design — it looks like a flash drive and doesn't produce the large plumes typically associated with other e-cigarettes — makes it easy to take discreet hits throughout the day.

To curb the epidemic of teen vapers, some states announced bans on some vape flavors. A few states are suing Juul Labs, alleging that the company used deceptive marketing practices to lure teens as customers. This fall, Juul Labs announced that it will cease sales of most of its flavored pods, including mango and mint. Those are the two top flavors used by adolescents, researchers reported in November in *JAMA*. ■

New level of worry

The CDC is investigating a rash of lung injuries and deaths tied to the use of e-cigarettes.

2,290
Cases of lung damage

47
Deaths in 24 states and Washington, D.C.

SOURCE: CDC, AS OF NOVEMBER 20, 2019

JUSTIN SULLIVAN/GETTY IMAGES

5 Denisovans emerged from the shadows

By Bruce Bower

Denisovans' days of Stone Age obscurity appear numbered.

The mysterious "ghost clan" floated into view over a decade ago, when a bit of a girl's pinkie bone, found in Siberia's Denisova Cave, yielded DNA that didn't match that of any known hominid. A few more fossils — three teeth and a limb fragment — plus genetic analyses indicated Denisovans were close relatives and occasional mating partners of Neandertals and *Homo sapiens* tens of thousands of years ago. But there was too little evidence to say what Denisovans looked like or how they behaved.

Discoveries reported in 2019 brought Denisovans into focus — but left plenty of room for interpretation. As fossils accumulate, investigators will grasp how Denisovan anatomy influenced the skeletal makeup of its mating partners in the *Homo* genus. Thanks to Denisovan discoveries, "we can now see that hybridization contributed to our own origins," says paleoanthropologist John Hawks of the University of Wisconsin–Madison.

Ancient DNA evidence reported this year suggests that Denisovans fanned out into three genetically separate lines that mated with various human groups in Asia. That finding played into an emerging view of human evolution as a braided stream, with closely related species flowing into and out of genetic exchanges.

A partial jaw, unearthed on the Tibetan Plateau, is one of several Denisovan fossils reported in 2019.

DONGJU ZHANG/LANZHOU UNIV.

But testing that possibility requires finding more Denisovan fossils. The discovery of two pieces of a skull in the Siberian cave, reported this year, gave a glimpse of the anatomy that the ghost clan brought to the ancient hybridization scene (*SN: 4/27/19, p. 15*). The bone's surprising thickness recalls *H. erectus* — a species dating back at least 1.8 million years. Yet a newly identified chunk of the girl's finger bone looks like people's digits today (*SN: 9/28/19, p. 14*).

These findings fit with the idea that Denisovans had a mix of their own skeletal traits plus characteristics like those of their breeding partners. That theme also emerged from a project that used the Denisovan girl's DNA to reconstruct her skeleton and face (*SN: 10/12/19 & 10/26/19, p. 24*). The youngster's portrait, which some researchers regard as too speculative, included a relatively flat, humanlike face but, like Neandertals, no distinct chin. Her broad nose had a look all its own.

This year also brought evidence that Denisovans traveled far beyond the Siberian cave. The population periodically inhabited that cave from nearly 300,000 to about 50,000 years ago, according to sediment studies (*SN: 3/2/19, p. 11*). But on the distant Tibetan Plateau, researchers identified a Denisovan lower jaw, dating to at least 160,000 years ago (*SN: 6/8/19, p. 6*). Denisovans' arrival there fits previous evidence that Tibetans today inherited a Denisovan gene that aids high-altitude survival.

Denisovans may also have shared a sophisticated thinking ability with other Stone Age *Homo* populations. Engraved animal bones found in China, possibly etched by Denisovans, raised the likelihood that these hominids created objects with symbolic meanings (*SN: 9/14/19, p. 8*). Perhaps most intriguing is the report that at least three genetically distinct Denisovan populations split from the same Siberian population and mated with ancient humans elsewhere in Asia. People now living in parts of East Asia, Indonesia and Papua New Guinea have ancestors from those three Denisovan lines.

"The world was genetically complex 50,000 to 100,000 years ago," says paleoanthropologist Bernard Wood of George Washington University in Washington, D.C. Wood suspects that three or four closely related *Homo* species, including Denisovans, interbred during that time.

Paleogeneticist E. Andrew Bennett of Paris Diderot University in France isn't so sure about Denisovans' status as a species. "The species concept is controversial and tricky," he says. Since interbreeding occurred among Denisovans, Neandertals and *H. sapiens*, "it is better to talk about different populations, not different species."

Evidence of the three Denisovan lineages complicates the ghost clan's identity, Hawks says. It's unclear whether some Denisovan offshoots interbred enough to genetically blend in with *H. sapiens* groups or stayed largely to themselves, he says. "Are the Denisovans a species? Are they three species? Or are they all different populations of *Homo sapiens*?"

To decipher Denisovans' place in human origins, archaeologist Eleanor Scerri of the Max Planck Institute for the Science of Human History in Jena, Germany, and colleagues advocate replacing the neatly branching traditional hominid evolutionary trees with a tangle of intertwined populations.

Fossil and genetic findings now support a scenario in which, between 500,000 and 300,000 years ago, *H. sapiens* groups across Africa — which varied in their skeletal makeup — genetically mixed and mingled until a package of physical traits typical of people today coalesced, the scientists argued September 23 in *Nature Ecology & Evolution*.

Populations in the *Homo* genus that periodically merged and separated probably inhabited Asia and Europe as well, producing Denisovans, Neandertals and perhaps other humanlike forms (*SN: 5/11/19 & 5/25/19, p. 7*), Scerri's team suspects. As humans moved out of Africa, populations such as the Denisovans that had already adapted to local conditions contributed survival-enhancing genes to the newcomers, the team holds.

Even with those limited interactions, discoveries this year cement Denisovans' status as coauthors of humankind's long and winding evolutionary story. ■

6 CRISPR gene editing entered tests in people

By Tina Hesman Saey

When it was unveiled in 2012, people had great hopes that the gene editor CRISPR/Cas9 could treat or even cure hundreds to thousands of genetic diseases. This year, researchers in the United States began testing the gene editor in people, a crucial first step in determining whether the technology can fulfill its medical promise.

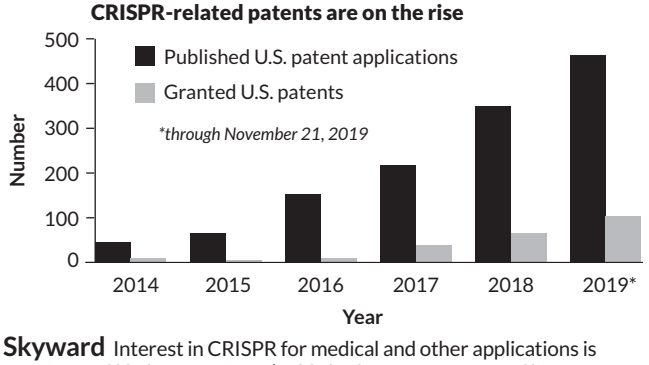
These first clinical trials are testing CRISPR/Cas9's safety and efficacy against cancer, blood disorders and one form of inherited blindness in people who already have the disease (*SN: 8/31/19, p. 6*). Many more such trials are expected to begin soon. Unlike the editing of human embryos that stirred up controversy in 2018 (*SN: 12/22/18 & 1/5/19, p. 20*), the genetic changes introduced in these trials would not be inherited by future generations.

CRISPR's rise as a potential medical tool happened in remarkably short time, says Janelle Waack, an intellectual property attorney at the law firm Bass, Berry & Sims in Washington, D.C. She has been tracking the dramatic growth of CRISPR patent filings, including for health care, medical research, agriculture and chemical processing. "People are investing in the technology and think it has great commercial value," she says.

These first tests in people are "bellwethers" of CRISPR's future, Waack says. Patients will benefit only if companies continue to invest in the technology, and that investment may depend on whether these early clinical trials succeed.

CRISPR/Cas9 is a bacterial defense system against viruses that scientists have repurposed to make precise changes to DNA in the cells of humans and other animals. A "guide RNA" tows the DNA-cutting enzyme Cas9 to specific genes, where it slices through the DNA. In three clinical trials now under way in the United States, and one just completed, those cuts are disabling genes or snipping out problem bits of DNA.

Results reported from the completed trial, led by researchers at the University of Pennsylvania, suggest that a CRISPR treatment designed to boost the cancer-fighting power of immune cells called T cells is safe. The results are from three patients — two with multiple myeloma and one with sarcoma — whose T cells were removed and edited in the lab. CRISPR disabled three genes in the T cells. Researchers then outfitted the cells with a "warhead" — a gene that directs the cells to tumor cells that have a specific protein on their surfaces. While immune cells engineered to fight cancer, called CAR-T cells, have been used in patients for years, souping up T cells with the help of CRISPR is a new innovation.



Skyward Interest in CRISPR for medical and other applications is growing and likely to continue (published reports of patent filings can include an 18-month lag). SOURCE: U.S. PATENT AND TRADEMARK OFFICE, J. WAACK

The findings, presented December 7 at the American Society of Hematology meeting in Orlando, Fla., showed that CRISPR-edited T cells took hold and reproduced in the cancer patients. None of the three people had any side effects associated with the cells. That's good news since other revved-up T cells have caused high fevers, low blood pressure, seizures and other side effects (*SN: 7/7/18, p. 22*). However, the experimental treatment didn't slow the growth of the people's cancers. "Now that we've demonstrated safety and feasibility, we'll be much more focused on the effectiveness of the therapy," says Edward Stadtmauer, a hematologist and oncologist who led the trial.

Similar tests of CRISPR-edited T cells are under way in China. And CRISPR Therapeutics, a Cambridge, Mass.–based company, expects to begin three trials next year in which edited T cells target blood and kidney cancers, says Samarth Kulkarni, the company's chief executive officer.

CRISPR Therapeutics has already started trials with Vertex Pharmaceuticals, based in Boston and London, to remove and edit cells from people with the blood disorders sickle cell disease or beta-thalassemia. The edits turn on production of fetal hemoglobin, usually made only until shortly after birth. Early results from one woman with beta-thalassemia and another woman with sickle cell disease suggest that the edited cells are safe and make enough fetal hemoglobin to relieve disease symptoms. "While these data are early, they show that this could be a onetime curative therapy for patients," Kulkarni said November 19 during a news briefing describing the results.

In another trial, researchers are snipping a small piece of DNA out of cells in the eyes of people with an inherited form of blindness called Leber congenital amaurosis 10. That DNA contains a mutation that causes the blindness. The trial, conducted by Editas Medicine, also based in Cambridge, Mass., and the global pharmaceutical company Allergan, is the first — and for now, only — trial using CRISPR to edit DNA directly in cells in the human body.

With direct editing, getting CRISPR to exactly the right place is the first challenge, Kulkarni says. From there, it's impossible to know whether the gene editor has made unwanted "off-target" edits as well. External editing allows researchers to check if the correct edits have been made, but the approach isn't feasible for many diseases.

Whether and how soon CRISPR becomes an accepted therapy, and how the U.S. government regulates the technology, may all depend in part on these initial trials. "Everybody is paying careful attention," Waack says. ■

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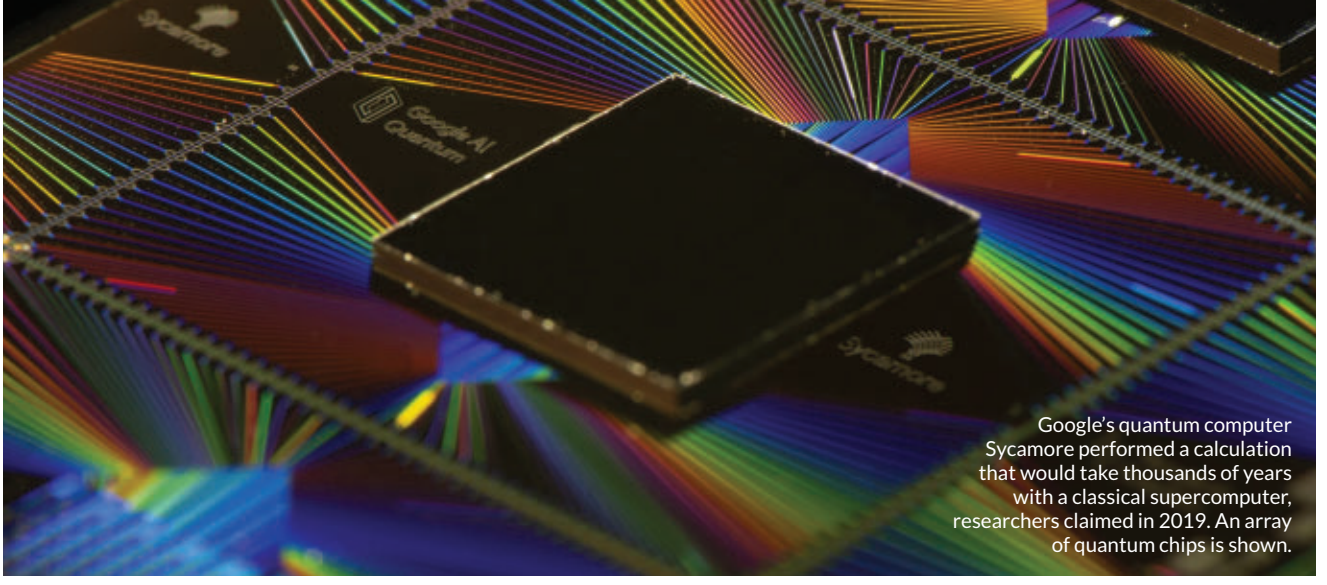


Google's quantum computer Sycamore performed a calculation that would take thousands of years with a classical supercomputer, researchers claimed in 2019. An array of quantum chips is shown.

GOOGLE

7 Google claimed quantum supremacy

By Emily Conover

Like Schrödinger's cat, a 2019 claim of quantum supremacy seems to be simultaneously alive and dead. Thanks to the rules of quantum mechanics, the fabled feline occupies two contradictory states at once, and the same applies to this year's most prominent quantum advance.

In October, researchers from Google claimed to have achieved a milestone known as quantum supremacy. They had created the first quantum computer that could perform a calculation that is impossible for a standard computer. But IBM researchers countered that Google hadn't done anything special. The clash highlights the intense commercial interest in quantum computing, as companies jostle for position at the forefront of the field.

"It's obviously a pissing contest," says quantum physicist Simon Devitt of the University of Technology Sydney.

IBM, for instance, has made a fleet of 14 quantum computers accessible via the cloud. The largest has 53 qubits — the quantum version of the bits found in everyday computers. Google's latest quantum computer, Sycamore, also has 53 qubits. Among the others vying for a piece of the quantum action are Intel, Microsoft and Chinese companies Alibaba and Baidu.

Eventually, those companies expect, quantum computers could leave standard computers in the dust on a variety of problems, such as database searches, chemistry calculations and machine-learning tasks. And one day, perhaps decades from now, quantum computers with many millions of qubits could undermine the widely used encryption technique based on factoring very large numbers.

Anyone with a sufficiently powerful quantum computer could then steal credit card numbers and other sensitive data sent over the internet (*SN: 7/8/17 & 7/22/17, p 28*). As a result, we may need to use new quantum techniques to keep our information safe (*SN: 10/15/16, p. 13*).

Google researchers reported a demonstration of quantum computing's power in the Oct. 24 *Nature*. Sycamore took only 200 seconds to perform a calculation that the researchers estimated would have taken a state-of-the-art supercomputer 10,000 years to compute (*SN: 10/12/19 & 10/26/19, p. 8*). But IBM hit back with a paper suggesting an improved supercomputing technique that could theoretically perform the task in just 2.5 days. That's still a serious chunk of computing time on the world's most powerful computer, but not unattainable.

Whether Google's result fully qualifies as quantum supremacy depends on whom you ask. Some researchers are awaiting computers with more qubits, which could make a more clear-cut demonstration. Still, the result reveals a new level of control. Qubits tend to be error-prone, allowing mistakes to slip into calculations. Google's team had to coax a large number of delicate qubits to behave all at once.

"What I think is most significant about what the Google group achieved is they built a really good piece of hardware," says theoretical physicist John Preskill of Caltech. "It's a testament to how the technology has been advancing."

Google researchers plan to continue increasing the number and performance of qubits in their quantum computers, solidifying their toehold in the quantum supremacy regime. And the team is now setting its sights on another goal: a technique known as quantum error correction that would tame the mistakes that do slip through. By combining several qubits into one effective qubit, researchers could detect when an error occurs and fix it. "We're definitely on the road to do that with this result," Google researcher John Martinis said October 23 in a news conference announcing the company's quantum supremacy result.

Whether it's here or just around the corner, quantum supremacy has been compared to the Wright brothers' first flight at Kitty Hawk, N.C., in 1903. Airplanes became a reality but weren't practically useful — yet the milestone still made the history books. In the same vein, quantum computers haven't yet achieved their revolutionary potential.

Quantum supremacy is "not going to change the world overnight. We have to be patient," Preskill says. But for now, he says: "Let's celebrate." ■

8 Big threats to biodiversity startled the world

By Susan Milius

Some big numbers from nature made news in 2019. They were enough of a shock to get people talking about the dwindling diversity of plants, animals and other life on Earth, and what to do about it.

Some of that dramatic news came from the Amazon, where satellites picked up signs of a very active start to the annual fire season. The risk of a record-breaking season renewed worries about one of the richest reservoirs of biodiversity on Earth.

In August alone, satellite-based imaging instruments called MODIS logged 11,516 detections of fire in the large, northwestern Brazilian state of Amazonas. The number isn't individual fires, but the number of pixels, each measuring at least a square kilometer, containing fire activity, explains Louis Giglio of the University of Maryland in College Park, a specialist in detecting fires with remote instruments. (Higher numbers reported by some news outlets tallied detections from an instrument with smaller pixels.)

As the fire season drew to a close in late October, Giglio worked out the big picture for the year. While fire risk in most of South America in 2019 was "very average," Amazonas was "where chaos ensued," he says. The fire detections for August exceeded all MODIS records for that month, which go back almost two decades, Giglio says. He ranks the 2019 fire season, from late June through October, as the second worst for Amazon burning, after the 2005 season.

The damage distresses Alexandre Aleixo of the University of Helsinki, who lived in the Amazon forest studying its birds for 16 years. He worries that the lure of land for farming in Brazil's pro-development political climate is leading to land-clearing fires that easily jump into protected areas, threatening the biodiversity there.

Clearing jungles for soybeans or cattle is a good example of what a 2019 United Nations report called the main threat to nature: humans taking over wilderness for their own uses. That report made news by saying that around a million or so species of plants and animals globally — about 1 in 8 — face accelerated extinction unless damaged habitats are restored (*SN: 6/8/19, p. 5*). "Dead species walking" is one term used in the 1,500-plus-page draft of the report, released in an early form in May by the U.N.'s Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.

The real total of Earth's imperiled species is probably larger than a million. The U.N. panel didn't assess the abundant forms of fungi, which have given humans bread, wine and antibiotics, or the vast universe of nonfungal microbes. Even plant and animal numbers are estimates, of course; humans haven't come anywhere close to giving names to all of Earth's complex life.

The number 3 billion also startled people, prompting stories of the way things used to be. It's the estimated total population drop in birds in the United States and Canada since 1970 (*SN: 10/12/19 & 10/26/19, p. 7*). Digging into decades of sightings of 529 species, including records from citizen scientists, researchers detected a growing bird deficit. Many rare birds known to be in peril have continued to decline, but unnervingly, even some common birds are dwindling. Pushy and adaptable starlings dropped 63 percent, for example. Today, overall, 29 percent fewer birds, the team estimates, are flying around in the United States and Canada than there were 50 years ago.

A fire burns in Brazil's Amazon region on August 25, 2019.

VICTOR MORIYAMA/GETTY IMAGES

That loss "is a punch in the gut," study coauthor Peter Marra of Georgetown University in Washington, D.C., told *Science News* when the research was released. It means fewer beaks to handle many ecosystem jobs, such as nabbing insects out of the air, spreading the pollen of deep-throated flowers or giving fruit seeds an intestinal ride to new homes.

Climate change is another of the U.N. report's top five threats to biodiversity, and fighting it by planting trees to trap greenhouse gases sparked conversation this year. Ethiopia's office of the prime minister tweeted that the nation planted more than 353 million tree seedlings on a Monday in July, declaring the feat a world record.

There's room left on Earth to plant enough trees to trap an enormous amount of carbon, estimated ecologist Tom Crowther of ETH Zurich and colleagues in a high-profile and controversial paper published in the July 5 *Science*. It claimed that Earth has around 0.9 billion hectares suitable for planting more trees, enough in theory to capture some 205 metric gigatons of carbon (*SN: 8/17/19, p. 4*).

The paper brought "fresh attention" to the science behind the idea, says Alan Grainger, a global change geographer at the University of Leeds in England. But more than 70 scientists joined forces to call those numbers an overestimation on October 18, also in *Science*. The debate over how much carbon could be captured goes on (*SN Online: 11/17/19*). Yet Crowther argues that planting trees across just 10 percent of the area the original paper identified would be a worthy goal. Even better, his critics say, is to avoid emitting all those greenhouse gases in the first place. ■

9 Moon landings were all the rage in 2019

By Maria Temming

Lunar-landing missions are back in vogue.

After decades with almost no traffic to the moon, space agencies clamored to send spacecraft to Earth's nearest neighbor in 2019. While the China National Space Administration parked the first spacecraft on the lunar farside, other missions met less-satisfying ends. Two probes, flown by the Israeli nonprofit SpaceIL and the Indian Space Research Organization, crash-landed on the moon and haven't been heard from since.

The moonshot renaissance is just getting started. China plans to launch another lunar lander next year. The European Space Agency is working on a series of moon landing missions with the Russian space agency Roscosmos. And NASA hopes to use several trips to the moon in the 2020s as a springboard for sending astronauts to Mars.

And "it's not just a government superpower that can achieve a lunar landing now," says planetary scientist Philip Metzger of the University of Central Florida in Orlando. Advances in navigation technology and robotics, along with lowered launch costs, have private companies planning their own trips.

Scientists are still learning from data collected by the Apollo missions (*SN: 7/6/19 & 7/20/19, p. 26*), and satellites have watched the moon from afar in the decades since. But orbital observations can't compete with closeup views, says Steven Clarke, deputy associate administrator for exploration at NASA's Science Mission Directorate in Washington, D.C. To help solve mysteries about the solar system's history and prepare for future human visits to the moon, "you really need to go actually touch the samples that you want to examine," Clarke says.

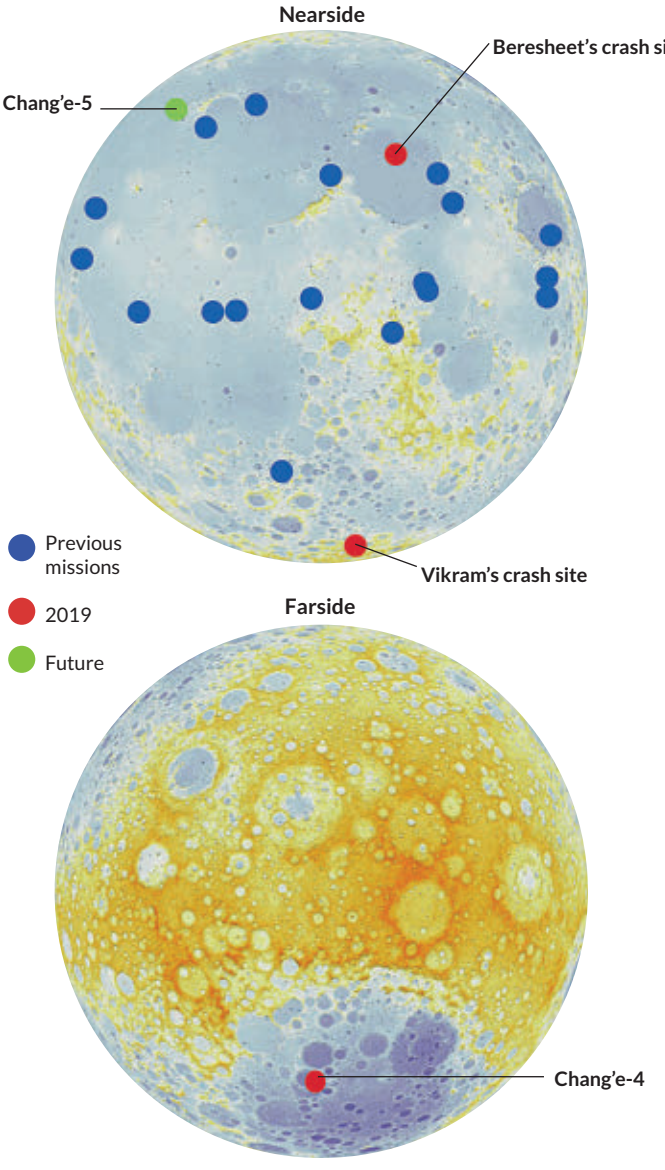
When the Chinese Chang'e-4 lander touched down on the moon's farside in January, it became the second spacecraft — after the Chang'e-3 mission in 2013 — to land on the moon since the Soviet Union's Luna 24 mission in 1976 (*SN Online: 1/3/19*). Already, the Chang'e-4 rover has discovered what appear to be bits of the lunar mantle mixed into the surface soil. If truly from the mantle, those minerals might help hammer out how the once-molten moon cooled and hardened (*SN: 6/8/19, p. 7*). Chang'e-5, expected to launch in 2020 and return moon rocks to Earth for the first time in over 40 years, could offer further insight into moon formation (*SN: 11/24/18, p. 14*).

The Israeli and Indian mission crashes were harsh reminders of how much can go wrong. In April, SpaceIL lost touch with its lunar lander, Beresheet, mere minutes before the spacecraft was supposed to land (*SN Online: 4/11/19*). Likewise, India lost contact with its Vikram lander right before the probe crashed on the lunar surface in September (*SN Online: 9/20/19*). Vikram was supposed to get closer than any other rover to the moon's south pole, where orbiters have detected water ice.

"Getting data on the ice [would] be game-changing," Metzger says. There's a good chance that much of this ice came to the moon on comets, and Earth could have gotten its water and other ingredients for life in a similar way. Studying the lunar ice could offer clues about when it arrived and where in the solar system it originated, he says.

Water from this ice might help sustain future human visitors on the moon, Clarke adds. To take inventory of that potential resource, NASA plans to send a rover called VIPER to the lunar south pole in 2022. China also has a lander bound for the south pole in 2023. The Israeli and Indian groups have not announced plans for new lunar landing attempts.

By sending spacecraft to never-before-visited locales, NASA and other lunar-landing hopefuls can help create a more global profile of the moon, Metzger says. "The area of the moon is equivalent to an entire continent on the Earth," he notes. Despite all we've learned, "we've barely touched the surface of the moon." ■



Touchdown Before 2019, 20 spacecraft had successfully landed on the moon (some at the same site). This year, China's Chang'e-4 became the first to visit the farside, and two other countries' landers crashed.

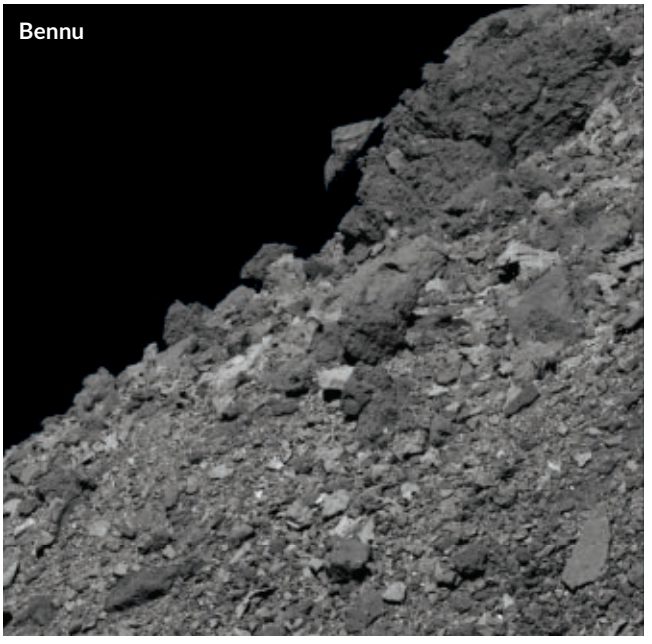
W. WU ET AL/NATURE GEOSCIENCE 2019. ADAPTED BY T. TIBBITTS

A year of closer looks at distant rocks

By Maria Temming

From asteroids to exoplanets, spacecraft are leaving no space rock unturned. While agencies in China, India and Israel made headlines with missions to the moon (see Page 31), here are some other places that space probes scouted in 2019.


Arrokoth (formerly known as Ultima Thule)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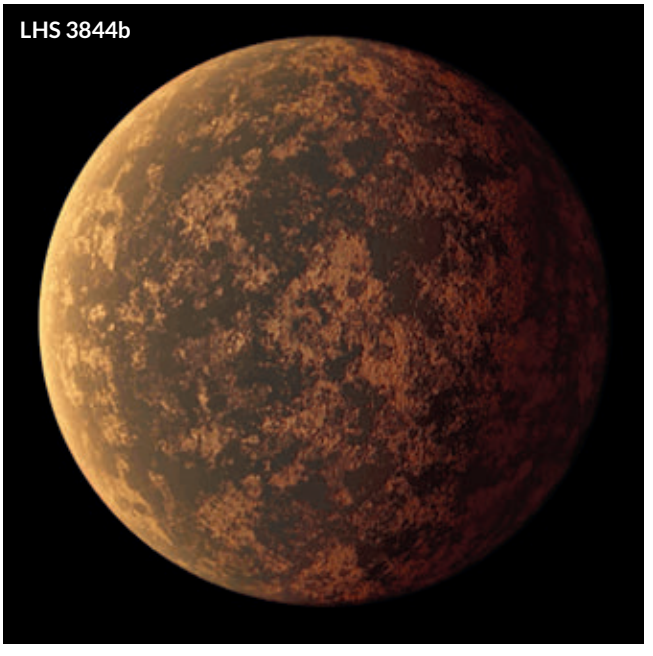

LHS 3844b

Zoom and enhance

Touring Pluto in 2015 may have been New Horizons' main event (*SN: 12/26/15, p. 16*), but flying by what used to be called Ultima Thule (shown above) was an awesome encore. The space probe zipped by this Kuiper Belt object, now called Arrokoth (see Page 5), on New Year's Day (*SN: 2/2/19, p. 7*). Scientists were on the edge of their seats as the probe snapped pictures and sent higher- and higher-resolution images over several weeks, revealing the visage of Arrokoth to look like an elongated blob, then a snowman and finally a pair of lumpy pancakes (*SN: 3/16/19, p. 15*). Uncovering the origins of Arrokoth's awkward shape may lend insight into the early stages of planet formation (*SN: 4/13/19, p. 11*).

I spy exoplanets

NASA's Transiting Exoplanet Survey Satellite, or TESS, racked up eight exoplanet finds in its first few months of observation (*SN: 2/2/19, p. 12*). That initial cache included some weirdos, such as a planet that is about as dense as pure water and a "lava world" known as LHS 3844b (illustrated above) that sizzles at about 540° Celsius. TESS has since discovered a new type of exoplanet called an ultrahot Neptune, which appears to be a fluffy gas giant in the process of stripping down to its rocky core (*SN: 8/31/19, p. 11*).

Asteroids to go

The Japan Aerospace Exploration Agency's Hayabusa2 is expected to become the second spacecraft ever to bring a bit of asteroid back to Earth, after the original Hayabusa probe returned with a souvenir from the asteroid Itokawa in 2010. Hayabusa2 touched down on the asteroid Ryugu in February to fetch a sample from the asteroid's surface. Then, to get a deeper sample, Hayabusa2 fired a copper projectile at Ryugu

CLOCKWISE FROM LEFT: NASA, JHUAPL, SWRI; GODDARD/NASA, UNIV. OF ARIZONA; TESS/MIT AND NASA

to punch a crater into the asteroid (*SN Online: 4/5/19*). The probe then ducked down to snag some rubble excavated from the interior (*SN: 8/17/19, p. 14*). Scientists won't know exactly how much of Ryugu was collected until Hayabusa2, which started its journey home on November 13, arrives at Earth in late 2020.

Another sample-return mission, NASA's OSIRIS-REx, is still orbiting its asteroid. When the spacecraft first arrived at Bennu in December 2018, observations unveiled a rugged surface littered with boulders (shown on opposite page) — bad news for a probe designed to navigate more beachlike terrain (*SN: 4/13/19, p. 10*). NASA plans to use OSIRIS-REx's detailed maps of Bennu from orbit to select a site for sample collection, scheduled for mid- to late 2020. Bits of Bennu, to be returned in 2023, may reveal whether a similar asteroid could have delivered to early Earth a molecular starter pack for life (*SN: 1/19/19, p. 20*).

Meanwhile, on Mars

InSight arrived on the Red Planet in November 2018, and the rookie rover may have already captured the first recording of a Marsquake (*SN Online: 4/23/19*). Unlike tremors on Earth, underground rumblings on Mars are thought to result from the planet contracting as it cools. Studying such seismic signals could help scientists better understand the structure of Mars' deep interior.

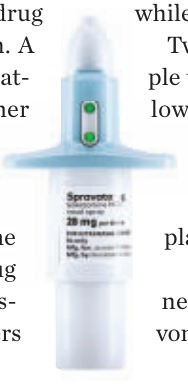
While InSight had its ear to the ground, the veteran Curiosity rover was measuring the consistency of a Martian mountain (*SN Online: 1/31/19*). As Curiosity scaled Mount Sharp, accelerometer readings indicated surprisingly loose rock beneath the rover's wheels — suggesting that winds formed the mountain by sweeping sediment into a giant pile. ■

10 New drug approved for severe depression

By Laura Sanders

For the first time in decades, a fundamentally new drug became available for people with severe depression. A nasal spray called Spravato offers a new option for treating people whose depression hasn't responded to other approaches. But there are still big questions about the drug's effectiveness and safety (*SN: 4/13/19, p. 8*).

In March, the U.S. Food and Drug Administration approved Spravato. The drug contains esketamine, one of two mirror-image molecules that make up the drug ketamine. Developed decades ago as a powerful anesthetic, ketamine is also a hallucinogen co-opted by ravers and other partiers for its swirly, out-of-body highs.



The antidepressant Spravato can be taken only at certified health clinics, to allow for close patient monitoring.

JANSSEN PHARMACEUTICALS, INC.

Many existing antidepressants target serotonin, a chemical messenger in the brain involved in mood. Scientists think ketamine and its relatives affect a different chemical messenger, glutamate, sometimes within hours.

For all the fanfare over Spravato's approval, ketamine's power to quickly turn around severe depression in some people has been known for years. Freestanding clinics, as well as academic medical centers, offer intravenous infusions of ketamine to people with severe depression. For some patients, the treatment has been life-changing. Yet others don't respond. "It's not for everybody," says Cristina Cusin, a psychiatrist who codirects the ketamine clinic at Massachusetts General Hospital in Boston.

Spravato received fast-track approval from the FDA based on what some critics call weaker-than-usual evidence: In two of three monthlong trials, Spravato didn't outperform a placebo, for instance. Janssen Pharmaceuticals, the drug's maker, is still tallying data and trying to determine which patients might be helped most by the drug.

On September 9, the company reported mixed results from two drug trials involving 456 people who were suicidal and hospitalized with severe depression. All participants received standard care, which included treatment with a standard antidepressant. On top of that, some people also received Spravato, while others took a placebo.

Twenty-four hours after beginning treatment, the people taking Spravato scored on average almost four points lower on a 60-point depression scale than people who had received a placebo — a small but consistent difference. Yet, suicidal behavior did not differ between people who took Spravato and those who took the placebo; both groups improved.

Spravato comes with a long list of side effects: sleepiness, dizziness, anxiety and feelings of disconnection, vomiting, increased blood pressure and bladder problems. And like ketamine, Spravato can be abused. For these reasons, the FDA requires that the drug be taken only in a certified health clinic, so the patient can be monitored for several hours after using it.

As of mid-October, more than 2,000 clinical sites had been certified to dispense Spravato, according to Janssen. A typical schedule might include twice-a-week doses for the first month, then a gradual tapering. The drug's estimated price is about $32,000 for a year, which doesn't include the costs of clinic time required for monitoring. It's unclear whether or how insurance companies will cover Spravato, Cusin says, though the U.S. Department of Veterans Affairs is offering the drug in limited cases.

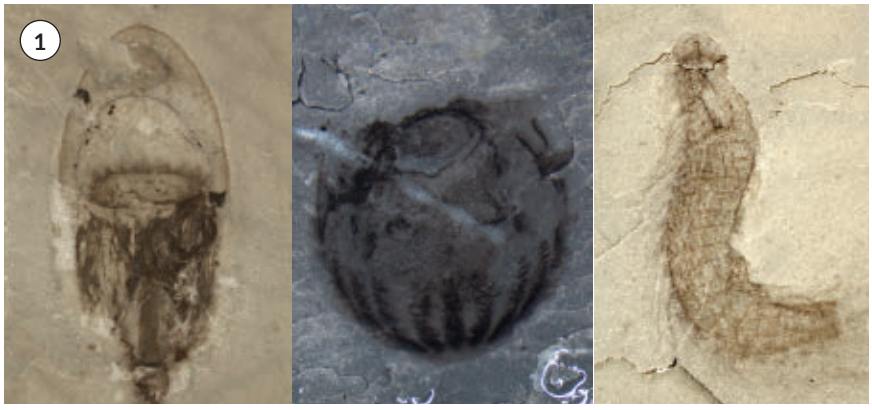
Researchers are pushing ahead on other ketamine offshoots. Early studies in lab animals suggest that arketamine, the mirror image of esketamine, and breakdown products of ketamine could be turned into drugs that are effective and have fewer side effects than ketamine or esketamine. ■

The National Suicide Prevention Lifeline can be reached at 1-800-273-TALK (8255).

Fabulous fossils

By Carolyn Gramling

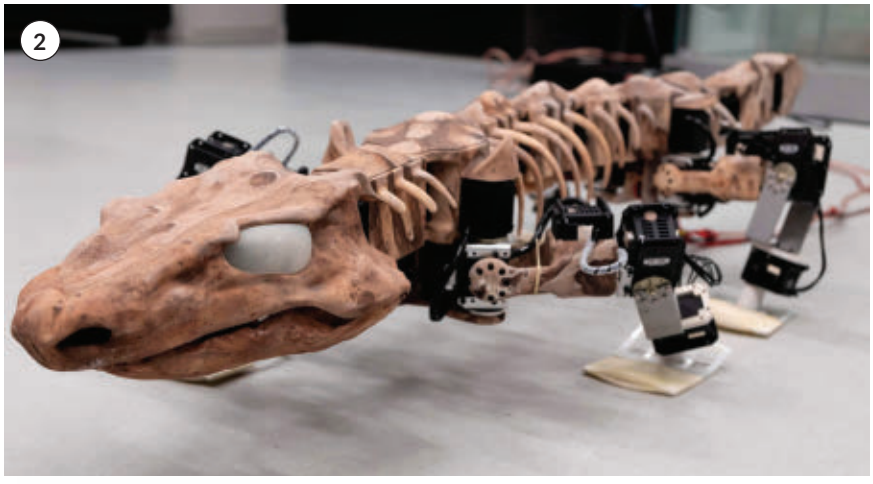
This year's fossil finds, from vast new collections of species to wonderful and weird curiosities, helped reveal the richness and diversity of life on Earth over the last half a billion years.



1. Impressive invertebrates

518 MILLION YEARS AGO

China's Qingjiang biota is a treasure trove of beautifully preserved fossils, including jellyfish (left), comb jellies (middle), mud dragons (right) and arthropods. The remains document the Cambrian explosion, a rapid flourishing of life-forms, and include many organisms never seen before — even at the most famous Cambrian fossil site, Canada's Burgess Shale (*SN: 4/27/19, p. 14*).



2. Tetrapod walking

290 MILLION TO 280 MILLION YEARS AGO

Using re-created skeletons, fossil trackways, computer simulations and a robot (shown), scientists concluded that four-footed *Orobates pabsti* held its belly off the ground as it walked with minimal side-to-side undulation. For such an ancient critter, *O. pabsti* — one of the earliest amniotes, a group that includes reptiles and mammals — had a surprisingly efficient gait (*SN: 2/16/19, p. 7*).

3. Oldest bone cancer

240 MILLION YEARS AGO

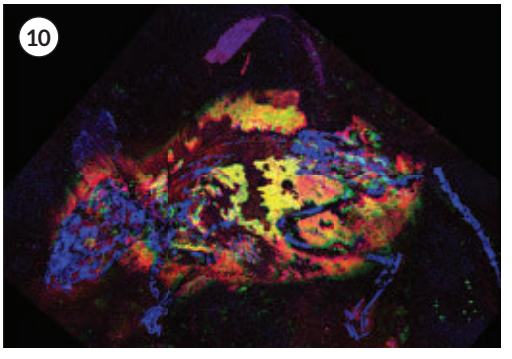
A growth preserved in the fossilized left femur of an ancient turtle relative is the oldest known case of bone cancer in an amniote (bracket indicates the tumor on the several-centimeters-long fossil) (*SN: 3/16/19, p. 5*).

4. A bone for chewing

165 MILLION YEARS AGO

Millions of years before true mammals emerged, a shrew-sized mammal relative, *Microdocodon gracilis* (illustrated), had a flexible bone called the hyoid connected to the jaw. The hyoid helps mammals chew, swallow and suckle — a key innovation that may be one secret to mammals' success (*SN: 8/17/19, p. 8*).

1: D. FU *ET AL/SCIENCE* 2019; 2: TOMISLAV HORVAT AND K. MELO/EPFL LAUSANNE; 3: Y. HARIDY *ET AL/JAMA ONCOLOGY* 2019; 4: APRIL I. NEANDER/UNIV. OF CHICAGO



5: A.M. BAILLEUL *ET AL/NAT. COMMUN.* 2019; 6: ZHONGDA ZHANG/*CURR. BIOL.*; 7: ANDREY ATUCHIN; 8: HHMI TANGLED BANK STUDIOS; 9: DALE OMORI/CLEVELAND MUSEUM OF NATURAL HISTORY; 10: P.L. MANNING *ET AL/NAT. COMMUN.* 2019

5. Unlaid egg

110 MILLION YEARS AGO

A small bird died with an egg (arrow) still inside her body, and problems laying that egg may have led to her death. Crushed and flattened over time by pressure, the specimen is the first unlaid bird egg found preserved as a fossil (*SN: 4/13/19, p. 15*).

6. Long-toed bird

99 MILLION YEARS AGO

A chunk of amber containing the right leg and foot of a sparrow-sized bird (illustrated) revealed a bizarrely long digit. The bird may have used the toe to feel around for food in hard-to-reach places (*SN Online: 7/11/19*).

7. Tiny *Tyrannosaurus rex* cousin

92 MILLION YEARS AGO

Decades after its discovery, a dinosaur was ID'd as a cousin to the giant tyrannosaurs. Just a meter tall at the hip, *Suskityrannus hazelae* (illustrated) had a strong jaw and powerful hind feet, like its bulkier kin *T. rex*, which lived 24 million years later (*SN: 6/8/19, p. 5*).

8. Life after the dinosaurs

66 MILLION TO 65 MILLION YEARS AGO

The story of how life rebounded after the mass extinction of nonavian dinosaurs is told by fossils found in Colorado (a mammal skull shown). The fossils, dating to within a million years after the die-off, reveal that mammals grew fivefold in size and big plants rapidly diversified (*SN: 12/7/19, p. 32*).

9. Face-off

3.8 MILLION YEARS AGO

A nearly complete skull gives the first glimpse at the face of *Australopithecus anamensis*, the oldest known species in the hominid genus that includes *A. afarensis*, best known for Lucy's skeleton. The find raises questions about how the two species were related (*SN: 9/28/19, p. 6*).

10. Little red mouse

3 MILLION YEARS AGO

An ancient mouse bears the first identifiable chemical traces of difficult-to-detect pheomelanin, the pigment responsible for reddish-brown fur (*SN: 6/22/19, p. 14*). X-ray spectroscopy revealed red to brown fur (yellow areas) on the mouse's back and sides. ■

Big science claims await more evidence

By Cassie Martin

Discoveries about dinosaurs' death knell, a watery exoplanet, a new hominid species and more are keeping us on the edge of our seats. But these reports require more proof before they can earn a spot on our list of top stories.

Dino doomsday

When an asteroid smashed into Earth about 66 million years ago, it triggered an immense earthquake. A fossil site in North Dakota records the mayhem in the hours after impact, scientists reported in the *Proceedings of the National Academy of Sciences*. But what's more tantalizing is what the researchers may have left out of their scientific paper. Robert DePalma, a paleontologist at the University of Kansas in Lawrence and an author on the paper, told the *New Yorker* that the team found fossilized dinosaurs, pterosaurs and even feathers at the site (*SN: 4/27/19, p. 10*). Because so few dinosaur fossils from just before the impact have been found, some scientists think that the animals were already dying out. If dinosaur fossils do exist at the site, that's more evidence that the asteroid impact was to blame.

Soggy skies

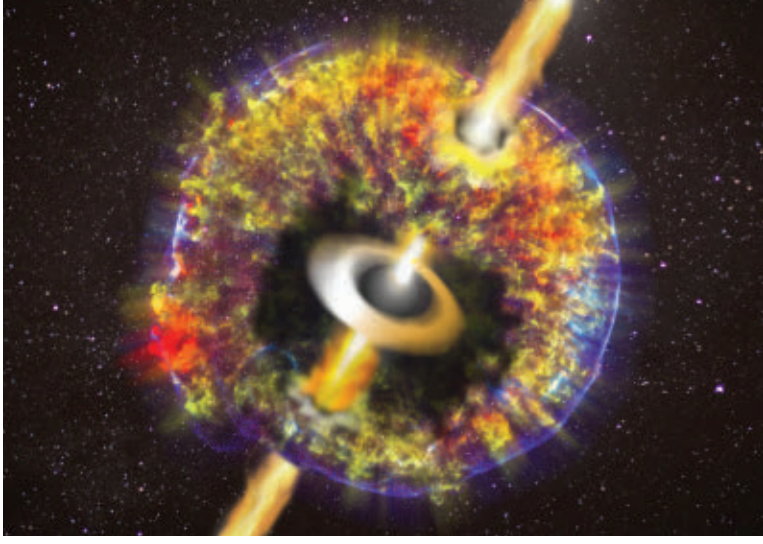
Water vapor detected in the atmosphere of an exoplanet 110 light-years away from Earth had astronomers saying K2 18b is the first known planet orbiting a distant star that might have liquid water (*SN: 10/12/19 & 10/26/19, p. 6*). K2 18b might even have water clouds and rain, scientists suggest. Observations with NASA's James Webb Space Telescope, slated to launch in 2021, could help determine if and how much liquid water, thought to be a key ingredient for life, K2 18b has. But even if the exoplanet is awash in the wet stuff, that doesn't mean the planet is habitable (*SN Online: 10/4/19*).

What lies beneath

A cache of tiny animal carcasses was dredged up from Antarctica's perpetually ice-covered Lake Mercer, scientists revealed this year. The find was a surprise because this extreme environment was thought to be friendly only for microbes (*SN: 2/16/19, p. 11*). The limits of habitability may be less narrow than previously thought. But it's also possible that the remains — including what look like tardigrades, crustaceans, spiders and worms — were carried into the lake by ice or water.

Hello, *Homo luzonensis*

Fossils discovered in a Philippine cave suggest that an unknown hominid species roamed the island now called Luzon at least 50,000 years ago. The proposed new species, dubbed *Homo luzonensis*, lived around the same time that small hominids wandered the Indonesian island called Flores. The shape and size of some of the fossils match corresponding bones from known *Homo* species. But the combination of features is unique, researchers say. If confirmed as a separate species, *H. luzonensis* would be the latest addition to the human evolutionary family tree. The find would also indicate that several *Homo* groups inhabited East Asia and Southeast Asian islands by the time humans reached southern China, complicating scientists' view of hominid evolution in Asia (*SN: 5/11/19 & 5/25/19, p. 7*).



Neutron star mergers (the aftermath of one is shown in this illustration) may be a source of short gamma-ray bursts, a team reported in February.

O.S. SALAFIA, G. GHIRLANDA, CXC AND GSFC/NASA, B. WILLIAMS *ET AL*

Stellar jet-setter

When two neutron stars crashed into each other, as reported in *Science News*' top story of 2017, the collision blasted a jet of charged particles into space, new observations suggest (*SN: 3/30/19, p. 7*). The find supports a theory that mysterious flashes of high-energy light called short gamma-ray bursts are actually jets from neutron star collisions. But researchers will need to observe more of these stellar smashups to figure out if the jets are the norm, or if the 2017 jet was a fluke.

Sixth sense

Similar to birds and fish, humans may sense Earth's magnetic field, a study of brain waves suggests (*SN: 4/13/19, p. 6*). In lab tests, people displayed a distinct brain wave pattern when exposed to an Earth-strength magnetic field. But the pattern formed only when the field pointed and moved in a certain way. Even if the finding is confirmed, it's not clear what we would do with this "sixth sense," or how we would pick up the signal.

Clearing the way

Flickering lights and clicks improved memory in mice with signs of Alzheimer's disease. The light and sounds boosted gamma waves in the brain, which seemed to wipe away disease-related plaques (*SN: 4/13/19, p. 9*). Mice that received treatment had fewer amyloid-beta plaques in areas of the brain usually hit hard by the disease, plus less of a harmful version of tau protein. Plaque-eating immune cells were kicked into a feeding frenzy, scientists reported. If the treatment works in people (tests are now under way), it would open a new way to target the degenerative disease. But many treatments that have reduced signs of the disease in mice haven't had the same effect in humans. ■

The waiting game

By Erin Wayman

A recap of the year in science is not complete without a look ahead. Rather than consult a crystal ball (we cover science, after all), we asked our reporters what events, projects and findings they're watching — or wishing — for in 2020.

Cosmic clarity

When astronomy writer Lisa Grossman and physics writer Emily Conover predicted in 2018 that the Event Horizon Telescope, or EHT, would soon capture an image of Sagittarius A*, the black hole at the Milky Way's center, they were half right. EHT's first image came through in 2019, but it was of the black hole at the center of galaxy M87 (see Page 22). Grossman and Conover have their fingers crossed that Sagittarius A* gets its big moment in 2020. Another cosmic recluse, dark matter, might also come into view in 2020. The LUX-Zeplin, or LZ, experiment, housed in a former gold mine in South Dakota, will begin its search for WIMPs, weakly interacting massive particles. These still-theoretical particles "have been the favored candidate for an explanation of dark matter," Conover says. Other searches have failed, but LZ will be 20 times as sensitive as previous WIMP searches.

Space explorers

Grossman looks forward to the midyear launches of two Mars missions: NASA's Mars 2020 and ExoMars, a joint mission of the European Space Agency and the Russian space agency Roscosmos. The missions' rovers will search for signs of past life. NASA's robotic explorer will also gather rocks for collection by a potential future mission that would bring bits of the Red Planet to Earth. Physical sciences writer Maria Temming is meanwhile preparing for a more distant visitor. This year, astronomers identified the second known interstellar object in the solar system (*SN: 11/9/19, p. 13*), what appears to be a comet. (The first visitor, 'Oumuamua, was spotted in 2017.) Estimates suggest that such guests should show up about once every year, Temming says.

Drug watch

Biomedical writer Aimee Cunningham expects results from a clinical trial of a male birth control pill. An early test found that the hormonal pill is safe and suppresses hormone levels necessary for sperm production (*SN: 4/14/18, p. 10*). The new study will assess how well the pill does the job.

A potential drug for Alzheimer's disease called aducanumab may move closer to approval. Pharmaceutical company Biogen is expected to seek U.S. Food and Drug Administration approval for the drug — "a move that promises to be controversial, considering the drug's checkered past," says neuroscience writer Laura Sanders. Aducanumab made our Top 10 list in 2016 after early studies suggested the drug can clear the amyloid-beta plaques seen in Alzheimer's (*SN: 12/24/16 & 1/7/17, p. 27*). But later results were disappointing, until reports in October that the highest dose of the drug seemed to slow memory decline.

Grizzly bears have benefited from protection under the U.S. Endangered Species Act. Changes to how the law is applied may limit species' protections.

JILL RICHARDSON/ISTOCK/GETTY IMAGES PLUS

The molecular level

Direct-to-consumer genetic testing companies could cause their own controversy, predicts molecular biology writer Tina Hesman Saey. Many of these companies, such as AncestryDNA, are expanding their services to offer more information about health, and the FDA may crack down on the kind of info that can be provided, Saey says. Behavioral sciences writer Bruce Bower expects molecular biology to play a bigger role in human evolution studies. Increasingly, researchers are supplementing studies of ancient DNA extracted from hominid fossils with analyses of extracted proteins, which preserve better in fossilized bones and teeth than DNA does, he says. As with DNA, proteins can help identify new species and untangle evolutionary relationships.

Science and politics

2020 will be a big year for science and policy. The U.S. Census is being offered online for the first time, and field-workers visiting the homes of those who don't respond will log their responses on smartphones. Social sciences writer Sujata Gupta wonders how that will turn out. "A lot of people still lack reliable access to the internet, so will that lead to an undercount? And among whom? What about cyberattacks?"

The effect of politics on wildlife is on the minds of life sciences writers Susan Milius and Jonathan Lambert. As the United Nations Decade on Biodiversity comes to an end in 2020, a draft report says that the world missed most of the decade's targets, Milius says. She's watching to see how experts regroup. For Lambert, changes to how the U.S. Endangered Species Act is applied, announced by President Donald Trump's administration in August, spark questions about the future of certain species.

By the end of 2020, "the world may get a glimpse of just how committed to combating climate change nations are," says earth and climate writer Carolyn Gramling. In 2015, signatories to the Paris climate treaty agreed to hold global warming by 2100 to well below 2 degrees Celsius relative to preindustrial levels. But current carbon-cutting pledges won't get us there. In December 2020, countries are required to submit updated emissions targets. The U.S. exit from the agreement will be finalized in November 2020, but the U.S. presidential election that month could determine whether the country re-enters the treaty in 2021. ■

BOOKSHELF

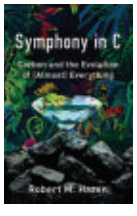
Our favorite books of 2019

Charismatic creatures, a life-giving element, crime-solving spores, the first Apollo moon landing and multiple universes are among the subjects of the books that enthralled the *Science News* staff this year. Find longer reviews of these must-reads at **bit.ly/SN_books2019**

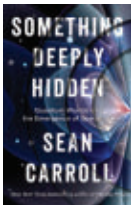
Mama's Last Hug
Frans de Waal
Joy, empathy, fear, envy, disgust, sadness and other emotions are found throughout the animal kingdom, a primatologist argues in this anecdote-filled book. Studying those reactions may lead to insights about the origins of human emotions (*SN: 3/2/19, p. 28*).
W.W. Norton & Co., $27.95

Slime
Ruth Kassinger
This ode to algae celebrates a diverse group of organisms that have shaped Earth's environment for billions of years — and have proved useful to humankind in everything from agriculture to industry (*SN: 6/22/19, p. 28*).
Houghton Mifflin Harcourt, $26

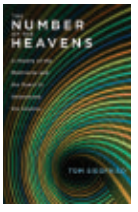
A Polar Affair
Lloyd Spencer Davis
At the center of this thought-provoking scientific mystery is the question of why an early 20th century explorer kept his observations of penguins' sex lives a secret (*SN: 12/7/19, p. 26*).
Pegasus Books, $29.95



Symphony in C
Robert M. Hazen
Carbon takes center stage in this fact-stuffed "biography" that documents the chemical element's history and vital role in chemistry, biology, geology and human society (*SN: 6/8/19, p. 29*).
W.W. Norton & Co., $26.95

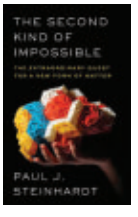


Something Deeply Hidden
Sean Carroll
In this highly readable book, a physicist builds a case for the Many-Worlds Interpretation of quantum mechanics, which states that all possible outcomes of quantum experiments actually exist, leading to multiple universes (*SN: 9/28/19, p. 26*). *Dutton, $29*

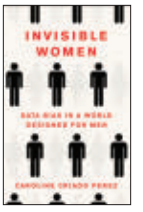


The Number of the Heavens
Tom Siegfried
Starting with the ancient Greeks, a former *Science News* editor in chief and current contributing correspondent chronicles how the concept of the multiverse has evolved as scientists' understanding of the universe has expanded (*SN: 10/12/19 & 10/26/19, p. 42*). *Harvard Univ., $29.95*

Moonbound
Jonathan Fetter-Vorm
In the style of a graphic novel, this book offers an exciting retelling of the Apollo 11 moon landing, weaving in key stories from the history of astronomy and space exploration (*SN: 7/6/19 & 7/20/19, p. 42*).
Hill and Wang, $35

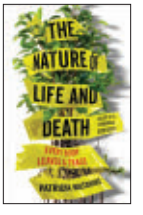


The Second Kind of Impossible
Paul J. Steinhardt
A physicist journeys from the lab to the Siberian wilderness to prove quasicrystals — materials whose atoms have an order that does not repeat — exist in nature (*SN: 3/2/19, p. 28*).
Simon & Schuster, $27



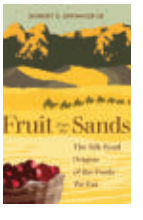
Invisible Women
Caroline Criado Perez
Using examples from medicine, economics and more, a journalist shows how research that views men as the norm and neglects to collect data on women puts women's health and well-being at risk (*SN Online: 4/19/19*). *Abrams Press, $27*

Good to Go
Christie Aschwanden
A science writer puts cryotherapy, compression tights, supplements and other postexercise activities to the test as she investigates whether these sports-recovery techniques work better than plain old rest (*SN: 2/2/19, p. 28*).
W.W. Norton & Co., $27.95



The Nature of Life and Death
Patricia Wiltshire
A botanist offers a crash course in forensic ecology, drawing on two decades' worth of her own cases to show how pollen and spores can bring criminals to justice (*SN: 9/14/19, p. 26*).
G.P. Putnam's Sons, $27

Archaeology from Space
Sarah Parcak
An archaeologist leads a lively tour of the past, present and future of space archaeology, which uses satellites and other remote-sensing techniques to discover ancient sites on Earth (*SN: 8/17/19, p. 28*).
Henry Holt and Co., $30



Fruit from the Sands
Robert N. Spengler III
This culinary journey back in time traces the spread of apples, rice, tea, wheat and other popular staples to Asia's ancient Silk Road trading routes (*SN: 8/3/19, p. 28*).
Univ. of California, $34.95

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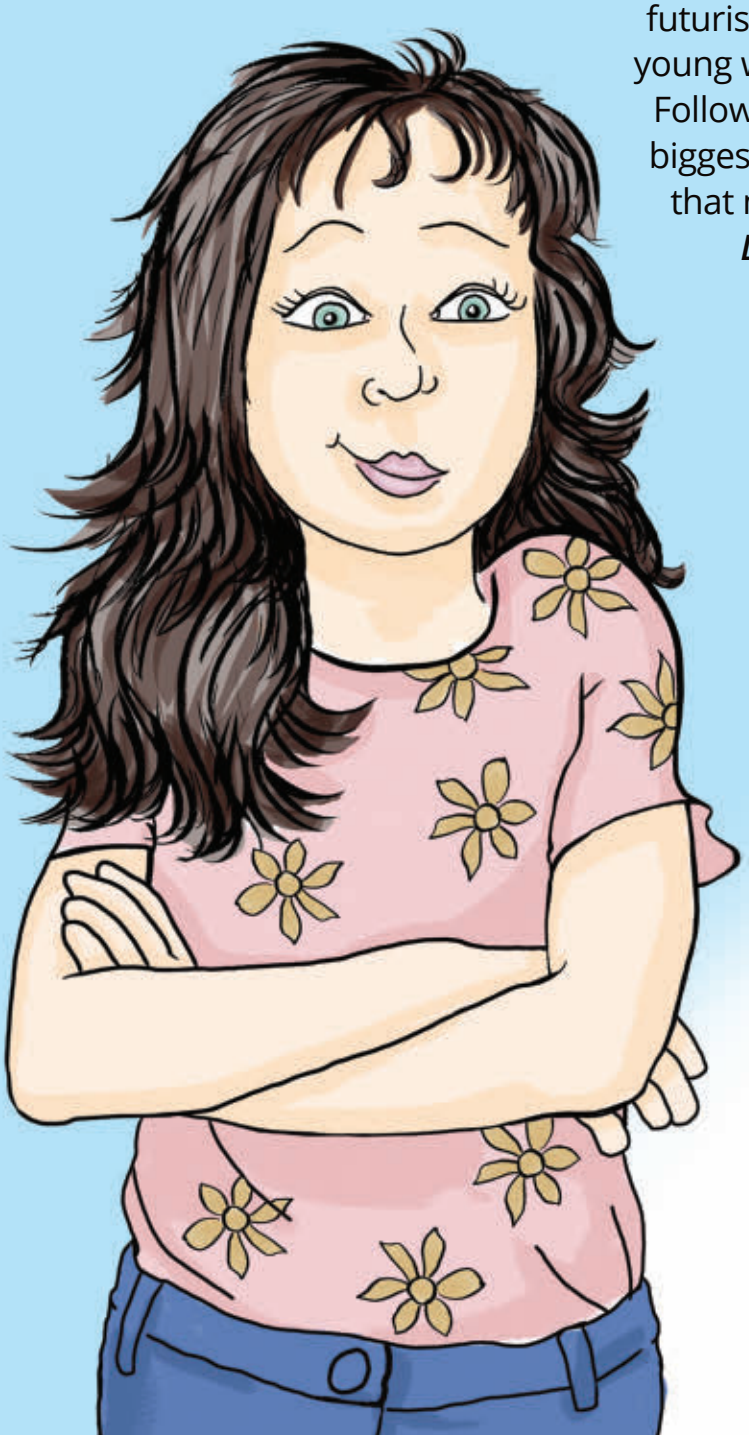

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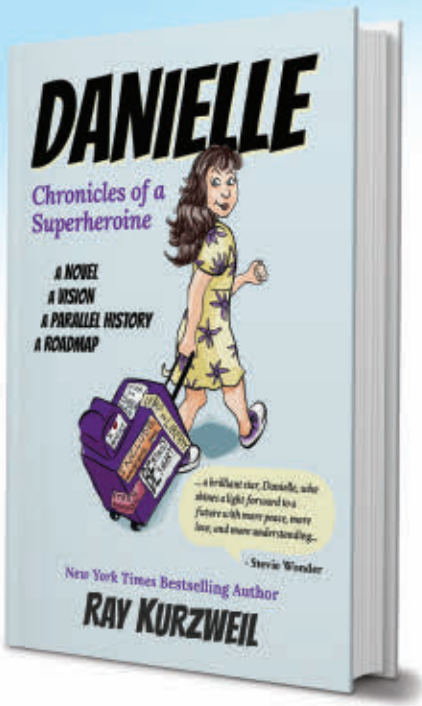
Pinnacle Book Achievement Award

Moonbeam Children's Book Awards GOLD

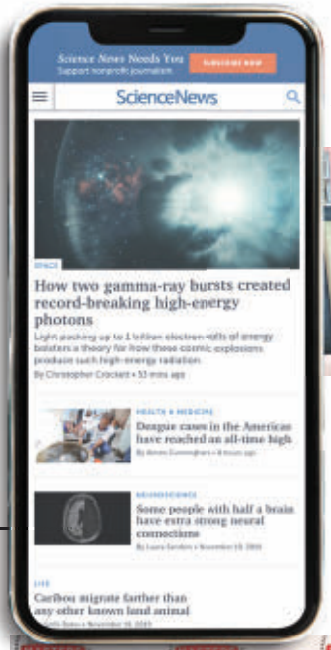


TOP MOMENTS 2019

Society for Science & the Public, which publishes *Science News*, had a successful year expanding scientific literacy, STEM education and scientific research. Here are some of the highlights.

Intel International Science and Engineering Fair (ISEF)

The Society hosted the largest ISEF ever with 1,842 finalists from 423 affiliated fairs in more than 80 countries, regions and territories.



New Websites

The Society, *Science News*, *Science News for Students* and *Science News* in High Schools unveiled redesigned websites this year.

Awards

Science News' Tina Hesman Saey (shown above) won the prestigious National Academies Communications Award, and *Science News for Students* was honored with a AAAS Kavli Science Journalism Award.

Middle School Expansion

The Society hosted our first Middle School Research Teachers Conference and launched the Lemelson Early Inventor Prize to recognize young inventors, including eighth-grader Izal Guerra (pictured above with his project).

Science News Coverage

Science News' award-winning breaking news coverage of the first image of a black hole was wildly popular, setting all-time website traffic records.

Broadcom MASTERS

For the first time, all the top winners in the Broadcom MASTERS, a nationwide STEM competition for middle school students, were girls.

Outreach and Equity

The Society named our largest number of Advocates — 60 educators and scientists — who mentor underrepresented and underserved students to guide them in entering science research competitions.

SOCIETY FOR SCIENCE & THE PUBLIC

New Leadership

The Society created a new Honorary Board made up of 22 distinguished scientists, engineers, entrepreneurs and innovators who are recognized leaders in their fields. The Society also welcomed *Washington Post* Health, Science and Environment Editor Laura Helmuth and California Institute of Technology President Thomas F. Rosenbaum to our Board of Trustees in 2019.

Regeneron Science Talent Search (STS)

Ana Humphrey won the top prize at the Regeneron STS, the nation's oldest and most prestigious science and math competition for high school seniors. She was the first Latina top award winner in 20 years.

GEOLOGIC ROAD TRIP OF THE MONTH

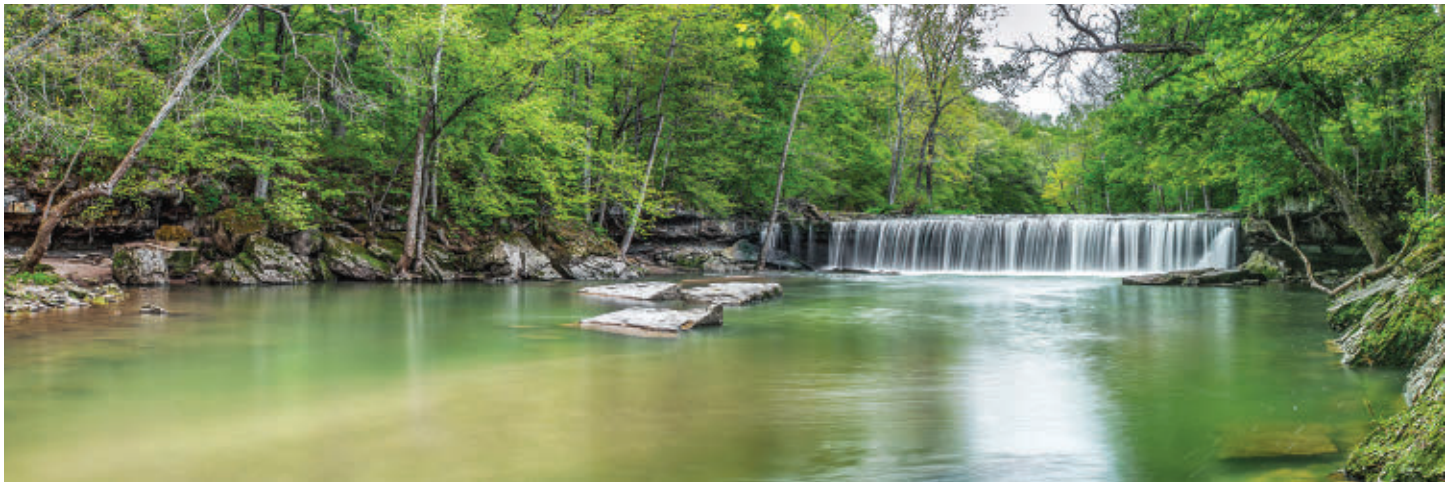
ANDERSON FALLS
Indiana's Niagara Falls

Anderson Falls in Bartholomew County is a miniature version of Niagara Falls. Located about 14 miles east of Columbus, the Fall Fork of Clifty Creek cascades over a 100-foot-wide bedrock ledge in the middle of the New Castle Till Plains. While significantly smaller than its New York counterpart, Anderson Falls provides a near-scale model of the geological processes at work in Niagara Falls and offers a welcome escape from the flat agricultural fields and residential areas that surround the region.

The rock-walled valley and waterfall at Anderson Falls are the result of differential erosion involving two bedrock formations. The lip of the falls is composed of erosion-resistant Geneva Dolomite of the Devonian-age Jeffersonville Limestone, and the underlying plunge pool is made of Silurian-age Waldron Shale. Just as the Niagara River eroded Silurian shale underlying dolostone to form Niagara Falls, the Fall Fork of Clifty Creek has undercut the soft, thinly bedded shale and limestone below a dolostone ledge to form Anderson Falls. Each time the dolomite ledge becomes unstable, large slabs break off and fall into the plunge pool below, moving the falls further upstream.

The 14-foot drop over the falls is the focal point of a 44-acre county park. To visit, park in the small lot on CR 1140 E, and walk across the road to an overlook platform. From here, follow the footpath upstream past the falls. When water levels are low and the limestone bedrock is exposed, you can carefully cross over the creek to the east bank and follow wooded trails through shaded ravines, floodplains, and streamside bluffs. Exposures of the Waldron Shale below the falls are full of fossils, but collecting is not permitted.

A 1-mile trail loops through the woods on the east bank of the Fall Fork of Clifty Creek. Be cautious of stream currents and slippery bedrock when crossing the river to reach the park trails.



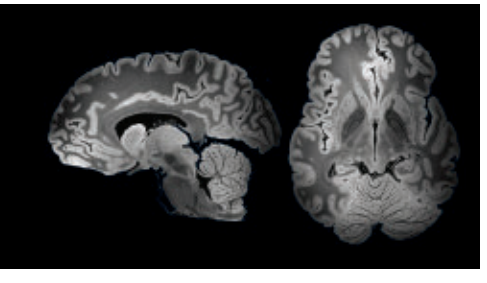
The Fall Fork of Clifty Creek streams over a lip of Geneva Dolomite to the less-resistant Waldron Shale below. —Courtesy of Lee Mandrell, Leman's Studios

Online favorites of 2019

Science News drew more than 15 million visitors to our website this year. Here's a rundown of the most-read news stories of 2019 that didn't make our Top 10 list (see Page 20), as well as the most popular longer reads.

Favorite visualization

Online readers were captivated by "A 100-hour MRI scan captured the most detailed look yet at a whole human brain" (*SN Online: 7/8/19*). With a high-resolution image of a preserved human brain (below), researchers could spot structures less than a tenth of a millimeter wide. That precision may someday help pinpoint in living brains abnormalities linked to comas, depression or other illnesses.



Top news stories

1 **A chip made with carbon nanotubes, not silicon, marks a computing milestone**
Researchers built a new kind of computer chip with thousands of carbon nanotube transistors. Though the prototype can't yet compete with silicon chips, carbon nanotube computing technology could lead to faster electronics (*SN: 9/28/19, p. 7*).

2 **People can sense Earth's magnetic field, brain waves suggest**
People's brain waves showed a distinct pattern when exposed to an Earth-strength magnetic field pointing in a specific direction in the lab. That finding hints that humans may have magnetoreception, similar to birds and certain other organisms (see Page 36).

3 **In a first, scientists took the temperature of a sonic black hole**
The temperature of a lab-made black hole that traps sound instead of light agrees with a prediction by cosmologist Stephen Hawking: that black holes emit a small stream of particles called Hawking radiation (*SN: 6/22/19, p. 14*).

4 **Why kids may be at risk from vinyl floors and fire-resistant couches**
Children from homes with all vinyl flooring and flame-retardant couches had higher levels of some potentially harmful chemicals in blood and urine than other kids did, one study found. The finding suggests that these home furnishings release the chemicals quickly enough for them to build up in residents' bodies (*SN: 3/16/19, p. 14*).

5 **Archaeologists tie ancient bones to a revolt chronicled on the Rosetta Stone**
An ancient soldier's skeleton unearthed from Egypt's Nile Delta may be physical proof of a revolt around 2,200 years ago. The Rosetta Stone describes the victory of pharaoh Ptolemy V, from a Greek dynasty, over a faction of the native Egyptian revolt. But archaeological evidence of the uprising is scarce (see Page 8).

Top feature stories

1 **Vitamin D supplements aren't living up to their hype**
Vitamin D's popularity soared after findings hinted that it could protect against multiple sclerosis, asthma, depression, heart disease, cancer and other ailments. But a series of studies has cast doubt on these supposed benefits (*SN: 2/2/19, p. 16*).

2 **Measles erases the immune system's memory**
Measles wipes away the immune system's memories of germs it has previously fought. This "immune amnesia" can leave people at risk of infections from harmful viruses and bacteria for months to years (*SN: 6/8/19, p. 20*).

3 **With its burning grip, shingles can do lasting damage**
The virus responsible for chicken pox can lay dormant for decades, only to reemerge later in life as shingles. The disease is more than just a painful rash. Shingles can damage arteries and may raise the risk of stroke and dementia, scientists are finding (*SN: 3/2/19, p. 22*).

4 **The CBD boom is way ahead of the science**
Food, health and wellness products infused with cannabidiol, also known as CBD, are becoming increasingly popular. The substance, derived from cannabis plants, is sold as a remedy for pain, anxiety, insomnia and other conditions without getting the user high. But most health benefits attributed to CBD don't yet have scientific backing (*SN: 3/30/19, p. 14*).

5 **How the periodic table went from a sketch to an enduring masterpiece**
Science News kicked off its coverage of the periodic table's 150th anniversary with a look at Russian chemist Dmitrii Mendeleev, whose original table had just 63 elements. Scientists have since added many more elements to the table, one of the most important tools in chemistry (*SN: 1/19/19, p. 14*).

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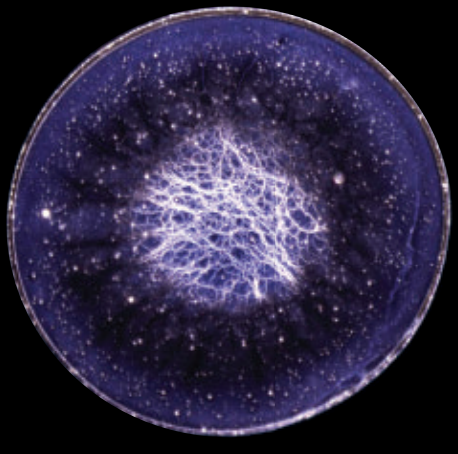
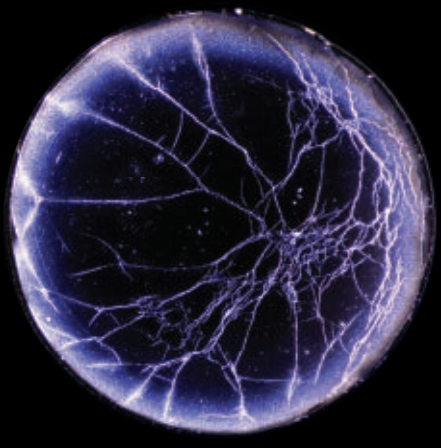
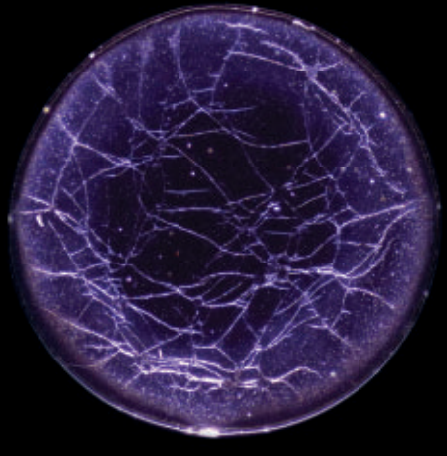


Pappy Van Winkle's Family Reserve 23 Year



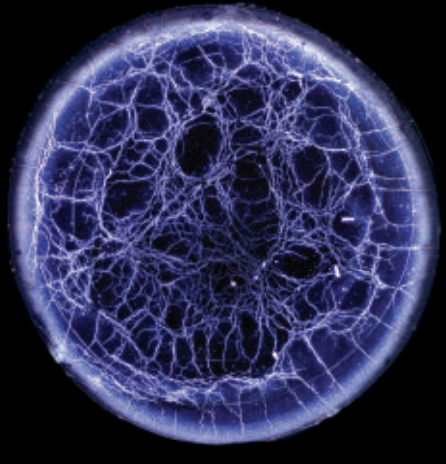
Woodford Reserve Double Oaked

Van Winkle Special Reserve 12 Year



Old Weller Antique

Buffalo Trace



Jack Daniel's Single Barrel

Bourbon brands leave singular designs

Step aside, whiskey connoisseurs. Scientists have a new way to discern quality among bourbons. An analysis of residues from evaporated drops of bourbon reveals that different types of American whiskey diluted to around 20 percent alcohol each leave behind a unique, microscopic weblike pattern.

Stuart Williams, a fluid dynamics researcher at the University of Louisville in Kentucky, and colleagues suspect that compounds that leach into the whiskey while it ages in charred oak barrels create these webs (some shown above). "A lot of [those compounds] do not like water," Williams says, so diluting the bourbon forces those particles to flee toward the surface and form a skin over the droplet. As liquid evaporates, that film contracts and buckles to create the web.

Williams' team couldn't create similar webs using Canadian or Scotch whiskies, suggesting that the webs are vestiges of flavor compounds specific to American whiskey distillation — where the alcohol is aged in new, rather than reused, barrels. That process may allow more web-forming compounds to leach into the whiskey. Such signature marks, described in the October *Physical Review Fluids*, could help scientists identify counterfeit liquors or test new techniques to speed up whiskey aging. — *Maria Temming*

ALL: S.J. WILLIAMS/WHISKEYWEBS.ORG

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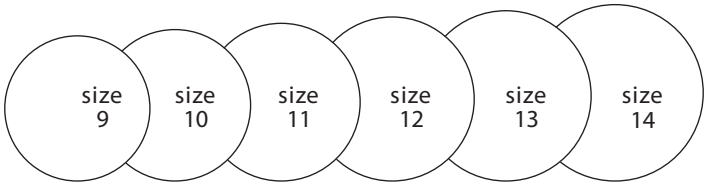

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