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MAGAZINE OF THE SOCIETY FOR SCIENCE ■ DECEMBER 17, 2022 & DECEMBER 31, 2022

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2022 Year in Review

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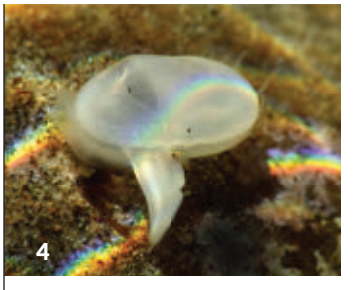

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Departments

COVER The James Webb Space Telescope reveals new details of the iconic Pillars of Creation. *NASA, ESA, CSA, STScI, Joseph DePasquale, Anton M. Koekemoer and Alyssa Pagan/STScI*

FROM TOP: KATTY HUERTAS; J. GODDARD; DAFNA GAZIT/ISRAEL ANTIQUITIES AUTHORITY

This was a year of both triumphs and challenges

The cover of this year-end issue of *Science News* spotlights a spectacular scientific achievement: an image of deep space captured by the James Webb Space Telescope. After decades of delay and cost overruns, the absurdly complicated craft started beaming back images this summer. Each image has exceeded scientists' wildest expectations. We had a hard time choosing just one for the cover.

These extraordinary views, some looking more than 13 billion years back in time, brought our staff joy too — so much so that we've led off our year-end review with this technological triumph, including more gorgeous images (Page 15). This year had plenty of other big news in astronomy, including the launch of NASA's Artemis I mission, a key step in sending people to the moon and beyond. For sheer fun, it's hard to beat NASA's DART spacecraft elbowing an asteroid off course. It was the first test of a method to protect our planet from dangerous collisions with space rocks (Page 30).

It was also a big year for efforts to counter the impacts of climate change, with the U.S. Congress passing legislation to invest billions of dollars in green energy technologies (Page 28).

And here at *Science News*, we wrapped our 100-year anniversary project, the Century of Science, taking deep dives into the evolution of climate science, our digital lives, quantum reality and more. Our March 26 issue (below) chronicled how our journalism, like the science, has evolved over the decades.

Please forgive me for opening with the good news; it's the optimist in me. There were many challenges in 2022 as well. The SARS-CoV-2 virus continues to defy hopes that it will slink off, with the omicron variant driving a historic surge in infections and deaths earlier this year. Vaccines for children and an updated booster were bright spots (Page 23). But "pandemic fatigue" plus mixed messaging from public officials encouraged many people to abandon precautions and skip booster shots, even though the virus is killing more than 300 people a day in the United States (Page 20). And now, when all we really want is a holiday season with no worries about spreading dreaded diseases, flu and other viruses are piling on (Page 24). When are these germs going to cut us a break? Never, a virologist would likely say.

But I take consolation in the fact that with each vast new challenge, scientists are continuing to lead the way in seeking solutions.

— Nancy Shute, Editor in Chief

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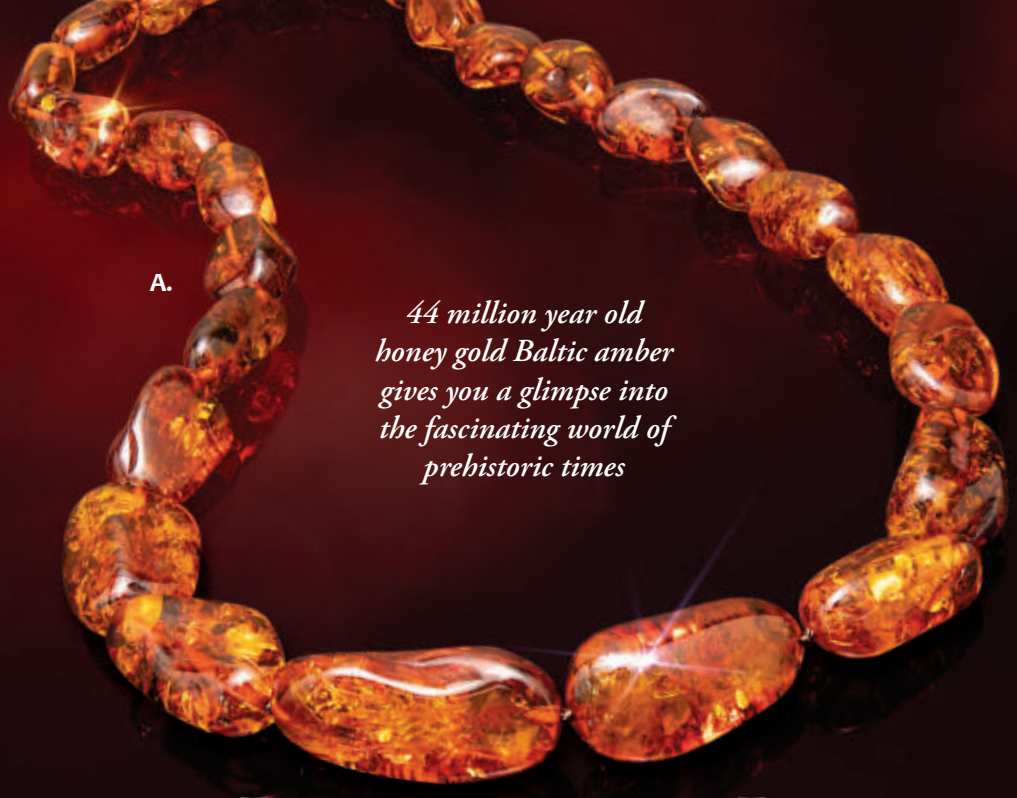
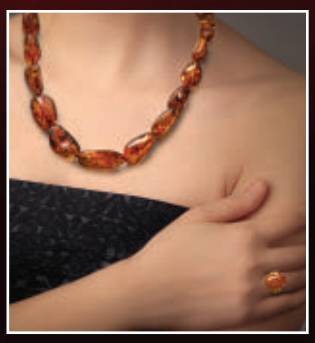


44 million year old honey gold Baltic amber gives you a glimpse into the fascinating world of prehistoric times



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Excerpt from the December 23, 1972 issue of *Science News*

50 YEARS AGO

A perfect ending for Apollo

Project Apollo ended this week. The last moon men … returned to Earth … and splashed down on a target in the Pacific Dec. 19.… All of the surface and orbital instruments appear to be working with the exception of the surface gravimeter.… The geology investigation team summed it up this way: "Apollo 17 will be remembered as the most scientifically sophisticated, not as the last, manned lunar landing."

UPDATE: The Apollo missions continue adding to our knowledge of the moon and Earth. Scientists have used lunar soil samples collected by Apollo astronauts to show that growing plants on the moon, while challenging, may be possible (*SN: 7/2/22, p. 4*). In May, NASA researchers began scrutinizing untouched lunar rock and soil samples from the Apollo 17 mission for hints of past moon conditions and the chemicals crucial for life. Then in November, a new era of moon missions dawned with the launch of NASA's Artemis I mission (see Page 30). NASA hopes to land humans on the moon in 2025 to pick up where Apollo 17 astronauts left off.

This *Cymatioa cooki* clam extends the foot it uses to move around in the sand beyond its translucent, white shell. Until now, the clam had been known only from fossils.

THE SCIENCE LIFE

Clam discovery resurrects a long-dead species

A species of clam is back from the dead.

Known as *Cymatioa cooki*, the clam had only ever been found as a fossil, and scientists presumed that the species had been extinct for about 30,000 years. Then, while scouring tide pools for sea slugs off the coast of Santa Barbara, Calif., in 2018, marine ecologist Jeff Goddard spotted something unfamiliar: a white, translucent bivalve roughly 11 millimeters long.

Not wanting to disrupt the clam, Goddard, of the University of California, Santa Barbara, photographed it and shared the images with a colleague. Paul Valentich-Scott, curator emeritus of malacology at the Santa Barbara Museum of Natural History, didn't recognize the marine critter either, which made him happy. "New discoveries are part of why we're in science," he says.

The pair captured a live specimen in 2019 and brought it back to the museum for comparison with known species from the fossil record. The creature bore a striking resemblance to a fossil bivalve first described in the 1930s by paleontologist George Willett.

"Once I physically saw that original specimen that Willett had used … I knew right away" that the live clam was the same species, Valentich-Scott says.

The researchers still puzzle over how the clam eluded scientists for so long. One idea is that *C. cooki*'s preferred habitat may be a remote area in Baja California, Mexico. A mass of warm water might have washed some clam larvae north toward Santa Barbara. So far, Valentich-Scott and Goddard have found at least two, and potentially four, of the living clams.

"It's rare to find something first as a fossil and then living," says David Jablonski, a paleontologist at the University of Chicago.

The triumphant reappearance of *C. cooki*, described November 7 in *ZooKeys*, places the clam among a group of "back-from-the-dead" creatures dubbed Lazarus taxa. Even with the vast array of animal specimens available to modern scientists, Jablonski says, "there's always more to find." —*Allison Gasparini*

A *Cymatioa cooki* clam (arrow) sits next to a larger mollusk called a chiton in a tide pool. The clam, presumed extinct for millennia, is about 11 millimeters long.

BOTH: J. GODDARD

SCIENCE STATS

Human population hits a milestone

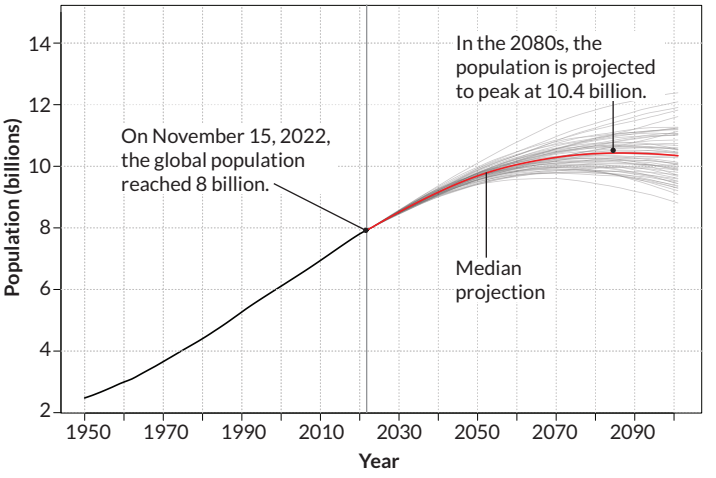
Eight billion. That's the number of humans estimated to be alive on Earth as of November 15, according to a projection from the United Nations.

The landmark "brings important responsibilities, and highlights related challenges for social and economic development and environmental sustainability," Maria-Francesca Spatolisano, the U.N. assistant secretary-general for policy coordination and interagency affairs, said at a July news conference.

Though the global population continues to expand, the rate of growth is slowing. Current projections predict the world's population will peak at about 10.4 billion in the 2080s and remain steady until 2100. Previously, the U.N. had predicted that the world's population could reach 11.2 billion by 2100, based on the rate of population growth in 2017.

In the coming decades, migration is expected to be the sole driver of population growth in high-income countries, according to the U.N.'s World Population Prospects 2022 report, released in July. What's more, the populations of 61 countries and territories are projected to decrease by 1 percent or more between now and 2050. In lower-income countries, population growth is expected to still be driven by more births than deaths.

Estimated global human population, 1950–2100



Population projections The global population is expected to peak at about 10.4 billion in the 2080s and then level off until the end of the century, according to projections from the United Nations. The red line is the median of many projections (some shown in gray), each computed by varying factors such as fertility and mortality rates.

While population growth may put more stress on the environment, Spatolisano said, developed countries that consume the most resources are the most responsible for mitigating that stress. —*Allison Gasparini*

FROM TOP: POPULATION DIVISION/DESA/UNITED NATIONS (CC BY 3.0 IGO); SELEN MANIOĞLU

MYSTERY SOLVED

Here's how mysterious 'last-resort' antibiotics kill infectious bacteria

To kill drug-resistant bacteria, "last-resort" antibiotics borrow a tactic from Medusa's playbook: petrification.

New high-resolution microscope images show that a class of antibiotics called polymyxins crystallize the cell membranes of bacteria. The resulting honeycomb-shaped crystals that form turn the microbes' usually supple skins into thin brittle sheets, researchers report October 21 in *Nature Communications*. When the petrified membranes break, the bacteria die.

The finding was a total surprise, says structural biologist Sebastian Hiller of the University of Basel in Switzerland.

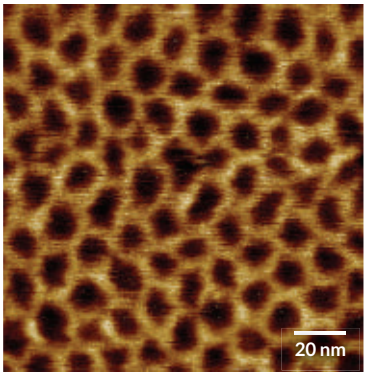
Hiller and colleagues had been using the antibiotics as a control for a different experiment. When the researchers turned on their microscopes, "we saw these waffles," Hiller says. "I immediately recognized, wow, this must be something special."

Polymyxin antibiotics like colistin were discovered in the 1940s and are now used as a powerful last-ditch defense against bacteria that have evolved resistance to most other drugs. Researchers already knew that polymyxins somehow interfere with bacterial cell membranes. But nobody had imagined a scenario like the crunchy waffles Hiller and colleagues discovered.

The team exposed bits of cell membrane from *E. coli* to varying concentrations of colistin. Atomic force microscopy imaging revealed that crystals formed at the minimum concentrations required to kill the bacteria. Membranes from colistin-resistant *E. coli* strains that were exposed to the drug didn't crystallize.

The results indicate that polymyxins work by arranging the cell membrane into a crystalline structure that leaves the skin brittle and vulnerable. "That's something that has not even remotely been hypothesized so far," says Markus Weingarth, a biochemist at Utrecht University in the Netherlands. "It's a very important study. I'd even say it's a breakthrough."

Bacterial membranes are usually supple and smooth. But polymyxin antibiotics crystallize the membranes and turn them into brittle sheets of hexagonal "waffles" (shown in this microscope image).



But how exactly polymyxins crystallize cell membranes remains unclear. That's a problem because some bacteria have developed resistance to polymyxins and are becoming more widespread. Hiller hopes that this first glimpse of polymyxins' petrifying powers will help scientists combat resistance to the antibiotics. "Understanding these concepts will definitely bring a lot of ideas," Hiller says. —*Elise Cutts*

BODY & BRAIN

Baby treated in utero for rare disorder

Pompe disease can begin damaging organs even before birth

Ayla Bashir, shown here with her mother, is the first child treated for a rare genetic disorder called infantile-onset Pompe disease while still in the womb.

CHEO MEDIA HOUSE

BY ERIN GARCIA DE JESÚS

A young girl is flourishing after receiving treatment for a rare genetic disease. In a first for this disease, she received that treatment before she was even born.

Sixteen-month-old Ayla Bashir has infantile-onset Pompe disease, a genetic disorder that can cause organ damage before birth. Babies born with Pompe disease typically have enlarged hearts and weak muscles. If left untreated, most infants die before they turn 2. Treatment usually begins after birth, but that tactic doesn't prevent the irreversible and potentially deadly organ damage that happens in utero.

Bashir received treatment while still in the womb as part of an early-stage clinical trial. Today, the toddler has a normal heart and is meeting developmental milestones, including walking. Her success is a sign that prenatal treatment of the disease can stave off organ damage and improve babies' lives, researchers report November 9 in the *New England Journal of Medicine*.

"It's a great step forward," says Bill Peranteau, a pediatric and fetal surgeon at the Children's Hospital of Philadelphia who wasn't involved in the work.

Infantile-onset Pompe disease is a rare condition affecting less than 1 in 138,000 people globally. It's caused by genetic changes that either reduce levels of an enzyme called acid alpha-glucosidase, or GAA, or prevent the body from making the enzyme at all.

Inside cells' lysosomes, structures that act as garbage disposals, GAA turns the complex sugar glycogen into glucose—the body's main source of energy. Without GAA, glycogen accumulates to dangerously high levels that can damage muscle tissue, including the heart and muscles that help people breathe.

While some people can develop Pompe disease later in life or have a less severe version that doesn't enlarge the heart, Bashir was diagnosed with the most severe form. Her body doesn't make any GAA. Replacing the missing enzyme through an infusion can help curb glycogen buildup, especially if treatment starts soon after birth (SN: 11/4/00, *p.* 303).

Early studies in mice suggested that treatment before birth showed promise for controlling a Pompe-like disease. So pediatric geneticist Jennifer L. Cohen of Duke University School of Medicine and colleagues launched an early-stage clinical trial covering Pompe disease and seven similar conditions broadly called lysosomal storage diseases.

The team began treating Bashir by infusing lab-made GAA through the umbilical vein when her mother was 24 weeks pregnant. Her mother received a total of six infusions, one every two weeks. Since Bashir's birth, the medical team has been treating her with now-weekly infusions. She will continue to need treatment throughout her life.

The therapy was safe for both mother and child, Cohen says. But until more patients are treated and monitored in the trial, it's unclear whether this enzyme replacement will always be a safe and effective option. So far, two other patients with other lysosomal storage diseases have received treatment in the trial, but it's too early to know how they're faring.

Researchers are also exploring in utero therapies for other rare genetic diseases, including the blood disorder alpha thalassemia. And in 2018, scientists described three children who were successfully treated for a life-threatening sweating disorder before they were born.

Such approaches have the potential to treat other rare diseases in the future, Peranteau says. But it will be important to first show that any newly developed treatments are safe and work when given after birth before trying them in utero.

For now, it's unclear how Bashir will fare over the long term, Cohen says. "We're cautiously optimistic, but we want to be careful and be monitoring throughout the patient's life. Especially those first five years, I think, are going to be critical to see how she does." ■

EARTH & ENVIRONMENT

Greenland is hemorrhaging ice

Inland flows may raise sea levels faster than expected

BY NIKK OGASA

Sea level rise may proceed faster than expected in the coming decades, as a gargantuan flow of ice slithering out of Greenland's remote interior both picks up speed and shrinks.

By the end of the century, the ice procession's deterioration could contribute nearly 16 millimeters to global sea level rise — more than six times as much as scientists had previously estimated, researchers report November 9 in *Nature*.

The finding suggests that inland portions of large flows of ice elsewhere could also be withering and accelerating due to human-caused climate change, and that past research has probably underestimated the rates at which the ice will contribute to sea level rise (*SN: 3/12/22, p. 16*).

"It's not something that we expected," says glaciologist Shfaqat Abbas Khan of the Technical University of Denmark in Kongens Lyngby. "Greenland and Antarctica's contributions to sea level rise in the next 80 years will be significantly larger than we have predicted until now."

In the new study, Khan and colleagues focused on the Northeast Greenland Ice Stream, a titanic conveyor belt of solid ice that crawls about 600 kilometers through the landmass's ice sheet out of the hinterland and into the sea. The stream drains about 12 percent of the country's entire ice sheet and contains enough water to raise global sea level more than a meter. Near the coast, the ice stream splits into two glaciers, Nioghalvfjerdsbrae and Zachariae Isstrøm.

While intact, these glaciers keep the ice behind them from rushing into the sea, much like dams hold back water in a river. When the ice shelf of Zachariae Isstrøm collapsed about a decade ago, scientists found that the ice flowing behind the glacier started accelerating. But whether those changes penetrated deep into Greenland's interior remained largely unresolved.

"We've mostly concerned ourselves with the margins," says atmosphere-cryosphere scientist Jenny Turton of the nonprofit Arctic Frontiers in Tromsø, Norway, who was not involved in the new study. That's where the most dramatic changes with the greatest impacts on sea level rise have been observed, she says.

Keen to measure small rates of movement in the ice stream far inland, Khan and colleagues used GPS, which in the past has exposed the tortuous creeping of tectonic plates. The team analyzed GPS data from three stations along the ice stream's main trunk, all located between 90 and 190 kilometers inland. The ice stream had accelerated at all three points from 2016 to 2019, the data showed. In that time frame, the ice speed at the station farthest inland increased from about 344 meters per year to surpassing 351 m/yr.

By comparing the GPS measurements with data from polar-orbiting satellites and aircraft surveys, the team detected that acceleration more than 200 kilometers upstream. What's more, shrinking — or thinning — of the ice stream that started in 2011 at Zachariae Isstrøm had advanced more than 250 kilometers upstream by 2021.

"This is showing that glaciers are responding along their length faster than we had thought previously," says Leigh Stearns, a glaciologist at the University of Kansas in Lawrence who was not involved in the study.

Khan and colleagues then used the data to tune computer simulations that forecast the ice stream's impact on sea level rise. The researchers predict that by 2100, the ice stream will have single-handedly contributed between about 14 and 16 millimeters to global sea level rise — as much as Greenland's entire ice sheet has in the last 50 years.

The findings suggest that past research has underestimated rates of sea level rise driven by the ice stream, Stearns and Turton agree. Similarly, upstream thinning and acceleration in other large flows of ice, such as those associated with Antarctica's shrinking Pine Island and Thwaites glaciers (*SN: 7/2/22, p. 8*; *SN: 1/29/22, p. 12*), might also cause sea levels to rise faster than expected, Turton says.

Khan and colleagues plan to investigate inland sections of other large ice streams in Greenland and Antarctica, with the aim of improving forecasts of sea level rise (*SN: 2/29/20, p. 18*).

Such forecasts are crucial for adapting to climate change, Stearns says. "They're helping us better understand the processes so that we can inform the people who need to know that information." ■

The Nioghalvfjerdsbrae glacier (shown) is one outlet of the roughly 600-kilometer-long Northeast Greenland Ice Stream, which drains ice from the country's massive ice sheet into the sea.

GUARDIAN_V2/ALAMY STOCK PHOTO

MATH & TECHNOLOGY

Sound helps wire stretchy electronics

Wearable devices could benefit from the new technique

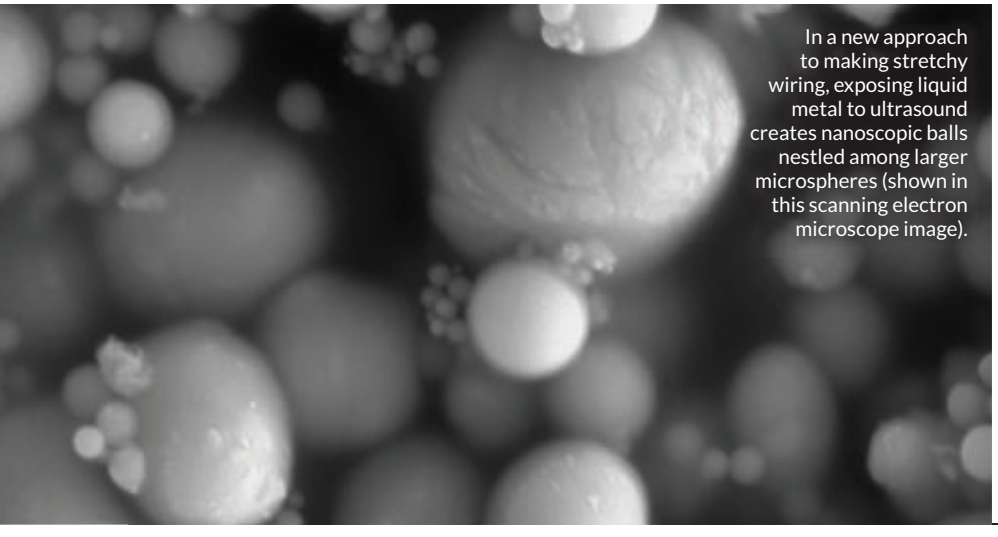
BY JAMES R. RIORDON

Zapping liquid metal droplets with ultrasound offers a new way to make wiring for stretchy, bendy electronics.

The technique, described in the Nov. 11 *Science*, adds a new approach to the toolboxes of researchers developing circuitry for skin-based medical sensors, wearable electronics and other applications where rigid circuit electronics are less than ideal (SN: 6/9/18, p. 18).

Researchers began by drawing lines on sheets of stretchy plastic with microscopic droplets of a metal alloy. The alloy, made of gallium and indium, is liquid at temperatures above about 16° Celsius.

Though the liquid metal conducts electricity, the droplets quickly oxidize. That process covers each droplet with a thin insulating layer. The layers carry static charges that push the droplets apart, making them useless for connecting the LEDs, microchips and other components in electronic circuitry.



In a new approach to making stretchy wiring, exposing liquid metal to ultrasound creates nanoscopic balls nestled among larger microspheres (shown in this scanning electron microscope image).

But hitting the microspheres with high-frequency sound waves causes the microscopic balls to shed even smaller, nanoscopic balls of liquid metal. The tiny spheres bridge the gaps between the larger ones, and that close contact allows electrons to tunnel through the oxide layers so that the droplets can carry electricity, the team found.

When the plastic that the drops are printed on is stretched or bent, the larger balls of metal can deform, while the smaller ones act like rigid particles that shift around to maintain contact.

The researchers demonstrated their conductors by connecting electronics into a stretchy pattern of LEDs displaying the initials of the Dynamic Materials Design Laboratory at the Korea Advanced Institute of Science and Technology in Daejeon, South Korea, where the work was done. The team also built a sensor with the conductors that can monitor blood through a person's skin.

Flexible electronics applications aren't new, says study coauthor Jiheong Kang, a materials scientist at the Korea Advanced

BODY & BRAIN

Brain implants 'read' thoughts

The devices could help people who can't speak communicate

BY LAURA SANDERS

SAN DIEGO — Scientists have devised ways to "read" words directly from brains. Brain implants can translate internal speech into external signals, allowing communication from people with paralysis or diseases that steal their ability to talk or type.

New results from two studies, presented November 14 at the annual meeting of the Society for Neuroscience, "provide additional evidence of the extraordinary potential" that brain implants have for restoring lost communication, says Leigh Hochberg, a neuroscientist and neurocritical care physician at Massachusetts General Hospital in Boston who was not involved in either study.

Some people who need help communicating can use devices that require small movements, such as eye gaze changes. But those tasks aren't possible for everyone. So the new studies targeted internal speech, which requires that a person only think.

"Our device predicts internal speech directly, allowing the patient to just focus on saying a word inside their head and transform it into text," says neuroscientist Sarah Wandelt of Caltech. Internal speech "could be much simpler and more intuitive than requiring the patient to spell out words or mouth them."

Neural signals associated with words are detected by electrodes implanted in the brain. The signals can then be translated into text, which can be made audible by computer programs that generate speech.

In a test, Wandelt and colleagues accurately predicted which of eight words a person who was paralyzed below the neck was thinking. The man was bilingual, and the researchers could detect both English and Spanish words.

Electrodes picked up nerve cell signals in his posterior parietal cortex, a brain area involved in speech and hand movements. A brain implant there might eventually be used to control devices that can perform tasks usually done by a hand, Wandelt says.

Another approach presented at the meeting, led by neuroscientist Sean Metzger of the University of California, San Francisco and his colleagues, relied on spelling. The participant was a man called Pancho who hadn't been able to speak for more than 15 years following a stroke. In

WONBEOM LEE/DEPT. OF MATERIALS SCIENCE AND ENGINEERING/KAIST

Institute. But the new approach has advantages over other designs, he says, such as those that rely on channels filled with liquid metal that can leak if the circuitry is damaged. Liquid metal in the conductors that Kang and colleagues developed stays trapped in the tiny spheres that are embedded in the plastic and remains in place even if the material is torn.

Wires made of liquid metal have often been the go-to conductors for stretchy electronics, says Carmel Majidi, a mechanical engineer at Carnegie Mellon University in Pittsburgh who was not involved with the study. Using ultrasound introduces a "novel approach to achieving that conductivity," Majidi says. Other groups have managed that feat by heating circuits, exposing them to lasers, squishing them or vibrating the circuits to get droplets to connect to each other, he says.

Majidi isn't convinced that the ultrasound approach is a game changer for flexible circuits. But, he says, it's high time the subject is appearing in a leading journal like *Science*. "I'm personally really excited to see the field overall, and this particular type of material architecture, is now gaining this visibility." ■

this study, Pancho attempted to silently think code words, such as "alpha" for A and "echo" for E. By stringing these letters into words, he produced sentences such as "I do not want that" and "You have got to be kidding." Each session would end when Pancho attempted to squeeze his hand, thereby creating a movement-related brain signal that stopped the decoding.

With this system, Pancho produced about seven words per minute. That's faster than the roughly five words per minute his usual communication device makes, but much slower than normal speech, typically about 150 words per minute. The techniques will need to get faster and more accurate to be useful. It's also unclear whether the technologies will work for people with more profound speech disorders. "These are still early days," Hochberg says. ■

DIEGO CAMEJO FOR BENEATH THE WAVES, 2019

EARTH & ENVIRONMENT

Sharks map a sprawling seagrass bed

The submarine carbon reservoir is two-thirds the area of Florida

BY NIKK OGASA

Scientists have teamed up with tiger sharks to discover the largest known expanse of seagrasses on Earth.

A massive survey of the Bahamas Banks—a cluster of underwater plateaus surrounding the Bahamas—has revealed up to 92,000 square kilometers of seagrasses, scientists report November 1 in *Nature Communications*. That area is roughly equivalent to two-thirds the size of Florida.

The finding expands the estimated global area covered by seagrasses by 41 percent, a potential boon for conservation efforts that aim to protect carbon-trapping ecosystems, says marine biologist Oliver Shipley of the ocean conservation nonprofit Beneath The Waves in Herndon, Va.

Seagrasses can sequester carbon for millennia at rates 35 times faster than tropical rainforests. The newly mapped sea prairie may store 630 million metric tons of carbon, equivalent to about a quarter of the carbon trapped by seagrasses worldwide, Shipley and colleagues estimate.

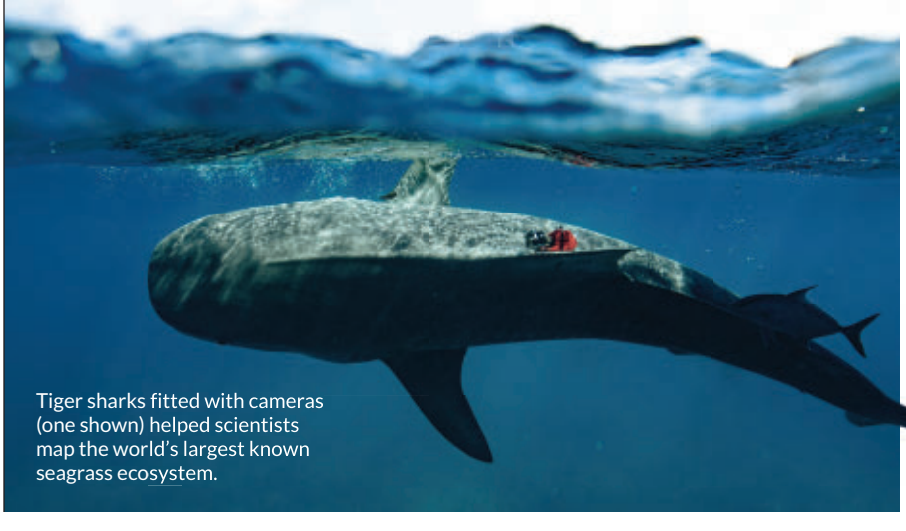
Mapping that much seagrass was a colossal task, Shipley says. Guided by previous satellite observations, he and colleagues dove into the sparkling blue waters 2,542 times to survey the meadows up close. The team also recruited seven tiger sharks to aid the efforts. Similar to lions that stalk zebra and other prey through tall grasses on the African savanna, the sharks patrol fields of wavy seagrasses for grazing animals to eat.

"We wouldn't have been able to map anywhere near the extent that we mapped without the help of tiger sharks," Shipley says.

The team captured the sharks with drum lines and hauled each one onto a boat, mounting a camera and tracking device onto the animal's back before releasing it. Sharks were typically back in the water in under 10 minutes. The team operated like "a NASCAR pit crew," Shipley says. After several hours in the water, the equipment fell off the sharks.

Researchers had previously suggested tracking seagrass-grazing sea turtles and manatees to locate pastures. But tiger sharks were a smart choice because they roam farther and deeper, says marine ecologist Marjolijn Christianen of Wageningen University & Research in the Netherlands. "That's an advantage."

Shipley's team plans to collaborate with other animals, such as ocean sunfish (*SN Online: 5/1/15*), to uncover more submarine meadows. With this approach, Shipley says, "the world's our oyster." ■



Tiger sharks fitted with cameras (one shown) helped scientists map the world's largest known seagrass ecosystem.

Watch a video of a shark mapping seagrass at **bit.ly/SN_GrassShark**

LIFE & EVOLUTION

Some marsupials shed loner label

Study stirs debate over mammalian social groups

BY JAKE BUEHLER

Marsupials may have richer social lives than previously thought.

Generally considered loners, the animals have a wide diversity of social relationships that have gone unrecognized, a new analysis published in the Oct. 26 *Proceedings of the Royal Society B* suggests. Because marsupials split from other groups fairly early in mammalian evolution, the findings could have implications for how scientists think about the lifestyles of early mammals.

"These findings are helpful to move us away from a linear thinking that used to exist in some parts of evolutionary theory, that species develop from supposedly simple into more complex forms," says Dieter Lukas, an evolutionary ecologist at the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany, who was not involved with the study.

Modern mammals run the gamut of social organization systems, ranging from transient interactions like aggregations of jaguars in South American wetlands to the antlike subterranean societies of naked mole-rats (SN: 11/6/21, p. 10).

But marsupials — a subgroup of mammals that give birth to relatively underdeveloped young often reared in pouches — have traditionally been considered largely solitary. Some kangaroo species were known to form transient or permanent groups of dozens of individuals. But among marsupials, long-term bonds between males and females were thought rare and there were no known examples of group members cooperating to raise young. Previous work on patterns of mammalian social evolution regarded about 90 percent of examined marsupial species to be solitary.

"If you look at other [studies] about some specific species, you will see [the researchers] tend to assume that the marsupials are solitary," says Jingyu Qiu, a behavioral ecologist at CNRS in Strasbourg, France.

Qiu and colleagues developed a database of 120 field studies that illuminated marsupial social organization, taking into account how populations vary within a species and delving into the evolutionary history of marsupial social lives.

The team compiled data on 149 populations representing 62 marsupial species. Each population was then categorized as solitary, living in pairs or falling into four kinds of group living: one male and multiple females (or vice versa), multiple males and females, or single-sex groups.

While 19 species, or 31 percent of those studied, appear to be strictly solitary, about half of the species always live in pairs or groups. The team also found lots of variation within species. More than 40 percent, or 27 of the 62 species, fell into multiple social group categories.

When the researchers looked at social variation among Australian marsupials against the country's climatic conditions, they found that social variability was more common in drier environments with less predictable rainfall. It's possible that being able to switch between solitary and group living lets species better adapt their lifestyles to changing environmental conditions, the team says.

The study's focus on social flexibility shows "there is nothing simple even about a supposedly solitary species," Lukas says.

Qiu and colleagues also ran computer analyses comparing the evolutionary relationships of the marsupials with how they form social relationships. This let the team predict the social organization of the earliest marsupials, which split from placental mammals about 160 million years ago. Because modern marsupials have been considered solitary, their ancestors have generally been assumed to be solitary as well.

Solitary was the most likely social category of the ancestral marsupials, the team found, with a 35 percent probability. But the probability that the ancestral species sometimes lived in pairs or one of several types of groups makes up the other 65 percent. It is likely that the ancestor was nonsolitary at times, Qiu says. That finding raises the possibility that this type of social organization predates marsupials' split from placental mammals, which would increase the odds that the earliest mammals — long assumed to have been solitary — were social too.

Many marsupials, such as the squirrel glider (*Petaurus norfolcensis*), can live in a variety of social groups, such as a mating pair or a bigger group of males and females, a new study claims.

SYLVAIN CORDIER/STOCKBYTE/GETTY IMAGES

Robert Voss, a mammalogist at the American Museum of Natural History in New York City, questions the research's insights about a potentially social ancestral marsupial. The uncertainty about the solitary ancestor, Voss says, is largely due to the scientists' benchmarks for what constitutes social behavior — thresholds that he views as too permissive. For example, he disagrees with the team's characterization of opossums as sometimes living in pairs or sex-specific groups.

"Anecdotal observations of [members of the same species] occasionally denning together is not compelling evidence for social behavior," Voss says. "None of the cited studies suggest that opossums are anything other than solitary."

Qiu's team plans to gather data on a larger subset of mammals to get a clearer picture of how social traits have evolved. ■

Scientists with the University of Glasgow in Scotland collect a piece of meteorite that suggests space rocks delivered water to Earth.

ATOM & COSMOS

A meteorite hints how Earth got water

Fragments of pristine space rock point to asteroids as the source

BY LISA GROSSMAN

Late in the evening of February 28, 2021, a coal-dark space rock about the size of a soccer ball fell through the sky over northern England. The rock blazed in a dazzling, eight-second-long streak of light, split into fragments and sped toward Earth. The largest piece went splat in the driveway of Rob and Cathryn Wilcock in the small, historic town of Winchcombe.

An analysis of those fragments now shows that the meteorite came from the outer solar system and contains water that is chemically similar to Earth's, scientists report November 16 in *Science Advances*.

How Earth got its water remains one of science's enduring mysteries. The results support the idea that asteroids brought water to the young planet (SN: 5/16/15, p. 18).

The Wilcocks were not the only ones who found pieces of the rock that fell that night. But they were the first. Bits of the Winchcombe meteorite were collected within 12 hours after they hit the ground, meaning they are relatively uncontaminated with earthly stuff, says planetary scientist Ashley King of London's Natural History Museum.

The first bits of the Winchcombe meteorite to be recovered were from a driveway in England. The rock's largest fragment was so brittle that it shattered on impact, making a small dent.

Other meteorites have been recovered after being tracked from space to the ground, but never so quickly (SN: 1/26/13, p. 5). "It's as pristine as we're going to get from a meteorite," King says. "Other than it landing in the museum on my desk, or other than sending a spacecraft up there, we can't really get them any quicker or more pristine."

After collecting about 530 grams of meteorite from Winchcombe and other sites, including a sheep field in Scotland, King and colleagues threw a kitchen sink of lab techniques at the samples. The researchers polished the material, heated it and bombarded it with electrons, X-rays and lasers to figure out what elements and minerals it contained.

The team also analyzed video of the fireball from the U.K. Fireball Alliance, a network of meteor-watching cameras around the world, plus videos from doorbell and dashboard cameras. The footage helped the scientists determine the meteorite's trajectory and where it originated.

The meteorite is a type of rare, carbon-rich rock called a carbonaceous chondrite, the team says. It came from an asteroid near the orbit of Jupiter and started its journey toward Earth about 300,000 years ago, a relatively short time for a trip through space, the researchers calculate.

Chemical analyses also revealed that the meteorite is about 11 percent water by weight, with the water locked in hydrated minerals. Some of the hydrogen in that water is actually deuterium, a heavy form of hydrogen. The ratio of hydrogen to deuterium in the meteorite is similar to that of the Earth's atmosphere. "It's a good indication that water [on Earth] was coming from water-rich asteroids," King says.

Researchers also found amino acids and other organic material in the meteorite pieces. "These are the building blocks for things like DNA," King says. The pieces "don't contain life, but they have the starting point for life locked up in them." Further studies can help determine how those molecules formed in the asteroid that the meteorite came from, and how similar organic material could have been delivered to the early Earth.

"It's always exciting to have access to material that can provide a new window into an early time and place in our solar system," says planetary scientist Meenakshi Wadhwa of Arizona State University in Tempe, who was not involved in the study.

Wadhwa hopes future studies will compare the samples of the Winchcombe meteorite with samples of asteroids Ryugu and Bennu, which were collected by spacecraft and sent to Earth (SN: 1/19/19, p. 20). Ryugu and Bennu are both closer to Earth than the main asteroid belt, where the Winchcombe meteorite came from. Comparing and contrasting all three samples will build a more complete picture of the early solar system's makeup, and how it evolved into what we see today. ■

FROM TOP: MIRA IHASZ, SPIRE GLOBAL; UNIV. OF GLASGOW; R. WILCOCK

HUMANS & SOCIETY

A Maya dynasty gained power slowly

Rulers took more than a century to attract a large following

BY BRUCE BOWER

Commoners may have played an unappreciated part in the rise of an ancient Maya royal dynasty.

Self-described "divine lords" at a Maya site called Tamarindito in what's now Guatemala left glowing hieroglyphic tributes to themselves as heads of the powerful Foliated Scroll dynasty. But new findings indicate that these bigwigs spent generations waiting for their subjects to show up, or perhaps hatching plans to attract followers, say archaeologist and epigrapher Markus Eberl of Vanderbilt University in Nashville and colleagues.

Tamarindito's kings founded their capital by about the year 400 as a hamlet of a few dozen individuals, consisting of a royal court and a couple of residential clusters for non-elites, the scientists report November 4 in *Latin American Antiquity*.

It took about 150 years for enough people to trickle in to Tamarindito to enable its rulers to expand their power, Eberl says. At that point, Foliated Scroll rulers founded a smaller, second capital and several settlements in northern Guatemala. Those rulers achieved peak power roughly between the years 550 and 800.

Royal art and writing at Tamarindito and other Classic Maya sites misleadingly suggest that kings wielded absolute power, Eberl contends. "Maya rulers had to legitimize their authority and build power, likely negotiating with and convincing non-elites" to become subjects, he says.

Hieroglyphics proclaiming the divine power and mythological origins of Foliated Scroll rulers have been studied since Tamarindito's discovery in 1958. The emblem from which the dynasty gets its name depicts the curly, leafy stalk of a water lily, representing a scroll. Over seven field seasons beginning in 2009, Eberl's group excavated much of the site and documented all surviving royal inscriptions.

Illegal logging made it possible to identify most of Tamarindito's structures in ground surveys. Early activity at the site focused on building a ceremonial center that consisted of a pyramid, a royal palace and a large plaza atop a 70-meter-high hill. That ritual area was a small-scale project. Roughly 23 to 31 laborers could have built the structures in 25 years, the team says.

But Foliated Scroll rulers' ambitions, as expressed at the ritual center, outpaced demographic reality. Despite a sparse number of locals, estimated from Tamarindito's early residential dwellings, the plaza initially fit about 1,650 people. Public assemblies would have fallen short of the crowd capacity, Eberl suspects.

Pottery from non-elite dwellings at Tamarindito date to between 600 and 850, when most residents arrived—hundreds of years after the city's founding. Even at its peak, no more than several thousand people lived at the site, Eberl says.

That's a surprisingly limited number. Aerial laser mapping has revealed large, interconnected Maya cities in other parts of northern Guatemala, says archaeologist Francisco Estrada-Belli of Tulane University in New Orleans. Mapping at least 100 square kilometers around Tamarindito could reveal whether it was built in relative isolation, he says. ■

DAFNA GAZIT/ISRAEL ANTIQUITIES AUTHORITY

HUMANS & SOCIETY

This ancient Canaanite comb warded off lice

Engraved into the side of a nearly 4,000-year-old ivory comb is a simple wish: Get these lice out of my hair. The faint inscription, written in the early language of the ancient Canaanites, represents the earliest known instance of a complete sentence written using a phonetic alphabet, says archaeologist Yosef Garfinkel of the Hebrew University of Jerusalem. The writing system of the Canaanites later served as a basis for many modern alphabets.

Researchers discovered the comb in 2016 among the ruins of Lachish, an ancient city in modern-day Israel. A closer look at the etched symbols revealed the sentence, "May this tusk root out the lice of the hair and the beard," Garfinkel and colleagues report October 20 in the *Jerusalem Journal of Archaeology*. The reference to a beard suggests the comb belonged to a man. The plea is "so human," Garfinkel says. Writings from the time tend to center on royal accomplishments or religion. It also appears the comb fulfilled its purpose: Between the teeth, the team found a louse's remains. —*Freda Kreier*

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2022 Year in Review

This was another tumultuous year. The pandemic dragged on. Russia's invasion of Ukraine unleashed a humanitarian crisis and global disruptions. And unprecedented heat waves and other natural disasters reminded us that the climate crisis is not some far-off problem. But there were bright spots too. The United States got serious about curbing greenhouse gas emissions. After many delays, the James Webb Space Telescope is up and running. And NASA also launched its Artemis I mission, a major move toward returning humans to the moon. *Science News* looks back at these and other events of 2022.

SEEING THE UNIVERSE IN NEW LIGHT

BY LISA GROSSMAN

This year marked the end of a decades-long wait for astronomers. The James Webb Space Telescope is finally in action.

The telescope, which launched in December 2021, released its first science data in July (SN: 8/13/22, p. 30) and immediately began surpassing astronomers' expectations.

"We've realized that James Webb is 10 times more sensitive than we predicted" for some kinds of observations, says astronomer Sasha Hinkley of the University of Exeter in England. His team released in September the telescope's first direct image of an exoplanet (SN: 9/24/22, p. 6). He credits "the people who worked so hard to get this right, to launch something the size of a tennis court into space on a rocket and get this sensitive machinery to work perfectly. And I feel incredibly lucky to be the beneficiary of this."

The telescope, also known as JWST, was designed to see further back into the history of the cosmos than ever before (SN: 10/9/21 & 10/23/21, p. 26). It's bigger and more sensitive than its predecessor, the Hubble Space Telescope. And because it looks in much longer wavelengths of light, JWST can observe distant and veiled objects that were previously hidden.

JWST spent its first several months collecting "early-release" science data, observations that test the different ways the telescope can see. "It is a very, very new instrument," says Lamiya Mowla, an astronomer at the University of Toronto. "It will take some time before we can characterize all the different observation modes of all four instruments that are on board."

That need for testing plus the excitement has led to some confusion for astronomers in these heady early days. Data from the telescope had been in such high demand that the operators hadn't yet calibrated all the detectors before releasing data. The JWST team is providing calibration information so researchers can properly analyze the data. "We knew calibration issues were going to happen," Mowla says.

The raw numbers that scientists have pulled out of some of the initial images may end up being revised slightly. But the pictures themselves are real and reliable, even though it takes some artistry to translate the telescope's infrared data into colorful visible light (SN: 3/17/18, p. 4).

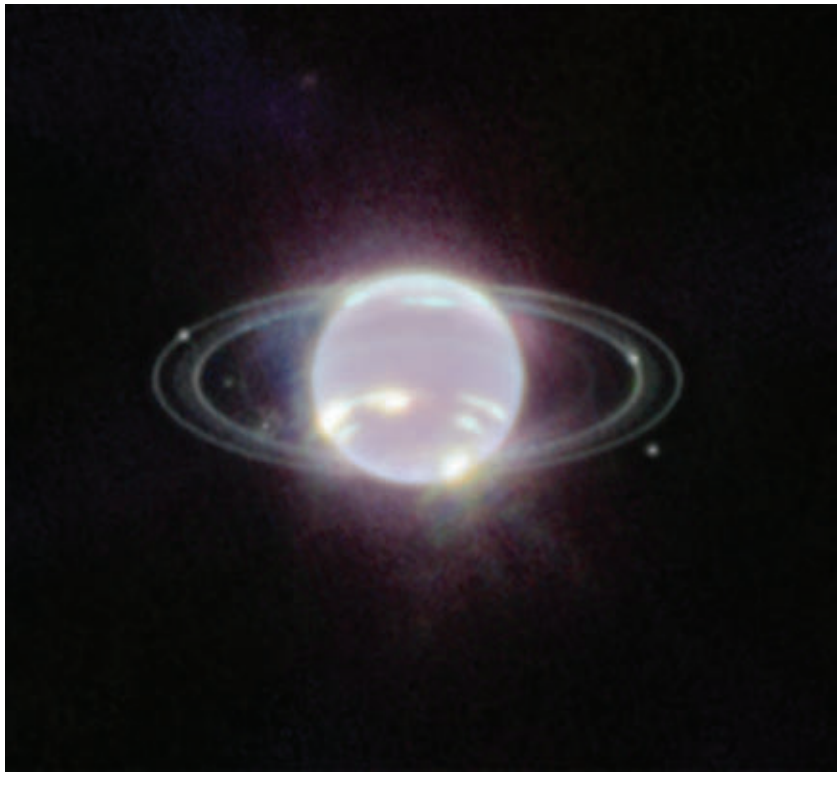
The stunning photos that follow are a few of the early greatest hits from the shiny new observatory.

NASA, ESA, CSA, STScI/Flickr (CC BY 2.0)

The Cosmic Cliffs are part of a star-forming region called the Carina Nebula, which is about 7,600 light-years from Earth. Thanks to the James Webb Space Telescope, astronomers are seeing many of the nebula's baby stars for the first time.

Deep space

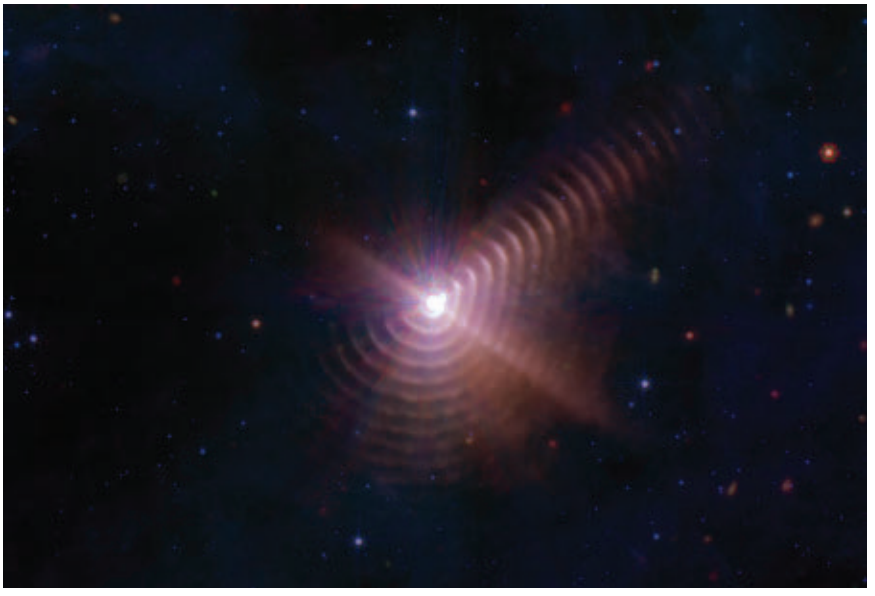
JWST has captured the deepest views yet of the universe (above). Galaxy cluster SMACS 0723 (bluer galaxies) is 4.6 billion light-years from Earth. It acts as a giant cosmic lens, letting JWST zoom in on thousands of even more distant galaxies that shone 13 billion years ago (the redder, more stretched galaxies). The far-off galaxies look different in the mid-infrared light (above left) captured by the telescope's MIRI instrument than they do in the near-infrared light (above right) captured by NIRCam. The first tracks dust; the second, starlight. Early galaxies have stars but very little dust.



Rings around Neptune

JWST was built to see over vast cosmic distances, but it also provides new glimpses of our solar system. This pic of Neptune was the first close look at its delicate-looking rings in over 30 years (*SN: 11/5/22, p. 5*).

TOP TWO: NASA, ESA, CSA, STScI; BOTTOM: NASA, ESA, CSA, STScI; IMAGE PROCESSING: JOSEPH DEPASQUALE/STScI, NAOMI ROWE-GURNEY/NASA GODDARD SPACE FLIGHT CENTER



Under pressure

The rings in this astonishing image are not an optical illusion. They're made of dust, and a new ring is added every eight years when the two stars in the center of the image come close to each other. One of the stars is a Wolf-Rayet star, which is in the final stages of its life and puffing out dust. The cyclical dusty eruptions allowed scientists to directly measure for the first time how pressure from starlight pushes dust around (*SN: 11/19/22, p. 6*).

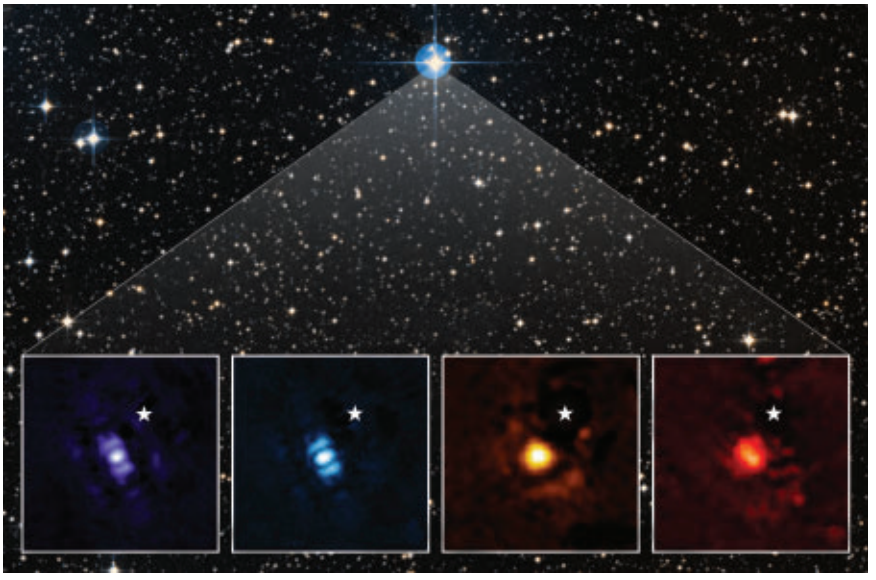
FROM TOP: NASA, ESA, CSA, STSCI, JPL-CALTECH/NASA; NASA JAMES WEBB SPACE TELESCOPE/FLICKR (CC BY 2.0)

Galaxy hit-and-run

With JWST's unprecedented sensitivity, astronomers plan to compare the earliest galaxies with more modern galaxies to figure out how galaxies grow and evolve. This galactic smashup, whose main remnant is known as the Cartwheel galaxy, shows a step in that epic process (*SN Online: 8/3/22*). The large central galaxy (right in the above composite) has been pierced through the middle by a smaller one that fled the scene (not in view). The Hubble Space Telescope previously snapped a visible light image of the scene (top half). But with its infrared eyes, JWST has revealed much more structure and complexity in the galaxy's interior (bottom half).

Exoplanet portrait

The gas giant HIP 65426b was the first exoplanet to have its picture taken by JWST (each inset at right shows the planet in a different wavelength of light; the star symbol shows the location of the planet's parent star). This image, released by astronomer Sasha Hinkley and colleagues, doesn't look like much compared with some of the other spectacular space vistas from JWST. But it will give clues to what the planet's atmosphere is made of and shows the telescope's potential for doing more of this sort of work on even smaller, rocky exoplanets (*SN: 9/24/22, p. 6*).



Shake the dust off

Another classic Hubble image updated by JWST is the Pillars of Creation. When Hubble viewed this star-forming region in visible light, it was shrouded by dust (above left). JWST's infrared vision reveals sparkling newborn stars (above right).

EXOPLANET: NASA, ESA, CSA, AARYNN CARTER/UCSC, THE ERS 1386 TEAM, ALYSSA PAGAN/STSCI; PILLARS, SCIENCE: NASA, ESA, CSA, STSCI, HUBBLE HERITAGE PROJECT/STSCI/AURA; IMAGE PROCESSING: JOSEPH DEPASQUALE, ANTON M. KOEKEMOER AND ALYSSA PAGAN/STSCI

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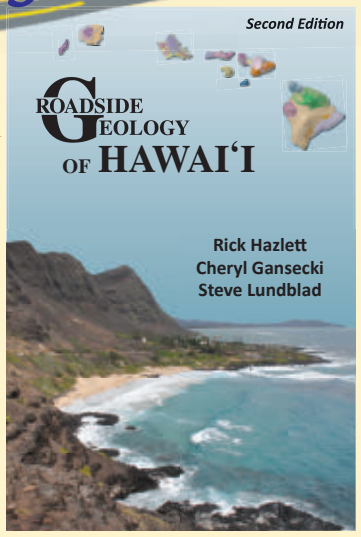

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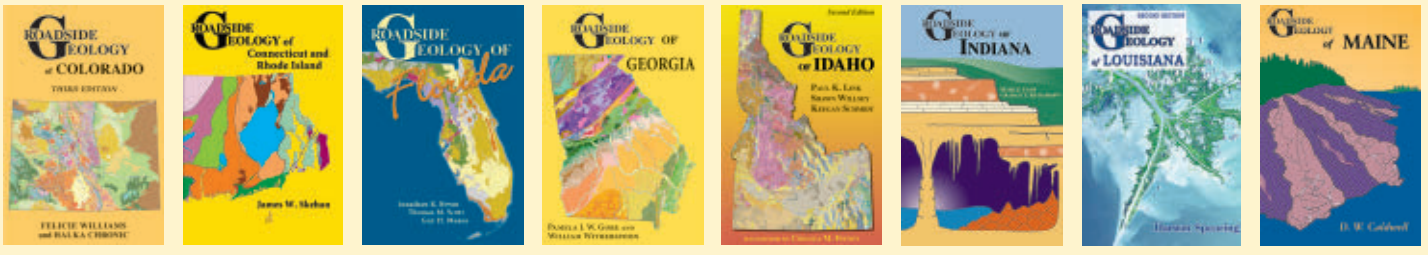

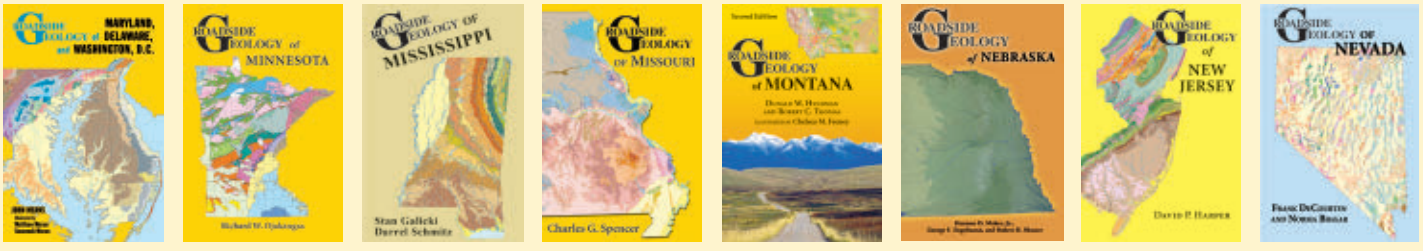

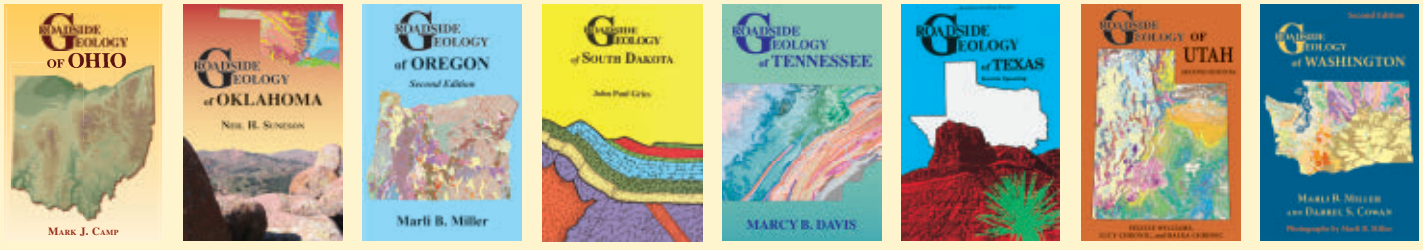

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The year pandemic fatigue took over

BY TINA HESMAN SAEY

2022 was the year many people decided the coronavirus pandemic had ended.

President Joe Biden said as much in an interview with *60 Minutes* in September. "The pandemic is over," he said while strolling around the Detroit Auto Show. "We still have a problem with COVID. We're still doing a lot of work on it. But the pandemic is over."

His evidence? "No one's wearing masks. Everybody seems to be in pretty good shape."

But the week Biden's remarks aired, about 360 people were still dying each day from COVID-19 in the United States. Globally, about 10,000 deaths were recorded every week. That's "10,000 too many, when most of these deaths could be prevented," the World Health Organization Director-General Tedros Adhanom Ghebreyesus said in a news briefing at the time. Then, of course, there are the millions who are still dealing with lingering symptoms long after an infection.

Those staggering numbers have stopped alarming people, maybe because those stats came on the heels of two years of mind-boggling death counts (*SN Online*: 5/18/22). Indifference to the mounting death toll may reflect pandemic fatigue that settled deep within the public psyche, leaving many feeling over and done with safety precautions.

"We didn't warn people about fatigue," says Theresa Chapple-McGruder, an epidemiologist in the Chicago area. "We didn't warn people about the fact that pandemics can last long and that we still need people to be willing to care about yourselves, your neighbors, your community."

Public health agencies around the world, including in Singapore and the United Kingdom, reinforced the idea that we could "return to normal" by learning to "live with COVID." The U.S. Centers for Disease Control and Prevention's guidelines raised the threshold for case counts that would trigger masking (*SN Online*: 3/3/22). The agency also shortened suggested isolation times for infected people to five days, even though most people still test positive for the virus and are potentially infectious to others for several days longer (*SN Online*: 8/19/22).

The shifting guidelines bred confusion and put the onus for deciding when to mask, test and stay home on individuals. In essence, the strategy shifted from public health — protecting your community — to individual health — protecting yourself.

KATTY HUERTAS

Doing your part can be exhausting, says Eric Kennedy, a sociologist specializing in disaster management at York University in Toronto. "Public health is saying, 'Hey, you have to make the right choices every single moment of your life.' Of course, people are going to get tired with that."

Doing the right thing—from getting vaccinated to wearing masks indoors—didn't always feel like it paid off on a personal level. As good as the vaccines are at keeping people from becoming severely ill or dying of COVID-19, they were not as effective at protecting against infection. This year, many people who tried hard to make safe choices and had avoided COVID-19 got infected by wily omicron variants (SN *Online*: 4/22/22). People sometimes got reinfected—some more than once (SN: 7/16/22 & 7/30/22, *p.* 8).

Those infections may have contributed to a sense of futility. "Like, 'I did my best. And even with all of that work, I still got it. So why should I try?'" says Kennedy, head of a Canadian project monitoring the sociological effects of the COVID-19 pandemic.

Getting vaccinated, masking and getting drugs or antibody treatments can reduce the severity of infection and may cut the chances of infecting others. "We should have been talking about this as a community health issue and not a personal health issue," Chapple-McGruder says. "We also don't talk about the fact that our uptake [of these tools] is nowhere near what we need" to avoid the hundreds of daily deaths (see Page 23).

A lack of data about how widely the coronavirus is still circulating makes it difficult to say whether the pandemic is ending. In the United States, the influx of home tests was "a blessing and a curse," says Beth Blauer, data lead for the Johns Hopkins University Coronavirus Resource Center. The tests gave an instant readout that told people whether they were infected and should isolate. But because those results were rarely reported to public health officials, true numbers of cases became difficult to gauge, creating a big data gap (SN *Online*: 5/27/22).

The flow of COVID-19 data from many state and local agencies also slowed to a trickle. In October, even the CDC began reporting cases and deaths weekly instead of daily. Altogether, undercounting of the coronavirus's reach became worse than ever.

"We're being told, 'it's up to you now to decide what to do,'" Blauer says, "but the data is not in place to be able to inform real-time decision making."

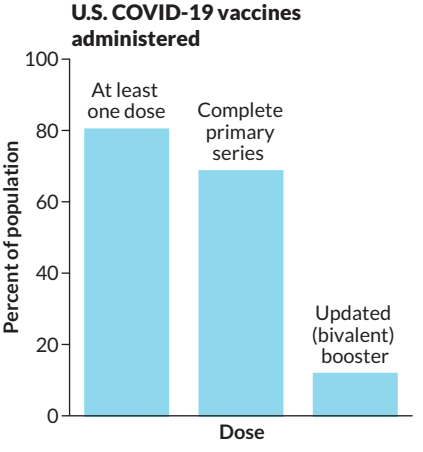
With COVID-19 fatigue so widespread, businesses, governments and other institutions have to find ways to step up and do their part, Kennedy says. For instance, requiring better ventilation and filtration in public buildings could clean up indoor air and reduce the chance of spreading many respiratory infections, along with COVID-19. That's a behind-the-scenes intervention that individuals don't have to waste mental energy worrying about, he says.

The bottom line: People may have stopped worrying about COVID-19, but the virus isn't done with us yet. "We have spent two-and-a-half years in a long, dark tunnel, and we are just beginning to glimpse the light at the end of that tunnel. But it is still a long way off," WHO's Tedros said. "The tunnel is still dark, with many obstacles that could trip us up if we don't take care." If the virus makes a resurgence, will we see it coming and will we have the energy to combat it again? ■

FROM TOP: MTA; E. OTWELL

Early in the pandemic, the New York Metropolitan Transportation Authority posted signs asking people to mask up on subways (left). In early September, MTA changed its policy, shifting to a focus on individual choice rather than protecting each other (below).

Lagging on vaccines About 80 percent of the U.S. population got the first COVID-19 vaccine dose and close to 70 percent completed the primary series. The updated booster, made available in September, had only made it into the arms of 12 percent of people age 5 and older as of November 24. SOURCE: CDC



Feeling the weight of long COVID

BY LAURA SANDERS

This year, the world had to face the growing burden of long COVID. A tidal wave of people with lingering symptoms — some mild, some profoundly disabling — commanded attention.

"We are in the middle of a mass disabling event," physician Talya Fleming of the JFK Johnson Rehabilitation Institute in Edison, N.J., told *Science News* (SN: 11/5/22, *p.* 22). A recent estimate suggests that over 18 million people in the United States have long COVID. Yet researchers know little about the disease and how to treat those who are suffering.

One key question is: Who is at risk? The search for risk factors has yielded few clear answers. Women may be slightly more likely than men to get long COVID, as are people who had more than five symptoms during their initial week of COVID-19 (SN: 10/8/22 & 10/22/22, *p.* 18).

Part of what confounds simple answers is that long COVID can hit multiple body systems, leading to fatigue, smell loss, memory trouble, blood clots and even sensations of internal tremors that feel like earthquakes (SN: 9/24/22, *p.* 14).

Symptoms could be due to persistent virus hiding out in the body, as well as the body's responses to the intruder. Micro blood clots, antibodies that turn against the body, inflammation and even disturbances of helpful bacteria are all being scrutinized for their roles in the disease.

The lack of clarity is what makes finding treatments so hard. Doctors at long COVID clinics, which are few and far between, are scrambling to ease people's symptoms, often borrowing therapies from other disorders that cause similar problems, such as myalgic encephalomyelitis/chronic fatigue syndrome (SN: 11/5/22, *p.* 25).

The long list of unanswered questions has taken on new urgency given the swell of people experiencing long COVID. Epidemiologist Priya Duggal of Johns Hopkins Bloomberg School of Public Health and colleagues suspect that between 10 and 30 percent of people who get COVID-19 may go on to get long COVID. That fits with federal data suggesting that about 30 percent of U.S. adults who have had COVID-19 have experienced long COVID. But surveys, medical records and other data all come with flaws, so exact numbers are impossible to come by, she says.

What's perhaps most useful, Duggal says, is to consider how many people are severely constrained by their illness. "These are the people [who] were living happy, healthy lives and now they're not," she says. About 1 to 5 percent of people who had COVID-19 may fall into this category, she estimates. That sounds like a tiny number, she says, but "even if it's 1 percent, it's 1 percent of all people who have had COVID. And that's just a really, really large number." An estimated 100 million people in the United States have had COVID-19. That's probably an undercount, Duggal says.

In the first days of the pandemic, Duggal and colleagues wanted to collect as much biological data on people as they could, before COVID-19 tore through the world. But logistics and a lack of funding prevented those baseline studies. "Had we had some of that in place, we could now be asking better questions and getting better answers," she says. "I would hope that some of what this has taught us is that the next time this happens — and let's hope it is no time soon — we have a bit more thought about what's to come." ■

KATTY HUERTAS

COVID-19 updates

BY AIMEE CUNNINGHAM

The third year of the COVID-19 pandemic in the United States introduced vaccines for very young children and an updated booster, plus wider availability of an antiviral drug and at-home antigen tests. Here's what we've learned since these achievements first made a splash.

Shots for the littlest kids

On June 18, the COVID-19 vaccine was recommended for children under 5, the last group in the United States waiting for the shots (SN *Online*: 6/17/22). The thumbs-up was supported by immunity and safety data and the clear-and-present health risks of COVID-19 for young kids.

UPDATE: Many young children in the United States are still unvaccinated. Only 10 percent of those 6 months through 4 years old, or 1.7 million children, had received at least one dose as of November 16. A survey from the Kaiser Family Foundation COVID-19 Vaccine Monitor conducted in mid-July explored some reasons for the lackluster response, including concerns that the vaccine hasn't been tested enough.

There are also barriers to getting the vaccine, with 44 percent of Black parents worried about taking time off from work to vaccinate young kids or take care of them if they have side effects. Among Hispanic parents surveyed, 45 percent are concerned they won't have the option to vaccinate at a place they trust.

A new booster

An updated COVID-19 vaccine became available as a booster in the United States in early September for those 12 and older, and for those 5 to 12 years old in mid-October (SN: 10/8/22 & 10/22/22, *p.* 7). The vaccine, which targets two omicron subvariants as well as the original version of SARS-CoV-2, was designed to spur a broader immune response, protecting against more versions of the virus.

UPDATE: Just 12 percent of people in the United States ages 5 and older, or more than 37 million people, had gotten the updated bivalent booster by November 24. In a survey conducted in September, half of U.S. adults had heard little or nothing about the new booster, underscoring the need for more public outreach. President Joe Biden, who had COVID-19 in July, received his updated vaccine on October 25 and announced new measures to get more boosters into arms. A study of U.S. adults reported in November found that the updated booster provided added protection against symptomatic COVID-19 in those who had already gotten at least two doses of the original vaccine.

At-home COVID-19 tests

Early in 2022, the use of at-home COVID-19 tests soared in response to the winter omicron surge (SN *Online*: 1/11/22). From January to September, the Biden administration mailed roughly 600 million free tests to people's homes.

UPDATE: At-home antigen tests are quick and easy, though the guidance on how to interpret the results has changed. With data that repeat testing improved the chances of detecting a SARS-CoV-2 infection, the U.S. Food and Drug Administration recommended in August that people with and without symptoms who were exposed to the virus and tested negative take additional tests over the next several days.

A drawback to at-home tests is that the results have not been systematically tallied, leading to an undercount of cases. Estimates vary on how many cases have been missed. One research group calculated that in New York City between April 23 and May 8, around 1.5 million adults had COVID-19, nearly 30 times as many as the official case count of 51,218.

A new drug

The antiviral Paxlovid — authorized at the end of 2021 — became one of a few COVID-19 treatment options in pill form.

Mary Bassett, New York state's commissioner of health, got an updated COVID-19 booster soon after it became available in September.

A study published in April reported that Paxlovid reduced the risk of severe COVID-19 by 89 percent compared with a placebo (SN *Online*: 5/11/22).

UPDATE: In July, the FDA authorized pharmacists to prescribe Paxlovid to get the drug more quickly to more people, since it needs to be taken early in an infection. A study conducted during the omicron surge suggested that the drug is beneficial for those 65 and older but is not helpful to those 40 to 64.

Paxlovid also made news this year when reports popped up of COVID-19 symptoms returning after treatment with the drug ended (SN *Online*: 8/12/22). It's not clear how common so-called Paxlovid rebound. Some research has found the incidence is similar among Paxlovid-treated and placebo-treated patients, while other researchers have reported that rebound occurs more often with Paxlovid than with no treatment.

There's also early evidence that Paxlovid may reduce the risk of developing long COVID. A preliminary study of U.S. veterans reported in November that treatment with Paxlovid within five days of a positive COVID-19 test was associated with a 26 percent reduction in risk of long COVID compared with a group that did not receive antiviral treatment after an infection. ■

ENRIQUE SHORE/ALAMY STOCK PHOTO

Viral surprises

Monkeypox (illustrated) caught public health officials off guard as it spread around the world in 2022.

JOAO PAULO BURINI/MOMENT/GETTY IMAGES

BY ERIN GARCIA DE JESÚS

This year delivered many frightening reminders that the coronavirus isn't the only viral threat out there.

Monkeypox went global

The monkeypox virus, a relative of the virus that causes smallpox, had never before spread widely among people outside of Central and West Africa. But in May, monkeypox burst onto the global scene (SN: 6/18/22, *p.* 6). As of November 28, there have been more than 81,100 cases across 110 countries and 55 deaths.

The disease, which can cause a rash with painful, pus-filled lesions, mainly spreads through close contact. Although anyone can be infected, outside of West and Central Africa the current outbreak is primarily affecting men who have sex with men. Waning immunity worldwide to smallpox — which was eradicated in 1980, ending vaccination programs — likely helped monkeypox spread.

In the United States and Europe, cases started going down in August as people at high risk changed their behavior or received vaccines. Preliminary data from the U.S. Centers for Disease Control and Prevention suggest that vaccination is protective. Yet vaccines are still not available in African countries where monkeypox has historically circulated.

Ebola surged in Uganda

Two small Ebola virus outbreaks were reported in Congo this year. But more worrisome was an outbreak in Uganda that began in September. Current Ebola vaccines and treatments don't offer protection against the strain causing that country's outbreak. But clinical trials for three vaccine candidates were set to begin in late 2022.

As of November 22, Uganda had 141 confirmed cases and 55 deaths, including at least seven health care workers.

Poliovirus found in sewage

A version of the poliovirus was detected in sewage in New York, Israel, the United Kingdom and some other places where polio had been eliminated, suggesting the virus — which can cause paralysis — was circulating there. In March, Israeli officials confirmed a case of paralytic polio in an unvaccinated 3-year-old; an unvaccinated man in New York was paralyzed by polio in June.

These cases were linked to vaccine-derived polioviruses (SN *Online:* 9/14/22). One type of polio vaccine relies on live but weakened virus to teach the body to mount immune defenses against the disease. In rare cases, that weakened, or attenuated, virus can spread, mutate and regain the ability to cause paralysis in people who are not vaccinated. Attenuated vaccines are not used in the United States, but are common in some countries, including Afghanistan and Pakistan, the last two places that are still working to eliminate polio.

Unexplained hepatitis hit children

Between October 2021 and July 8, the last time the World Health Organization released an update, more than 1,000 children globally had developed severe hepatitis, an inflammation of the liver. Experts still aren't sure why. They also don't know whether it's a new outbreak, or if doctors are just paying more attention in the wake of the pandemic.

Many cases were linked to an adenovirus, which typically causes colds (SN *Online*: 5/19/22). But having a previous case of COVID-19 could also factor in. Another hypothesis is that kids with a certain genetic susceptibility are getting hepatitis after a double infection, perhaps with an adenovirus plus a second virus called AAV2.

Bird flu wreaked havoc

Birds around the world also faced a deadly viral foe this year: the H5N1 influenza virus. In the United States alone, 3,700 wild birds have tested positive for the virus. More than 50 million farmed poultry died, either from infection, or because they were culled to control the virus' spread. In Europe, the 2021–2022 season was the largest known epidemic of highly pathogenic avian influenza, with more than 2,600 outbreaks across 37 countries in farmed or captive birds.

Researchers are concerned that H5N1 poses a long-term threat to poultry, wild birds and potentially other animals; the virus was linked this year to a seal die-off in Maine.

People can also be susceptible, with two confirmed cases since December 2021. Although bird flu doesn't easily spread among people, experts worry that as the epidemic continues the virus will pick up mutations that allow it to transmit from person to person. ■

Russia's war in Ukraine reshaped global science

BY CASSIE MARTIN

Russia's invasion of Ukraine in late February horrified the world. Images of civilians fleeing their homes, broken bodies strewn across city streets, smoldering apartment complexes and mass graves have permeated the news and social media platforms ever since. This war has killed tens of thousands of people and displaced 14 million more.

Wars aren't fought in a vacuum. The ripple effects of the war in Ukraine, from skyrocketing energy and food costs to environmental damage and the threat of nuclear disaster (*SN*: 7/2/22, *p.* 6; *SN Online*: 3/7/22), have been felt around the globe—especially amid two other crises, the ongoing coronavirus pandemic and climate change.

"A convergence of all these crises at the same time is very, very dangerous for the world," Tedros Adhanom Ghebreyesus, director-general of the World Health Organization, said in May.

We often look to science for solutions to the world's problems. But this tectonic shift in the geopolitical landscape has upended global science collaboration, leaving many researchers scrambling to find solid footing. While the outcome of this change—like the outcome of the war itself—is uncertain, here are some examples of how the conflict has affected scientists and their research.

Science in a war zone

Ukraine's infrastructure has sustained massive damage since the invasion began. Hospitals, universities and research institutions have not been spared.

Some scientists have sought refuge in other countries while roughly half remain in Ukraine, with male researchers between the ages of 18 and 60 expected to serve in the military, says George Gamota, a U.S.–based physicist who advises the National Academy of Sciences of Ukraine. Gamota was born in Ukraine and moved to the United States as a child. He maintains close ties with his country of birth. When Ukraine became an independent country in 1991 after the fall of the Soviet Union, he helped advise Ukraine as it built its scientific infrastructure.

"When Russia attacked Ukraine, all hell broke loose. This situation really has not stabilized," Gamota says.

Research funding in Ukraine has declined by 50 percent, he says. Scientific bodies across the globe have stepped up to offer aid through grants, job opportunities and resettlement programs. But monetary support, whether it's from Ukraine's government or independent organizations, still takes too long to reach scientists' pockets, Gamota says. "Some are not getting anything."

The National Academy of Sciences of Ukraine is already looking ahead to how to rebuild. In September, the organization met with its counterparts in Europe and the United States. Latvia, Poland and other places described how they restructured after the end of the Soviet Union, Gamota says. "It was an exercise that I think is important to have. But probably what the Ukrainians were looking for is how can the world help us right now."

In March, the Breakthrough Prize Foundation donated $1 million to directly support Ukrainian researchers. The organization donated an additional $2 million in October for rebuilding efforts, a move that Gamota calls "fantastic."

Slowdowns for physics and space

While science in Ukraine has struggled as the war drags on, Russian science has become more and more isolated. Sanctions from Western countries have directly and indirectly targeted Russia's scientific enterprise.

In June, the White House Office of Science and Technology Policy announced that the United States will "wind down" collaborations with Russia, following an earlier ban on exports of U.S. technology there. The policy applies to national labs, as well as projects that receive federal funding and involve Russian government–affiliated universities and research institutions. Many research organizations in the West have also cut ties with collaborators in Russia.

These steps have particularly affected some large-scale collaborations in space and physics research.

There have been mission delays and the temporary shutdown of at least one space telescope (*SN*: 3/26/22, *p.* 6). The International Space Station, which is run jointly by NASA and the Russian space agency Roscosmos, however, continues to operate normally for now.

In the world of high-energy physics research, the CERN particle physics lab near Geneva announced that it will not be renewing its international cooperation agreements with Russia and Belarus,

Researchers watch from a control room as the Large Hadron Collider at the CERN lab was restarted this year. In the wake of the invasion of Ukraine, CERN said it would cut ties with Russia.

R. GONZALEZ SUAREZ/CERN

which is aiding Russia's invasion, when the contracts expire in 2024.

When that happens, the roughly 8 percent of CERN staff affiliated with Russian institutions, equaling about 1,000 researchers, will be unable to use CERN facilities. And Russia will stop contributing resources to experiments.

These measures strongly condemn the invasion "while leaving the door ajar for continued scientific collaboration should conditions allow in the future," CERN Director-General Fabiola Gianotti wrote in a memo to staff about the decision. Until 2024, Russian and Belarusian scientists can continue working on current collaborations, such as ATLAS — one of the detectors that spotted the Higgs boson in 2012 and is part of ongoing searches for theoretical particles, including dark matter (SN: 7/2/22, p. 18). But new efforts are prohibited.

Science outside of Ukraine and Russia has not escaped the geopolitical maelstrom's economic fallout. Rising energy costs — spurred by Russia cutting off exports of natural gas — are causing European research labs to reassess their energy use, the journal *Nature* reported in October. CERN is a major consumer, using the equivalent of about a third of Geneva's annual average energy consumption.

The lab ended the run of its largest accelerator on November 28, two weeks ahead of schedule, to decrease its load on the electrical grid and prepare for surging prices and potential winter shortages. CERN officials announced that the number of particle collisions in 2023 will decrease, tightening competition among researchers for accelerator time, *Nature* reported.

The war also has put pressure on an already faltering global supply chain, which has led to shortages and shipping delays. The delays have created snags in the construction of ITER, the world's largest nuclear fusion experiment that's slated to open in 2025, in France. "We have been through thick and thin with this project, and we will manage," says ITER spokesperson Sabina Griffith. ITER had been expecting a ring magnet and other equipment from Russia, one of seven partners along with the European Union and the United States. Due to intergovernmental contracts, Russia is still part of the project. But for now, "everything is put on ice," Griffith says.

The war in Ukraine has made it difficult to study climate change in the Russian Arctic, where thawing permafrost can create craters (one shown) and release greenhouse gases.

PADI PRINTS/TROY TV STOCK/ALAMY STOCK PHOTO

A chilling effect on Arctic research

Northern Russia is home to about two-thirds of Earth's frozen soil, or permafrost. Collectively, the world's permafrost contains almost twice as much carbon as is in the atmosphere. With temperatures in the Arctic rising almost four times as fast as the global average, the region's permafrost is thawing. By the end of this century, the defrosted soil could exhale hundreds of billions of tons of carbon dioxide and methane, according to some estimates. To better understand how climate change is reshaping the Arctic and vice versa, researchers need detailed measurements of permafrost carbon, temperature, microbial communities and more.

But the deteriorating relationship between the West and Russia is "throwing a major wrench into bringing the data together so that we can get the clearest picture of the Arctic as a whole," says Ted Schuur, an ecologist at Northern Arizona University in Flagstaff and the principal investigator of the Permafrost Carbon Network. Now that much of the Arctic's permafrost is inaccessible, Schuur and colleagues are looking for sites in North America and Europe that could serve as a proxy for Russian permafrost, he says.

Terminated collaborations, "while intended to 'punish' Russia, are realistically affecting the global Arctic community by limiting the researchers' access to scientific information and undermining the resilience of Arctic (including notably Indigenous) communities," Nikolay Korchunov, Russia's ambassador-at-large for Arctic affairs, wrote in an e-mail to *Science News*.

Korchunov chairs the Arctic Council, an eight-member intergovernmental body that acts as a steward for the region, forging agreements on oil spill cleanup, commerce, wildlife conservation, climate change research and more. In March, the council's other seven member nations — Canada, Denmark, Iceland, Finland, Sweden, Norway and the United States — announced they would pause collaboration with Russia.

Work among the so-called "Arctic 7" continues. But the freeze-out has derailed Russia's planned biodiversity- and pollution-monitoring projects, Korchunov says. "A cold scientific environment only increases uncertainty and risks of an ineffective response to the warming Arctic."

But some cooperation in the Arctic has continued, for now. Vladimir Romanovsky is a geophysicist at the University of Alaska Fairbanks who studies permafrost temperature and relies on data provided by scientists in Russia. This year, his team got results, but whether his Russian collaborators will be able to take measurements in 2023 is unclear, Romanovsky says. "It is changing so quick, so fast that we don't know what the situation will be by then."

Most of the researchers in Russia that Romanovsky knows are struggling with funding. At the moment, there is enough money to keep his collaborators employed but not enough to do fieldwork.

Cutting off Russian scientists from communication and data sharing is a "big, big problem," Romanovsky says. They now are almost completely excluded from international meetings and collaborations, he notes. In the long term, Romanovsky thinks that Russian science could lose many young researchers, like what happened in the 1990s when the Soviet Union collapsed. "They just went to go somewhere else," he says, leaving to find work in other fields to continue to support their families. He and many others hope it won't happen again. ■

A winning year for climate legislation

BY NIKK OGASA

The world needed bold climate action this year, and we got it.

California and other states announced plans to phase out gas-powered cars after 2035. The United States ratified an international treaty to slash production of the climate-warming hydrofluorocarbons used in cooling and refrigeration. The European Union is finalizing its plan to cut greenhouse gas emissions by 55 percent relative to 1990s levels by 2030. The list of legislative victories goes on. But the biggest win came August 16, when President Joe Biden signed into law the Inflation Reduction Act.

On August 16, President Joe Biden signed into law the Inflation Reduction Act.

The historic legislation marks the first major move by the United States, which has emitted more carbon dioxide than any other country, toward neutralizing greenhouse gas emissions. It gets the ball rolling by investing $369 billion into accelerating the adoption of wind, solar and other renewable energy sources and decarbonizing the economy. By the end of the decade, the act will help cut U.S. greenhouse gas emissions by around 40 percent of the levels in 2005, when U.S. emissions nearly peaked, scientists project, bringing the nation within reach of fulfilling its pledge to halve emissions by 2030.

The legislation is no panacea for the climate emergency, but researchers and activists are optimistic that it will be the helping hand that clean energy needs to flourish. "There would be no way to really mitigate the climate crisis without the investments in this bill," says Raul Garcia, a legislative director at Earthjustice, a nonprofit environmental law organization.

Here's a look at some of the law's major provisions and a few of its limitations.

Cheaper clean energy

The law aims to ease and incentivize the transition away from fossil fuels by creating tax credits that reduce the cost for companies to adopt clean energy. For instance, small businesses can qualify for credits that support up to 30 percent of the cost of transitioning to solar power.

The act also aims to help consumers, with $9 billion for rebates that help people ditch gas and buy appliances powered by electricity, such as electric induction cooktops and heat pump water heaters. Households can also get up to $7,500 in tax credits for electric vehicle purchases.

"It's huge," Denise Mauzerall, an atmospheric scientist at Princeton University, says of the law's potential to advance clean energy. But if the United States is to take full advantage of the increased clean energy capacity, it will be crucial to also construct sufficient infrastructure to deliver that energy, she notes. The bill offers only some support to build overhead power lines and other ways to transmit energy. "Without transmission," she says, "we will really slow ourselves down."

More clean energy jobs and goods

A major goal is to build up a clean energy economy by promoting high-quality jobs in industries such as solar and wind. To maximize tax credits, companies must pay workers a "prevailing wage" and employ apprentices to work a minimum number of hours on clean energy projects.

The legislation also invests in the domestic manufacturing of clean energy goods. Tax credits of up to 30 percent are available to companies that build or recycle wind turbine blades, solar panels, energy storage equipment and other clean energy products, and funds grants to retool factories to make electric vehicles.

Less air pollution

Methane — a greenhouse gas that can trap more than 25 times as much heat as CO_2 — is another target. The legislation devotes $850 million to the monitoring and mitigation of methane emissions from fossil fuel operations. It also establishes a fine for operations that annually release amounts of methane that exceed 25,000 metric tons of CO_2 equivalent.

And CO_2 is legally defined as an "air pollutant," cementing the Environmental Protection Agency's authority to regulate its production under the Clean Air Act.

But there's more to the climate problem than decarbonizing today's pollutive energy industry, Mauzerall says. "Going forward, we need to pay more attention to reducing emissions from the agricultural sector," she says. About 11 percent of U.S. greenhouse gas emissions and about a third of global emissions come from agriculture (SN: 5/7/22 & 5/21/22, *p.* 22).

Climate justice

Billions of dollars are slated to go toward climate justice, a movement that confronts the disproportionate impacts of climate change on marginalized communities. Funding includes $2.8 billion in grants for community-based projects, such as those that increase energy efficiency in affordable housing developments or monitor air quality in marginalized communities.

"But there are some troubling provisions," Garcia says. The law authorizes new offshore oil and gas leases and provides fossil fuel companies with carbon capture and sequestration tax credits. These could prolong the life of pollutive oil and gas operations, which are often located near marginalized communities.

It will be crucial to follow these investments with laws that enforce both climate justice and the clean energy transition, Garcia says. "We need rules and regulations that hold industries' feet to the fire, to make sure that those investments are going where they need to." ■

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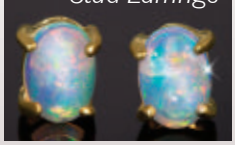

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Dispatches from space

BY LISA GROSSMAN

While the stunning images from the James Webb Space Telescope captured space fans' attention this year, other telescopes and spacecraft were busy on Earth and around the solar system. Here are some of the coolest space highlights that had nothing to do with JWST.

Back to the moon

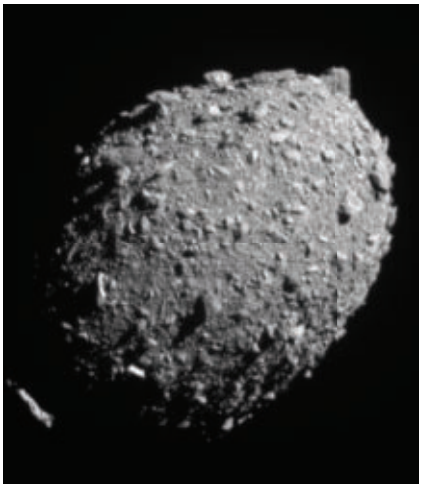
After several aborted attempts, NASA launched the Artemis I mission on November 16. That was a big step toward the goal of landing people on the moon as early as 2025 (SN: 12/3/22, p. 14). No human has set foot there since 1972. Artemis I included a new rocket, the Space Launch System, which had previously suffered a series of hydrogen fuel leaks, and the new Orion spacecraft. No astronauts were aboard the test flight, but Orion carried a manikin in the commander's seat and two manikin torsos to test radiation protection and life-support systems, plus a cargo hold full of small satellites that went off on their own missions.

Push comes to shove

NASA's DART spacecraft successfully nudged an asteroid into a new orbit this year. On September 26, the Double Asteroid Redirection Test slammed into asteroid Dimorphos, about 11 million kilometers from Earth at the time of impact. In October, NASA announced that the impact shortened Dimorphos' roughly 12-hour orbit around its sibling asteroid, Didymos, by 32 minutes (SN: 11/5/22, p. 14). Dimorphos posed no threat to Earth, but the test will help inform future missions to divert any asteroids on a potentially dangerous collision course with our home planet, researchers say.

Massive Marsquakes

The InSight Mars lander is going out on a high note. After scientists reported in May that InSight had recorded the largest known Marsquake, roughly a magnitude 5, news came in October that the lander's seismometer had also detected the rumblings of the two biggest meteorite impacts ever observed on Mars. Those impacts created gaping craters and sent seismic waves rippling along the top of the planet's crust.



In September, NASA's DART spacecraft shifted the course of asteroid Dimorphos, shown here seconds before DART smashed into it.

The details of how those waves and others moved through the Red Planet gave researchers new intel on the structure of Mars' crust, which is hard to study any other way. The data also suggest that some Marsquakes are caused by magma moving beneath the surface (SN: 12/3/22, p. 12). The solar panels that power the lander are now covered in dust after four years on Mars, a death knell for the mission.

Chemistry of life

All five bases in DNA and RNA have been found in rocks that fell to Earth. Three of the nucleobases, which combine with sugars and phosphates to make up the genetic material of all known life, had previously been found in meteorites. But the last two — cytosine and thymine — were reported from space rocks only this year (SN: 6/4/22, p. 7). The find supports the idea that life's precursors could have come to Earth from space, researchers say.

Sagittarius A* snapshot

The supermassive black hole at the center of the Milky Way became the second black hole to get its close-up. After releasing a picture of the behemoth at the heart of galaxy M87 in 2019, astronomers used data from the Event Horizon Telescope, a network of radio telescopes around the world, to assemble an image of Sagittarius A* (SN: 6/4/22, p. 6). The image, released in May, shows a faint fuzzy shadow nestled in the glowing ring of the accretion disk. That may not sound impressive on its own, but the result provides new details about the turbulence roiling near our black hole's edge. ■

The Event Horizon Telescope revealed this first-ever image of the supermassive black hole at the center of the Milky Way.

FROM TOP: NASA; EHT COLLABORATION

Let's wait and see

BY ELIZABETH QUILL

The youngster (left) being groomed by an adult female silvered leaf monkey may be a rare hybrid.

KEN S.H. CHING

These reported discoveries from 2022 could be game changers, if only we were sure of the findings. News reports this year left us wondering…

Is new physics around the corner?

A measurement of the mass of an elementary particle called the W boson has physicists holding their breath. Data from the Collider Detector at Fermilab, or CDF, suggest the particle is heftier than expected (SN: 5/7/22 & 5/21/22, *p.* 12). If so, the finding would be just the kind of crack that researchers have been looking for in the standard model of particle physics. That theory successfully describes the basic constituents of our world but doesn't explain how gravity fits in. Whether the discovery dissolves with further measurements or points the way to a new and better understanding of matter remains to be seen.

Was Old MacDonald a gopher?

Root-munching southeastern pocket gophers (*Geomys pinetis*) tend their tunnels like farmer tend their fields, scientists claimed (*SN Online:* 7/14/22). The gophers, which live in Alabama, Georgia and Florida, spread their feces in the tunnels, churn the soil and nibble existing roots. All of that encourages new roots to grow, and so secures future lunch. But some researchers say the gophers' inadvertent environmental changes don't count as agriculture. For now, it's an open question whether any mammals but people cultivate crops.

Do limb bones reveal our roots?

There's no doubt that fossils of a part of a leg and two forearms unearthed in 2001 in Chad are a window into the past. But what they can tell us about our own evolution has been hotly debated. The bones, which date to around 7 million years ago, belong to *Sahelanthropus tchadensis* and confirm that the species walked upright, scientists reported (SN: 9/24/22, *p.* 7). That conclusion cements the species' status as the earliest known hominid, those scientists argue. Other proposed early hominids are much younger, dating from about 5 million to 6 million years ago. But some scientists say the 7-million-year-old bones don't clearly point to a two-legged gait and belonged instead to an ancient ape. With all the uncertainty, these findings may yet be walked back.

Do tetraneutrons exist?

Scientists have been on the hunt for six decades. Now for the first time they may have spotted an elusive quartet: a cluster of four neutrons called a tetraneutron (*SN Online:* 6/22/22). These clumps seem to last for a fleeting instant, less than a billionth of a trillionth of a second in an experiment reported this year. Studying the clusters could be a boon to researchers who want to know how neutrons behave within atomic nuclei. But disagreements among various theoretical calculations leave some experts unconvinced that tetraneutrons even exist.

Is a mystery monkey a hybrid?

An odd-looking primate spotted some six years ago in Borneo might be a rare hybrid. But researchers won't be sure until they can collect animal droppings for genetic analysis (SN: 6/18/22, *p.* 11). Photographs suggest that the primate's mother is a silvered leaf monkey (*Trachypithecus cristatus*), its father a proboscis monkey (*Nasalis larvatus*). If true, it's a concerning coupling. Mating across genera suggests the two species are under extreme pressure, probably from the deforestation for oil palm plantations that's fragmenting the habitat the monkeys share along the Kinabatangan River.

Did humans arrive early in Europe?

Humans may have migrated to Europe as early as 56,800 years ago, scientists reported based on discoveries at a rock-shelter in southern France. Those finds would put *Homo sapiens* on the continent about 10,000 years earlier than previously thought and long before Neandertals died out (SN: 3/12/22, *p.* 9). The disappearance of the Neandertals, the work suggests, may have been a more complex and drawn-out process than had been realized. The researchers suggest that *H. sapiens* not only traded off occupation of the site with Neandertals, but also took survival tips. Still, the evidence rests on a single human tooth and tools that other researchers say could have been made by Neandertals.

Has a 'photon ring' been detected?

Remember that stunning first picture of a black hole, unveiled in 2019 by the Event Horizon Telescope team? It showed the shadow of galaxy M87's black hole on its swirling ring of hot matter. Well, astrophysicists announced this year that they had teased out a ring within a ring in M87, identifying the thin circle of light created by the orbiting photons that are flung around the black hole before they fly toward Earth (SN: 9/24/22, *p.* 8). This "photon ring" would offer a new way to test what we think we know about gravity, but some researchers are critical of the methods used to identify the ring. A clear detection of the photon ring might have to wait for space telescopes to join the black hole–imaging effort. ■

Biomedical advances

BY MEGHAN ROSEN

COVID-19 may continue to dominate headlines, but this year's biomedical advances weren't all about "the Rona." 2022 saw fruitful and seemingly fantastical research that could one day mean good news for patients.

In July, a surgical team at NYU Langone Health transplanted a pig heart into a brain-dead patient, part of a larger effort to evaluate the potential of using animal organs for transplantation.

Next-level organ transplants

Organ transplants have started mirroring science fiction. In January, an ailing 57-year-old man received a heart from a genetically engineered pig and survived for two months with the transplanted organ (SN: 3/12/22, p. 26). Other surgeries plugged pig hearts into the bodies of brain-dead patients, a step that prepares researchers for future clinical trials (SN *Online*: 7/12/22). And a high-tech system hooked up to pigs' bodies an hour after death helped keep organs functioning. The technology, which might one day preserve human organs slated for surgery, pumps a mix of real and artificial blood through the animals (SN: 9/10/22, p. 12).

Epstein-Barr's link to MS

Scientists dropped an Epstein-Barr bombshell early this year when they suggested that the virus is the main cause of the neurodegenerative disease multiple sclerosis. Infection with the virus greatly upped the odds of later developing MS, an analysis of millions of U.S. military recruits found. The link between the virus and MS, which scientists had suspected but never outlined so clearly, might guide the way to potential MS treatments — or even, one day, vaccines to prevent the disease (SN: 8/13/22, p. 14).

A complete human genome, finally

Researchers announced back in 2003 that they had read all the genetic info packed into strands of human DNA — the first sequence of the human genome. But that genome was not quite complete; some tangled-up lengths of DNA remained difficult to decipher. This year, a team tied up the loose ends. In March, the researchers reported a new and improved human genome — this time, complete from end to end (SN: 4/23/22, p. 6).

AI predicts protein structures

Artificial intelligence has taken structural biology to warp speed. A deep-learning program called AlphaFold has now

Awesome animals

BY DEBORAH BALTHAZAR

From spiders that catapult their way to safety to sea sponges that sneeze themselves clean, here are the creature features that most impressed us in 2022.

Fishing fox

Pics or it didn't happen. In the first recorded instance of a fox fishing, a team from Spain filmed a red fox (*Vulpes vulpes*) catching 10 carp over a couple hours (SN: 11/5/22, p. 4). This makes foxes only the second type of canid — wolves can do it too — that are known to fish for a feast.

Skydiving salamander

Flying squirrels, yes, but a skydiving salamander? This bold amphibian, native to northwestern California, can jump and glide among the tops of towering redwood trees. By extending its front and hind legs like a skydiver, the wandering salamander (*Aneides vagrans*) can control and adjust its speed and direction while in the air (SN: 6/18/22, p. 12).

Crafty cockatoos

In an interspecies battle for the ages, people in Sydney have had to up their defenses to stop cockatoos from rifling through outdoor trash bins (SN: 10/8/22 & 10/22/22, p. 10). The birds have learned to push bricks off the bin covers using brute force, while sneakers jammed through a bin's handles are a better deterrent. But these trash thieves may eventually find a way around that blockade too.

Spring-to-safety spiders

Philoponella prominens males perform a death-defying stunt to keep from being eaten by a mate after sex. The orb weaver uses hydraulic pressure within its leg joints to launch nearly 90 centimeters per second to safety (SN *Online*: 4/25/22).

After mating, a male *Philoponella prominens* orb weaver spider (reddish brown) uses its front legs to catapult backward and escape becoming lunch for the female (dark brown).

FROM TOP: JOE CARROTTA FOR NYU LANGONE HEALTH; SHICHANG ZHANG

predicted the 3-D shapes of more than 200 million proteins (SN: 9/24/22, *p.* 16). Though the shapes are not lab-verified structures, the massive dataset could help researchers studying health and disease in all sorts of organisms, from humans to honeybees. Now, looking up a protein's predicted structure is almost as easy as typing it into Google, according to the cofounder of the AI company that created AlphaFold.

Growing synthetic embryos

Two reports this year revealed how to fabricate the early stages of mammalian life. With a bit of laboratory wizardry, scientists mingled mouse stem cells, which self-assembled to spawn what appears to be a kind of fledgling embryo—no egg or sperm required. As they grow, these stem cell–derived synthetic embryos can form proto hearts, brains and guts. But the similarity to natural mouse embryos fades quickly. The synthetic and natural versions match up for only about eight days of development. Still, studying similar clusters of human stem cells might one day offer a way to probe the development of human embryos without relying on the real thing. ■

Joyriding goldfish

Teach a fish to drive a motorized fish tank and it will drive wherever it wants. Goldfish taught to drive showed they could navigate outside their natural environment and reach a target (SN: 2/12/22, *p.* 4). Maybe one day these cruising fish will boldly go where no fish has gone before.

Snotty, sneezy sea sponges

These creatures take self-care to the next level. Sponges are filter feeders, sucking up water through their pores to get nutrients. But when unwanted junk comes in, an *Aplysina archeri* tube sponge traps the particles in mucus, then expels it in one slow-motion sneeze (SN: 9/10/22, *p.* 4). The Caribbean sponges are constantly oozing mucus like a child with a runny nose. Looks like someone could use a tissue. ■

T.R. MALONEY *ET AL*/*NATURE* 2022

Record breakers

BY ERIN WAYMAN

New scientific records are set every year, and 2022 was no exception. A bacterial behemoth, a shockingly speedy supercomputer and a close-by black hole are among the most notable superlatives of the year.

Biggest single-celled bacterium

Bacteria normally dwell in the microscopic world. Not *Thiomargarita magnifica*. Averaging about a centimeter long, this newfound bacterium is visible to the naked eye (SN: 7/16/22 & 7/30/22, *p.* 17). *T. magnifica*, which lives in the mangrove forests of the Caribbean's Lesser Antilles, is about 50 times larger than other species of big bacteria and about 5,000 times larger than typical bacteria. Why this species evolved into such a giant is unknown.

Fastest supercomputer

A supercomputer named Frontier crunched numbers with mind-blowing speed this year: 1.1 quintillion operations per second (SN *Online*: 6/1/22). That makes the machine, run by Oak Ridge National Laboratory in Tennessee, the first exascale computer—a computer that can perform at least 10^{18} operations per second. The next fastest computer tops out at 442 quadrillion (that's 10^{15}) operations per second. Exascale computing is expected to lead to breakthroughs in everything from climate science to health to particle physics.

Earliest surgery

The first known surgical operation was a leg amputation (SN: 10/8/22 & 10/22/22, *p.* 5). That's the conclusion researchers came to after investigating the skeleton of a person who lived on the Indonesian island of Borneo about 31,000 years ago. Healed bone where the lower left leg had been removed suggests the individual survived for several years after the procedure.

This human skeleton (shown from the waist down) from the island of Borneo bears evidence that the lower left leg was amputated roughly 31,000 years ago.

The discovery pushes surgery's origin back by some 20,000 years.

Largest fish colony

Deep off the coast of Antarctica, icefish congregate in a breeding colony as big as Orlando, Fla. Some 60 million nests of Jonah's icefish (*Neopagetopsis ionah*) stretch across at least 240 square kilometers of seafloor (SN: 2/12/22, *p.* 12). Previously, nest-building species of fish were known to gather in only the hundreds. An abundant food supply and access to a zone of unusually warm water may explain the exceptionally large group.

Closest black hole

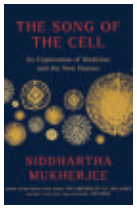
By sifting through data released by the Gaia spacecraft, astrophysicists discovered a black hole that's just over 1,560 light-years from Earth (SN *Online*: 11/4/22). Dubbed Gaia BH1, it's about twice as close as the previously nearest known black hole. But that record may not stand. About 100 million black holes are predicted to exist in the Milky Way. Since most are invisible, they're hard to find. But when Gaia, which is precisely mapping a billion stars, releases its next batch of data in a few years, even closer black holes may turn up. ■

BOOKSHELF

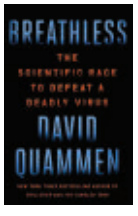
Our favorite books of 2022

Books about the pandemic. Books about the ancient past. Books about outer space. These were a few of *Science News* staff's favorite reads. If your favorite didn't make this year's cut, let us know what we missed at feedback@sciencenews.org.

Vagina Obscura
Rachel E. Gross
For centuries, scientists (mostly males) have ignored female biology, and women's health has suffered. But researchers are finally paying attention, as Gross explains in this fascinating tour of what little is known about female anatomy (*SN: 4/9/22, p. 29*).
W.W. Norton & Co., $30



The Song of the Cell
Siddhartha Mukherjee
Patient stories and conversations with scientific luminaries enliven this tale of cell biology's past, present and future, and how advances in the field have reshaped medicine (*SN: 11/5/22, p. 28*).
Scribner, $32.50

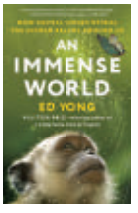


Breathless
David Quammen
In this portrait of the coronavirus and the scientists who study it, Quammen investigates some of the most pressing questions about the pandemic, including whether or not the coronavirus could have accidentally escaped from a lab (*SN: 9/24/22, p. 28*). *Simon & Schuster, $29.99*

Virology
Joseph Osmundson
This wide-ranging collection of essays is a meditation on society's complicated relationship with viruses. In pondering SARS-CoV-2, HIV and more, Osmundson calls for more equitable access to medical care (*SN: 7/16/22 & 7/30/22, p. 37*).
W.W. Norton & Co., $16.95

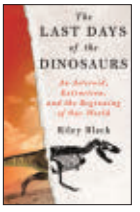
The Milky Way
Moiya McTier
This absorbing "autobiography," written from the perspective of the Milky Way (a very sassy Milky Way), draws on mythology and astronomy to persuade readers that our home galaxy deserves respect and admiration (*SN: 9/10/22, p. 28*). *Grand Central Publishing, $27*

A Portrait of the Scientist as a Young Woman
Lindy Elkins-Tanton
In this moving memoir, Elkins-Tanton recounts her journey to becoming a planetary scientist and leader of a NASA asteroid mission. Her struggles with childhood trauma and sexism in her career lay bare the barriers that many women in the sciences still face (*SN: 8/13/22, p. 26*).
William Morrow, $29.99



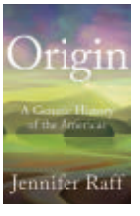
An Immense World
Ed Yong
So much of the world is beyond the grasp of human perception, but this safari through animal senses helps readers imagine what we're missing (*SN: 7/16/22 & 7/30/22, p. 36*). *Random House, $30*

How Far the Light Reaches
Sabrina Imbler
By drawing parallels between their own life and the stories of bobbit worms, octopuses, sperm whales and other deep-sea dwellers, Imbler muses on such weighty themes as adaptation, survival and sexuality.
Little, Brown & Co., $27

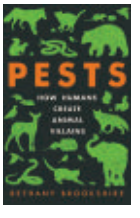


The Last Days of the Dinosaurs
Riley Black
The basic story of the downfall of nonbird dinosaurs is familiar: They were killed off by an asteroid that slammed into Earth 66 million years ago. Using the most up-to-date science, Black fleshes out this tale, painting a vivid portrait of life before and after this apocalypse (*SN: 4/23/22, p. 28*). *St. Martin's Press, $28.99*

The Rise and Reign of the Mammals
Steve Brusatte
The perfect follow-up to Black's book (above) on how the Age of Dinosaurs ended is this sweeping history of how the Age of Mammals began. Brusatte traces the origins of the evolutionary innovations that have made mammals so successful (*SN: 6/18/22, p. 28*). *Mariner Books, $29.99*



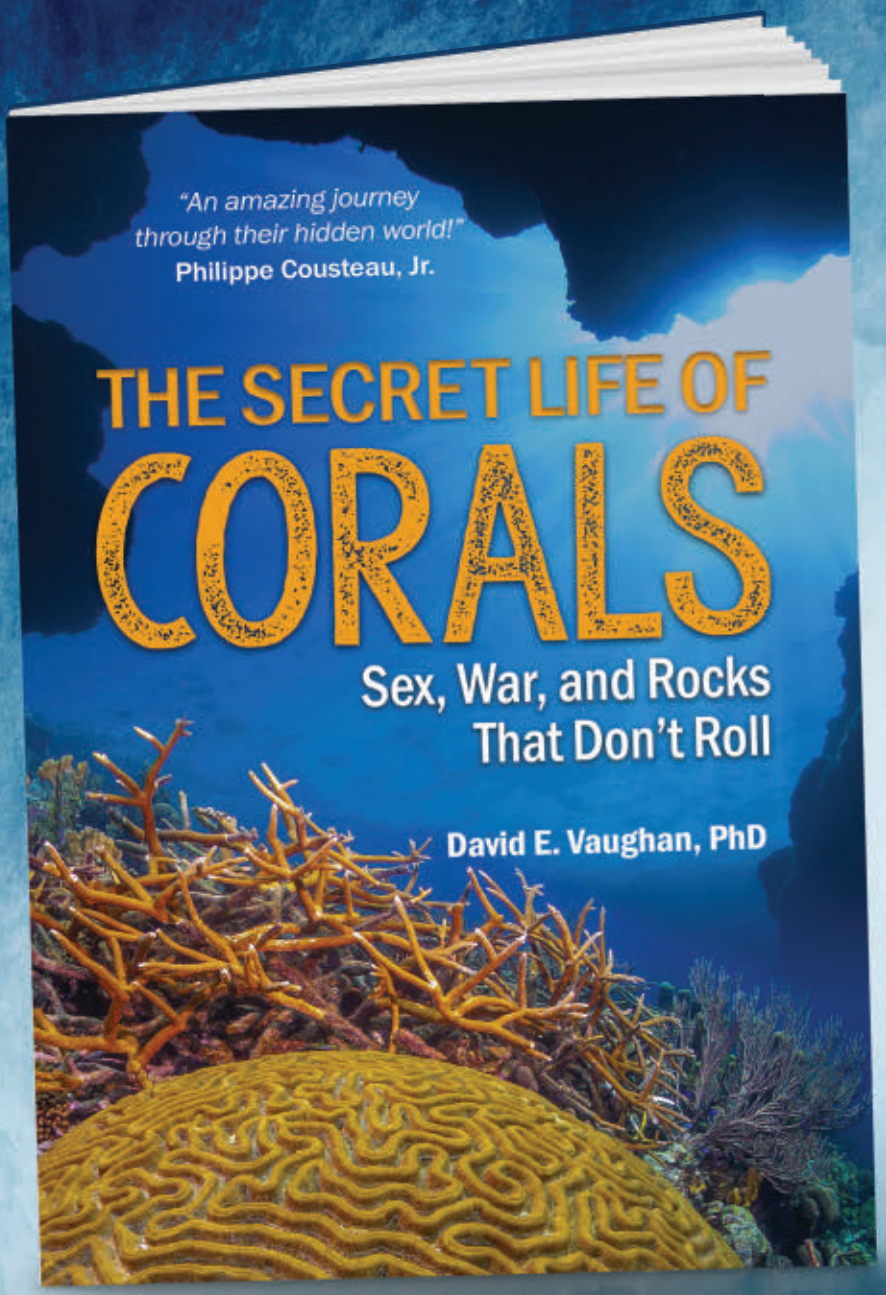
Origin
Jennifer Raff
Exactly how and when humans first came to the Americas is still unsettled science. But Raff gathers archaeological and genetic evidence to piece together a convincing scenario. She also points out past mistreatment of Indigenous communities by geneticists and calls on researchers to do better and foster more collaborations (*SN: 2/12/22, p. 29*). *Twelve, $30*



Pests
Bethany Brookshire
So-called pests are a human invention, argues Brookshire, a former staff writer for *Science News for Students* (now *Science News Explores*). In coming face-to-face with rats, feral cats, pythons and even elephants, Brookshire teases out the various social factors that cause people to deem certain animals a nuisance (*SN: 12/3/22, p. 26*). *Ecco, $28.99*

“Fantastic! This book reveals how remarkable and spectacular corals truly are. While coral reefs are now under constant threat from climate change, Dave Vaughan has illuminated a path forward—one that offers real hope for corals and all life that depends on them.”

— Jeff Orlowski-Yang
Filmmaker, Director of Chasing Coral, Chasing Ice, and The Social Dilemma



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TOP MOMENTS

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

Launched a New Magazine

The Society launched *Science News Explores*, a new print magazine for children ages 9 and up and their families, teachers and community. The Society also changed the name of Science News for Students online, which is written at a middle school level, to Science News Explores.

Our First Hybrid Competition

Regeneron International Science and Engineering Fair 2022 was the Society's first hybrid competition, with students competing in Atlanta and virtually around the world. The competition featured 1,750 young scientists representing 49 states and 63 countries, regions and territories. Robert Sansone of Fort Pierce, Fla., won the $75,000 George D. Yancopoulos Innovator Award.

Back in Person

After two years in a virtual setting, the Regeneron Science Talent Search was once again held in person in Washington, D.C. — with COVID-19 safety precautions in place. Christine Ye of Sammamish, Wash., won the $250,000 top award.

Thermo Fisher Scientific Junior Innovators Challenge | A program of Society for Science

New Sponsor

The Society named Thermo Fisher Scientific as the new title sponsor of our middle school STEM competition, which will be called the Thermo Fisher Scientific Junior Innovators Challenge. Thermo Fisher's sponsorship begins in 2023, making it only the third title sponsor in the competition's 25-year history.

Science News Centennial Concludes

In 2022, *Science News* ended its year-long celebration of the magazine's centennial, culminating in an excellent tour of the magazine's storied history, including its coverage of the Scopes trial, the first spacewalk and Dolly the Sheep.

Highlighting Alumni

In celebration of its centennial, the Society launched a website showcasing its extraordinary competition alumni. The highlighted alumni were selected based on their accomplishments and lasting contributions to the world.

ScienceNews Learning

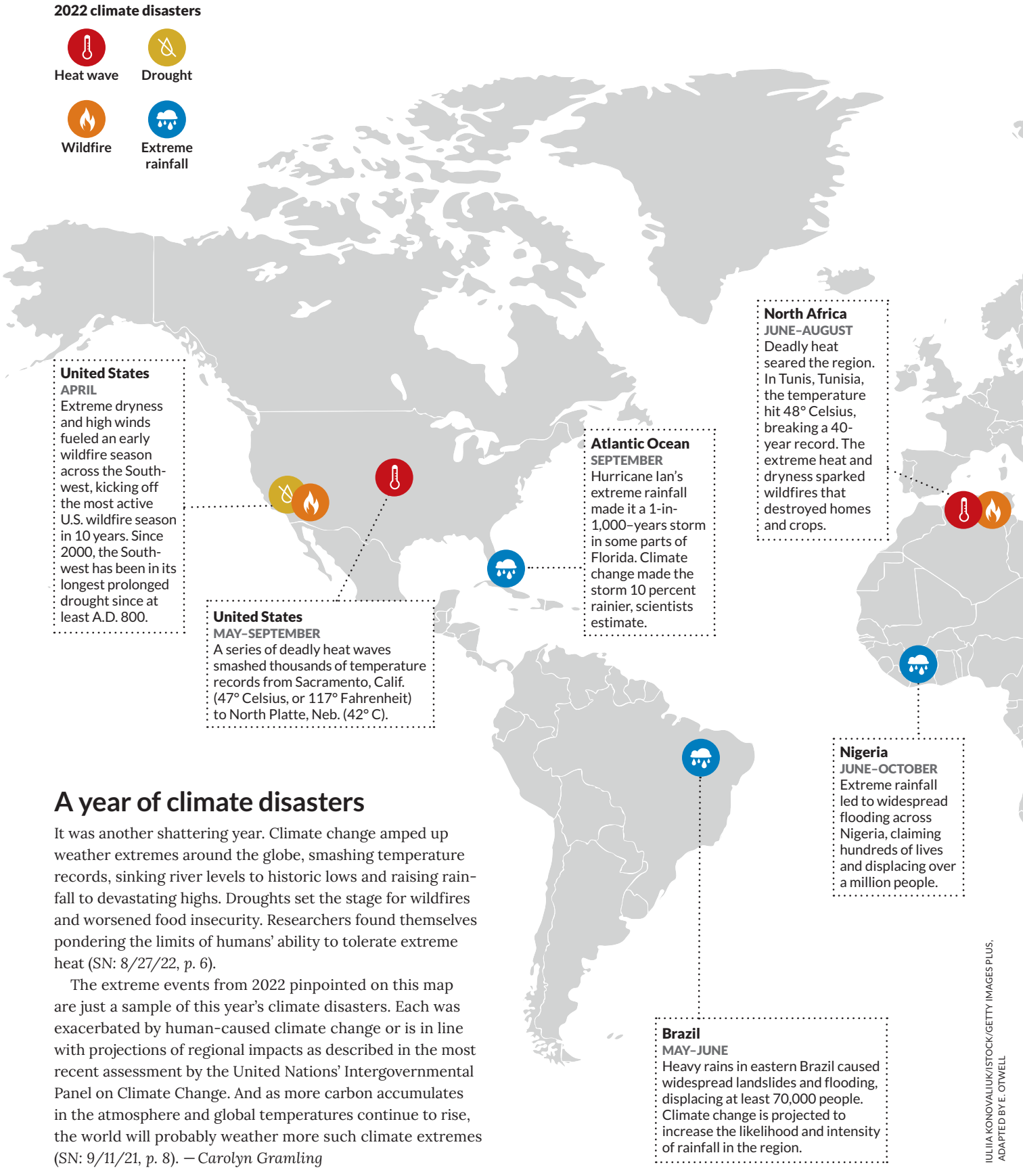
Same Program, New Name

The Society changed the name of *Science News* in High Schools to Science News Learning as the program expanded its audience to include middle school students and teachers.

End of an Era

The 2022 Broadcom MASTERS, which was the last competition held with Broadcom Foundation as the title sponsor, took place in person after two years of virtual competitions. Thomas Aldous of Pittsburgh won the $25,000 Samueli Foundation Prize.

SOCIETY FOR SCIENCE

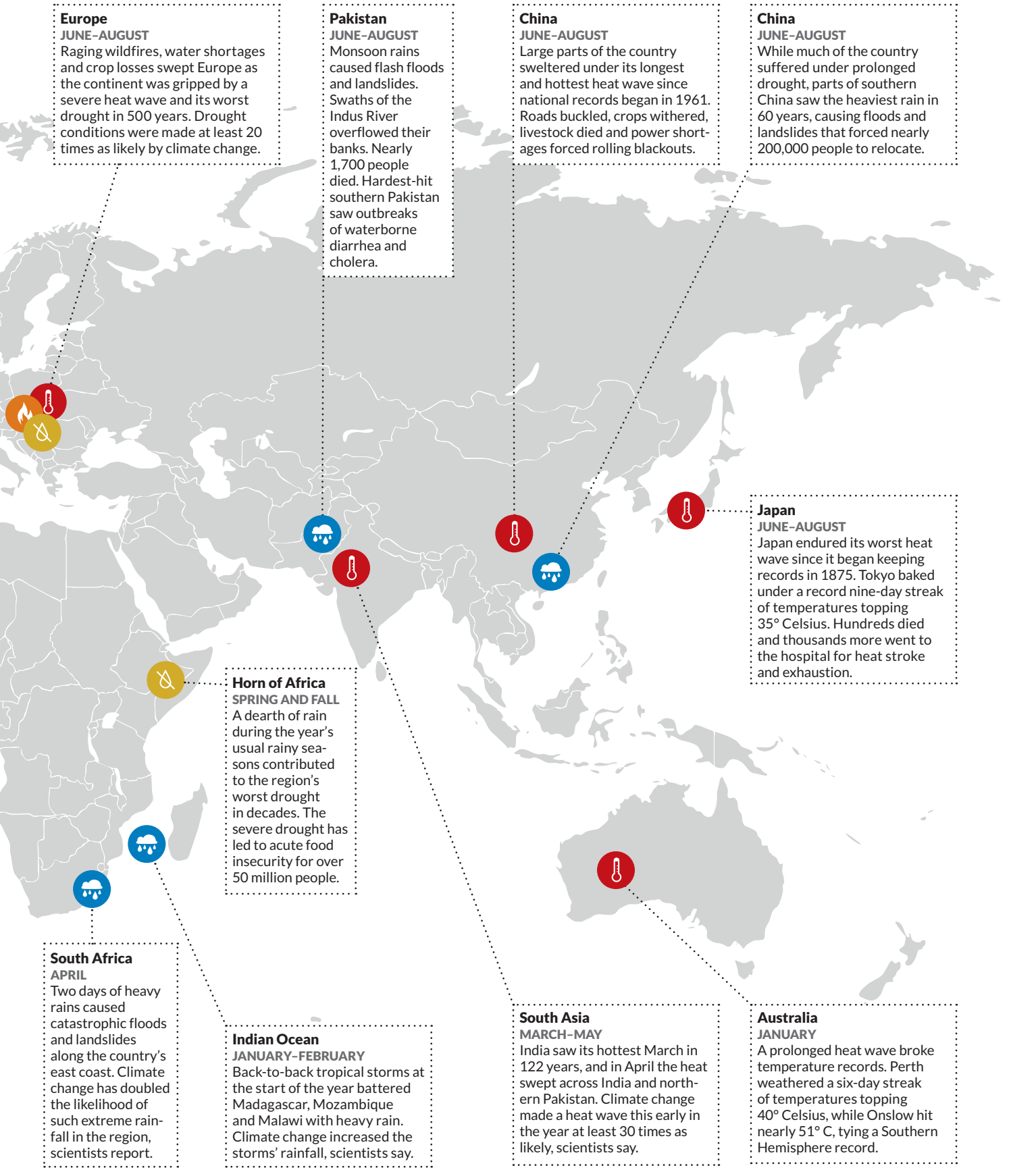


A year of climate disasters

It was another shattering year. Climate change amped up weather extremes around the globe, smashing temperature records, sinking river levels to historic lows and raising rainfall to devastating highs. Droughts set the stage for wildfires and worsened food insecurity. Researchers found themselves pondering the limits of humans' ability to tolerate extreme heat (SN: 8/27/22, p. 6).

The extreme events from 2022 pinpointed on this map are just a sample of this year's climate disasters. Each was exacerbated by human-caused climate change or is in line with projections of regional impacts as described in the most recent assessment by the United Nations' Intergovernmental Panel on Climate Change. And as more carbon accumulates in the atmosphere and global temperatures continue to rise, the world will probably weather more such climate extremes (SN: 9/11/21, p. 8). — *Carolyn Gramling*

IULIIA KONOVALIUK/ISTOCK/GETTY IMAGES PLUS, ADAPTED BY E. OTWELL



Europe
JUNE–AUGUST
Raging wildfires, water shortages and crop losses swept Europe as the continent was gripped by a severe heat wave and its worst drought in 500 years. Drought conditions were made at least 20 times as likely by climate change.

Pakistan
JUNE–AUGUST
Monsoon rains caused flash floods and landslides. Swaths of the Indus River overflowed their banks. Nearly 1,700 people died. Hardest-hit southern Pakistan saw outbreaks of waterborne diarrhea and cholera.

China
JUNE–AUGUST
Large parts of the country sweltered under its longest and hottest heat wave since national records began in 1961. Roads buckled, crops withered, livestock died and power shortages forced rolling blackouts.

China
JUNE–AUGUST
While much of the country suffered under prolonged drought, parts of southern China saw the heaviest rain in 60 years, causing floods and landslides that forced nearly 200,000 people to relocate.

Japan
JUNE–AUGUST
Japan endured its worst heat wave since it began keeping records in 1875. Tokyo baked under a record nine-day streak of temperatures topping 35° Celsius. Hundreds died and thousands more went to the hospital for heat stroke and exhaustion.

Horn of Africa
SPRING AND FALL
A dearth of rain during the year's usual rainy seasons contributed to the region's worst drought in decades. The severe drought has led to acute food insecurity for over 50 million people.

South Africa
APRIL
Two days of heavy rains caused catastrophic floods and landslides along the country's east coast. Climate change has doubled the likelihood of such extreme rainfall in the region, scientists report.

Indian Ocean
JANUARY–FEBRUARY
Back-to-back tropical storms at the start of the year battered Madagascar, Mozambique and Malawi with heavy rain. Climate change increased the storms' rainfall, scientists say.

South Asia
MARCH–MAY
India saw its hottest March in 122 years, and in April the heat swept across India and northern Pakistan. Climate change made a heat wave this early in the year at least 30 times as likely, scientists say.

Australia
JANUARY
A prolonged heat wave broke temperature records. Perth weathered a six-day streak of temperatures topping 40° Celsius, while Onslow hit nearly 51° C, tying a Southern Hemisphere record.

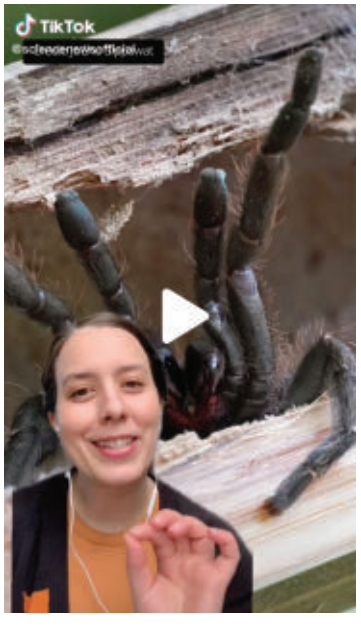
Online favorites of 2022

Science News drew over 13 million visitors to our website this year. Here's a recap of the most-read news stories and long reads of 2022.

SOCIAL MEDIA

Science News joins TikTok

TikTok became one more way we tell stories, as we premiered our first TikTok video — a tribute to the "bambootula" tarantula. Find out what makes this spider so peculiar and discover other amazing science tidbits **@sciencenewsofficial**



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Top news stories

1 **A special brew may have calmed Inca children headed for sacrifice**

The mummified remains of two Inca children ritually sacrificed more than 500 years ago contain chemical clues to their final days and weeks. On the journey to the Peruvian mountain where they were sacrificed, the children may have chewed coca leaves and drunk a beverage with antidepressant-like ingredients to soothe their nerves (*SN: 6/4/22, p. 10*).

2 **A 'mystery monkey' in Borneo may be a rare hybrid. That has scientists worried**

An unusual monkey first spotted six years ago appears to be a cross between a female silvered leaf monkey (*Trachypithecus cristatus*) and a male proboscis monkey (*Nasalis larvatus*). The possible cross-genera pairing has scientists worried because such matings are usually a sign that species are facing ecological pressures (see Page 31).

3 **What experts told me to do after my positive COVID-19 at-home test**

After *Science News* intern Anna Gibbs came down with COVID-19, she turned to health experts to figure out how to report her case to public health officials and how long she needed to isolate (*SN Online: 4/22/22*).

4 **All of the bases in DNA and RNA have now been found in meteorites**

Here's more evidence that life's precursors could have come from space. All five of the nucleobases that store information in DNA and RNA have been discovered in meteorites. This year, scientists reported detecting cytosine and thymine in fallen space rocks, completing the list (see Page 30).

5 **Humans may not be able to handle as much heat as scientists thought**

For years, it was thought the human body can tolerate heat up to a "wet bulb" temperature — a measure combining humidity and air temperature — of 35° Celsius (95° Fahrenheit). But experiments hint that the threshold may be several degrees lower (*SN: 8/27/22, p. 6*).

Top feature stories

1 **Tardigrades could teach us how to handle the rigors of space travel**

Tardigrades can withstand punishing levels of radiation, the freezing cold and the vacuum of outer space. Researchers are learning the death-defying tricks of these hardy microscopic animals to better prepare astronauts for long-term voyages (*SN: 7/16/22 & 7/30/22, p. 30*).

2 **Muons spill secrets about Earth's hidden structures**

Just like doctors use X-rays to see inside the human body, scientists are using muons, a type of subatomic particle, to peer inside Egyptian pyramids, volcanoes and other hard to penetrate structures (*SN: 4/23/22, p. 22*).

3 **Multiple sclerosis has a common viral culprit, opening doors to new approaches**

Evidence is mounting that Epstein-Barr virus somehow instigates multiple sclerosis. Understanding the link between the virus and MS may lead to better treatments for the neurological disorder. Vaccines against the virus may even prevent MS altogether (see Page 32).

4 **The discovery of the Kuiper Belt revamped our view of the solar system**

In 1992, two astronomers discovered a doughnut-shaped region far beyond Neptune, dubbed the Kuiper Belt, that's home to a swarm of frozen objects left over from the solar system's formation. By studying these far-off objects over the last 30 years, scientists have gained new insights into how planets form (*SN: 8/27/22, p. 22*).

5 **Clovis hunters' reputation as mammoth killers takes a hit**

Ancient Americans may have been big-game scavengers rather than big-game hunters. Some recent analyses suggest that Clovis stone points were more likely tools for butchering large carcasses than weapons for taking down mammoths and other large animals (*SN: 1/15/22, p. 22*).

SECRETS OF ANCIENT EGYPT – NEW DISCOVERIES

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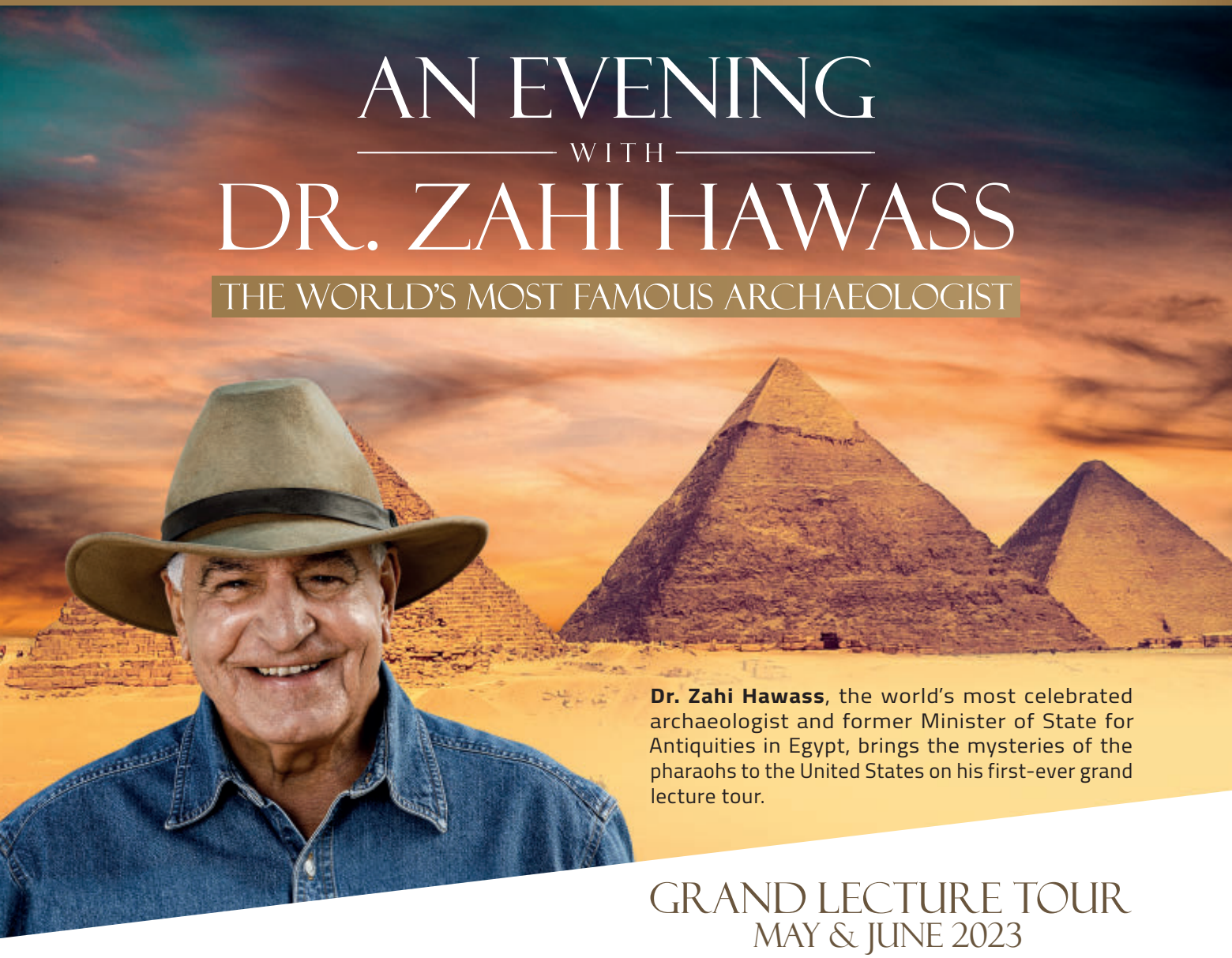

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