A Century of Epidemics | Brazilian Jaguars Go Fish

ScienceNews

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Spidey Senses

Tiny jumping arachnids navigate a surreal landscape

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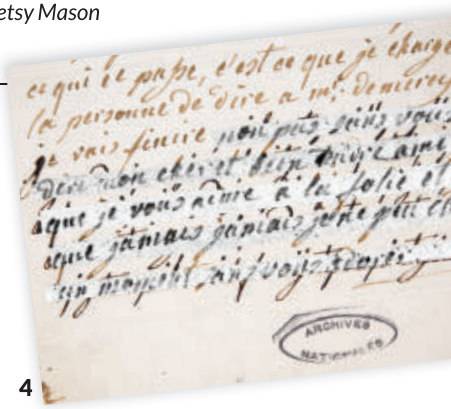
COVER STORY Clever experiments open a portal to how these eight-eyed creatures, some smaller than a grain of rice, experience their surroundings and find a mate. *By Betsy Mason*



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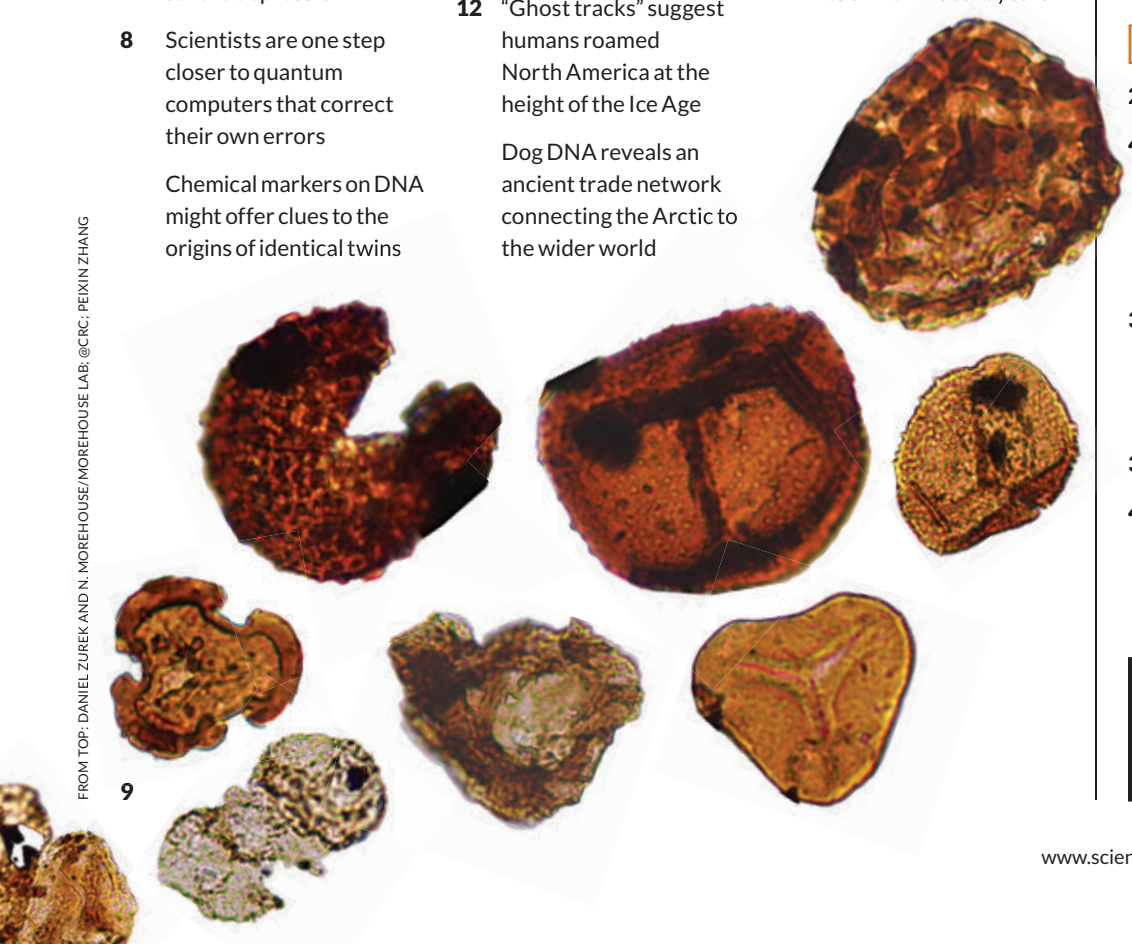

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COVER Jumping spiders use their primary eyes to see a colorful, sharp slice of the world. *Jan Rozehnal/iStock/Getty Images Plus*

Looking back on science can refocus our attention

Back in late 2019, the staff at *Science News* began planning how to celebrate our 100th birthday. We could tell the story of our founding, invite longtime readers to share their memories and, of course, look back at all that has changed in science. At the time, we had no idea that pandemics would bookend the magazine's first century.

Science News launched its first news bulletins in April 1921, not long after the 1918 pandemic ended. That historical context wasn't on our radar until the COVID-19 pandemic struck. Suddenly, reviewing a century of advances in infectious diseases became essential to our centennial coverage. As biomedical writer Aimee Cunningham dove into the story — the many, many stories of lives upended by epidemics past and present — she realized that what hasn't changed is perhaps more poignant than what has. In the latest story from our Century of Science project (Page 18), Cunningham recounts how new vaccines have saved lives and freed people from fears of devastating infections. The research accomplishments since 1918 are clear. But other aspects of the story echo across the ages — the suffering, the isolation and the social inequities, notably the disproportionate effects on Black, Latino and Native American communities in the United States. Cunningham's powerful reporting draws our attention to problems — scientific and societal — that still need solving.

There's an unexpected parallel in a lighter story in this issue, about jumping spiders (Page 26). These charismatic beasts have a pair of principal eyes that sharply focus on the world, plus smaller scanning eyes that alert those bigger eyes to what's worth noticing. The spiders' visual world is not entirely unlike our own. "Like the spider," Betsy Mason writes, "we focus our attention on a relatively small area and largely ignore the rest until something catches our attention."

COVID-19 has been a red alert that infectious foes are still out there, and that health disparities persist. What else are we ignoring?

— Elizabeth Quill, Special Projects Editor

In the next few months, various *Science News* editors will share their thoughts in the Editor's Note.

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— Maya Ajmera, Publisher

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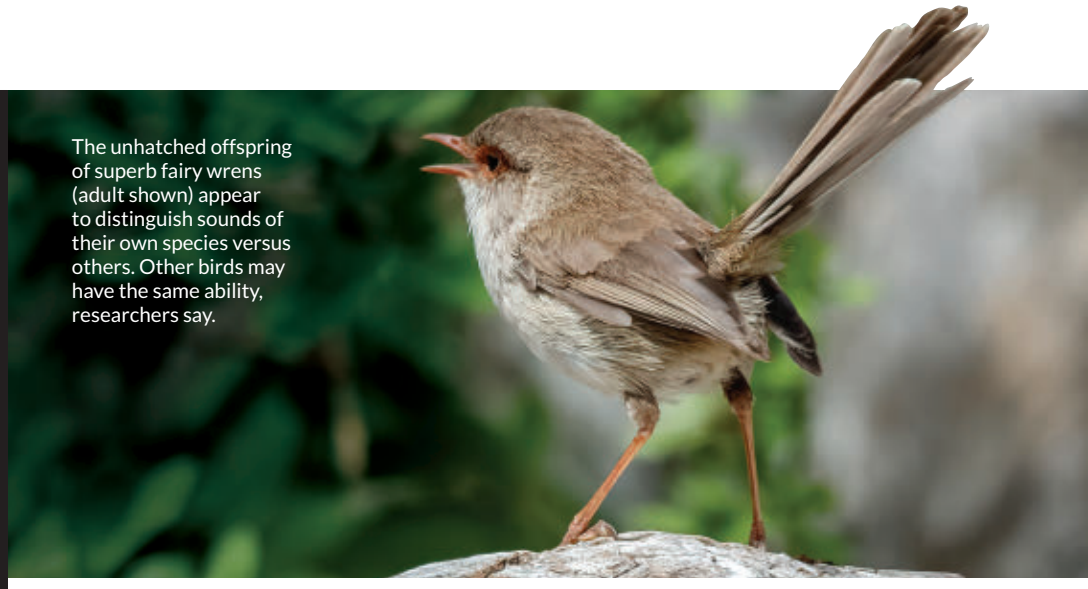
Excerpt from the November 6, 1971 issue of *Science News*

50 YEARS AGO

Learning and memory transfer

The first memory molecule has been isolated, characterized and synthesized ... [from the brains of] rats that had been shocked in the dark.... It is a protein and dubbed "scotophobin," after the Greek words for "fear of the dark." [One researcher] has injected synthetic rat scotophobin into the brains of hundreds of goldfish. While the fish indeed exhibited fear of the dark and resisted learning to swim into the dark, the fear was of brief duration.

UPDATE: The idea that scotophobin stores memories and can be used to transfer them between organisms was met with intense skepticism and was eventually discredited by neuroscientists. But the search for a physical basis of memory continues. Over the last few decades, other memory molecule candidates have popped up, including a protein called PKM-zeta, which may help with memory retrieval, and even RNA (*SN: 6/9/18, p. 9*). Still, the dominant theory is that memories are stored in synapses, connections between nerve cells in the brain (*SN: 2/3/18, p. 22*).



The unhatched offspring of superb fairy wrens (adult shown) appear to distinguish sounds of their own species versus others. Other birds may have the same ability, researchers say.

ANDREW HAYSOM/ISTOCK/GETTY IMAGES PLUS

THE SCIENCE LIFE

Birds learn the call of the wild while still in their eggs

Behavioral ecologist Diane Colombelli-Négrel was wiring the nests of superb fairy wrens to record the birds' sounds when she noticed something odd. Mothers sang while incubating their eggs, even though keeping quiet would avoid attracting predators.

That early discovery "was a bit of an accident," says Colombelli-Négrel, of Flinders University in Adelaide, Australia. It made her wonder: Could the baby birds be learning sounds, or even songs, before hatching?

Scientists have long pondered how early in development individuals learn to perceive distinct sounds. It's known that humans learn to recognize their mother's voice from the womb (*SN: 2/9/13, p. 9*). For birds such as superb fairy wrens, which perfect their songs with parental tutoring, it was thought that sound perception began after hatching. But when it became obvious that mother birds were intentionally singing to their eggs, "we knew we were on to something," says Sonia Kleindorfer, an avian ecologist at the University of Vienna.

Colombelli-Négrel, Kleindorfer and a colleague reported in 2014 that superb fairy wrens learn to distinguish between sounds of their own species and others while still in their eggs. In a new study, reported in the Oct. 25 *Philosophical Transactions of the Royal Society B*, that ability appears to extend to at least four more bird species.

In birds and humans, a drop in embryonic heart rate suggests attention to a stimulus. In the scientists' earlier work, unhatched fairy wrens' heart rate slowed in response to repeated sounds of their own species, but not others.

To investigate whether this phenomenon is more widespread among birds, the team also turned its attention to the embryonic heartbeats of Japanese quail, little penguins, red-winged fairy wrens and Darwin's small ground finches.

The team measured the heart rates of 109 unhatched chicks before, during and after exposure to playbacks of songs from their own species or others. Then the scientists looked at whether 138 embryos stopped paying attention to, or habituated to, repeated sounds of unfamiliar individuals of their own species singing. This habituation, measured by the heart rate returning to normal, would imply learning had occurred.

To the team's surprise, all of the eggs showed a slowed heart rate in response to their species' sounds and showed habituation. That finding suggests that these unhatched birds learned to perceive the sounds of their species' songs.

The scientists don't know why the penguins and quail, which have their calls genetically baked in instead of taught to them by a tutor, have this ability before birth. The team hopes to study prenatal sound perception in more bird species to probe the advantages of this early egg-u-cation.

— Lesley Evans Ogden

MYSTERY SOLVED

Marie Antoinette's letters are uncensored by X-rays

In a world torn apart by the French Revolution, doomed Queen Marie Antoinette exchanged secret letters with a rumored lover. Someone later censored them. Now, chemical analyses of the ink reveal the obscured words plus the censor's identity, scientists report October 1 in *Science Advances*.

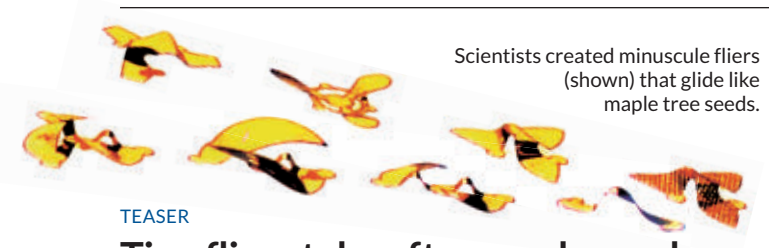
From June 1791 to August 1792, as Antoinette and her family were confined to Paris' Tuileries Palace, the queen managed a correspondence with Swedish Count Axel von Fersen.

Whether the two exchanged words of love or state secrets was a long-standing question, says chemist Anne Michelin of the National Museum of Natural History in Paris. Michelin and colleagues analyzed the letters using X-ray fluorescence spectroscopy. The noninvasive technique works by shooting an X-ray beam at a sample, which kicks atoms in the sample into a higher-energy state. The sample then emits its own X-rays at wavelengths characteristic of the sample's elemental makeup.

Michelin and colleagues zoomed in on the ink. Both correspondents used ink made from iron sulfate, but different inks contain different proportions of trace elements, Michelin says. The team scanned the letters pixel by pixel, finding consistent differences in the copper-to-iron and the zinc-to-iron ratios of the original and redacting inks. Mapping each pixel's elemental differences onto a gray scale revealed the hidden words, which include "beloved," "tender friend" and "madly."

The censor was von Fersen himself, Michelin says. The count made copies of Antoinette's letters, and the ink used for the redactions matched those copies. Whether the relationship was just about love or politics too may never be known, Michelin adds. But "he kept these letters, even though it was risky for him." — *Carolyn Gramling*

A redacted passage (top) in a letter written by Marie Antoinette in January 1792 is unveiled (bottom) with X-ray fluorescence spectroscopy.



Scientists created minuscule fliers (shown) that glide like maple tree seeds.

TEASER

Tiny fliers take after maple seeds

Like helicoptering maple seeds, small new fliers whirl gracefully as they glide. The miniature aircraft, which can be made as small as a grain of sand, could be dispersed by air over long distances. Scientists envision that these microfliers, when equipped with wee sensors, could assess hazards like chemical spills. The devices could also track conditions in the atmosphere while aloft (*SN: 3/13/21, p. 5*).

The maple tree–lined streets north of Chicago, where materials scientist John Rogers lives, served as inspiration for the microflier designs. But Rogers, of Northwestern University in Evanston, Ill., and colleagues went smaller-than-life when designing their fleet. Some of the whirligigs are just half a millimeter across, the team reports in the Sept. 23 *Nature*.

As with maples' seed-copters , the blades of the fliers induce spinning motions that help stabilize flight. The designs also decrease the speed at which the microfliers fall, giving them more time to disperse. One flier fell at about 28 centimeters per second, less than half the speed of natural whirligigs from various plants. In the future, the team plans to make biodegradable fliers so that the objects could be scattered without defiling the environment. — *Emily Conover*

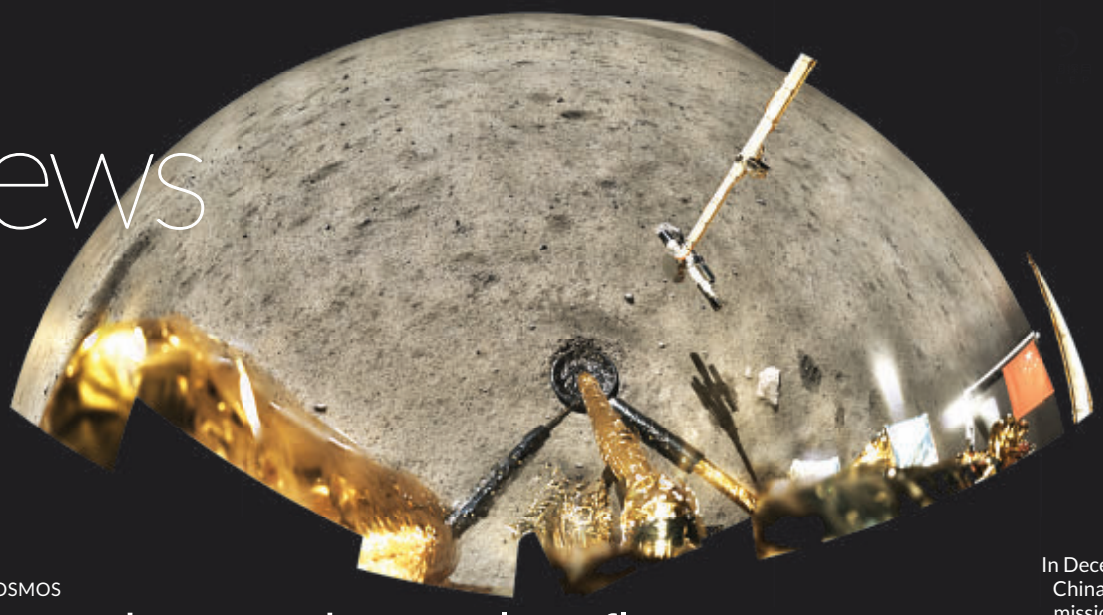
THE –EST

Codex recounts ancient quakes

A 50-page codex of colorful, complex pictograms that dates to the early 16th century includes one of the oldest and most complete written chronologies of early earthquakes in the Americas. Created by an unknown pre-Hispanic civilization, the *Telleriano-Remensis* describes 12 earthquakes that rocked Mexico and Central America from 1460 to 1542, scientists report August 25 in *Seismological Research Letters*. The team pored over the codex, comparing pictorial representations of quakes — four helices around a central circle or eye, and one or more rectangular layers filled with dots — to accounts of quakes in other codices and in texts written by Spanish friars. The *Telleriano-Remensis* uses a 52-year cycle to roughly date the quakes. Years are represented by four signs — knife, house, rabbit and reed — arranged in 13 permutations. Those images helped the team match some pictorial accounts of quakes, such as one in 1507 that may have triggered flooding that drowned warriors, to later descriptions of the events. — *Carolyn Gramling*

This pictogram tells of an earthquake in 1507 that may have led to the drowning of 1,800 warriors in a river.

CLOCKWISE FROM TOP: @CRC; G. SUÁREZ AND V. GARCÍA-ACOSTA/*SEISMOLOGICAL RESEARCH LETTERS* 2021; NORTHWESTERN UNIV.



In December 2020, China's Chang'e-5 mission landed on the moon (shown) and collected rocks to bring to Earth.

LUNAR EXPLORATION AND SPACE ENGINEERING CENTER/ CHINESE NATIONAL SPACE AGENCY

ATOM & COSMOS

Moon rocks record young lava flows

Newly returned samples raise questions about lunar volcanism

BY FREDA KREIER

Lava oozed across the moon's surface just 2 billion years ago, bits of lunar rocks retrieved by China's Chang'e-5 mission reveal.

A chemical analysis of the volcanic rocks confirms that the moon remained volcanically active for far longer than its size would suggest possible, researchers report October 7 in *Science*.

Last December, Chang'e-5 retrieved lunar rocks and returned them to Earth, the first mission to do so in more than 40 years (*SN: 1/16/21, p. 7*). An international group of researchers has found that these rocks formed 2 billion years ago. That makes them the youngest moon rocks ever collected, says study coauthor Carolyn Crow, a planetary scientist at the University of Colorado Boulder.

The moon formed roughly 4.5 billion years ago. Lunar rocks from the Apollo and Soviet missions in the late 1960s and the '70s revealed that volcanism on the moon was commonplace for the first billion and a half or so years of its existence, with lava flows that lasted for millions, if not hundreds of millions, of years.

Given its size, scientists thought that the moon started cooling off around 3 billion years ago, eventually becoming the quiet, inactive neighbor it is today. Yet a dearth of craters in some regions has left scientists scratching their heads. Where there's no volcanism, celestial bodies accumulate more and more craters over time, in part because there aren't lava flows depositing new material that hardens into smooth stretches. The moon's smoother spots seem to suggest that volcanism persisted past the moon's first 1.5 billion years.

"Young volcanism on a small body like the moon is challenging to explain because usually small bodies cool fast," says Juliane Gross, a planetary scientist at Rutgers University in Piscataway, N.J., who was not involved in the study.

Scientists had suggested that the presence of radioactive elements might explain more recent volcanism. Radioactive decay generates a lot of heat. Enough radioactive material in the moon's mantle, the layer just below the visible crust, would have provided a heat source that could explain younger lava flows.

To test this theory, the Chang'e-5 lander gathered chunks of basalt — a type of rock that forms from volcanic activity — from a previously unexplored part of the moon's surface thought to be younger than 3 billion years old. The team determined that the rocks formed from lava flows 2 billion years ago, but chemical analysis did not yield the concentration of radioactive elements one would expect if radioactive decay was responsible for the volcanism.

This finding is compelling scientists to consider what other forces might have maintained volcanic activity on the moon.

One theory is that gravitational forces from Earth could have liquefied the lunar interior, says study coauthor Alexander Nemchin, a planetary scientist at the Beijing SHRIMP Center and Curtin University in Bentley, Australia. That could have kept lunar magma flowing for another billion or so years past when it would have otherwise stopped.

"The moon was a lot closer 2 billion years ago," Nemchin explains. As the moon slowly inched away from Earth — a slow escape still at work today — these gravitational forces would have become less and less powerful until volcanism eventually petered out.

Heat generated by impacts from asteroids and comets also could have kept the moon's volcanic juices flowing. "At this point, any guess is a good guess," says Jessica Barnes, a planetary scientist at the University of Arizona in Tucson who was not involved in the study.

"This is a good example of why we need to get to know our closest neighbor," Barnes says. "A lot of people think we already know what's going on with the moon, but it's actually quite mysterious." ■

Brain implant lifts severe depression

The device eased a woman's symptoms for at least two months

BY LAURA SANDERS

A personalized brain implant eased the crushing symptoms of a woman's severe depression, allowing her to once again see the beauty of the world. "It's like my lens on the world changed," said Sarah, the research volunteer who requested to be identified by her first name only.

The technology, described October 4 in *Nature Medicine*, brings researchers closer to understanding how to detect and change brain activity in ultraprecise ways (*SN: 2/16/19, p. 22*).

The device was bespoke; it was built specifically for Sarah's brain. The details of the new system may not work as a treatment for many other people, says Alik Widge, a psychiatrist and neural engineer at the University of Minnesota in Minneapolis. Still, the research is "a really significant piece of work," he says, because it points out a way to study how brain activity goes awry in depression.

Researchers at the University of California, San Francisco implanted temporary, thin wire electrodes into Sarah's brain. The 36-year-old woman had suffered from severe depression for years. The electrodes let researchers monitor the brain activity that corresponded to depression symptoms — a pattern that the team could use as a biomarker, a signpost of trouble to come. In Sarah's case, a particular sign emerged: a fast brain wave called a gamma wave in her amygdala, a brain structure involved in emotions.

With this biomarker in hand, the researchers figured out where to stimulate the brain to interrupt Sarah's distressing symptoms. A region called the ventral capsule/ventral striatum, or VC/VS, seemed to be the key. That's not surprising; previous research suggested the region is involved with feeling good and other emotions. When researchers applied tiny jolts of electric current to this region, Sarah's mood improved. "We could learn the road map of Sarah's brain in a way that we could really improve her depression symptoms," UC San Francisco neuroscientist Katherine Scangos said September 30 in a news briefing.

During the mapping phase of the experiment, Sarah felt joy when the right spot was stimulated. "I laughed out loud," she said in the briefing. "This was the first time I had spontaneously laughed and smiled where it wasn't faked or forced in five years."

Researchers at the University of California, San Francisco check an implant that measures Sarah's brain activity, which can be displayed on a computer screen. This process allows Sarah's clinicians to find the most effective dose, duration and location of deep brain stimulation.

Deep brain stimulation eased the depression of a woman named Sarah, allowing her to pursue hobbies such as gardening.

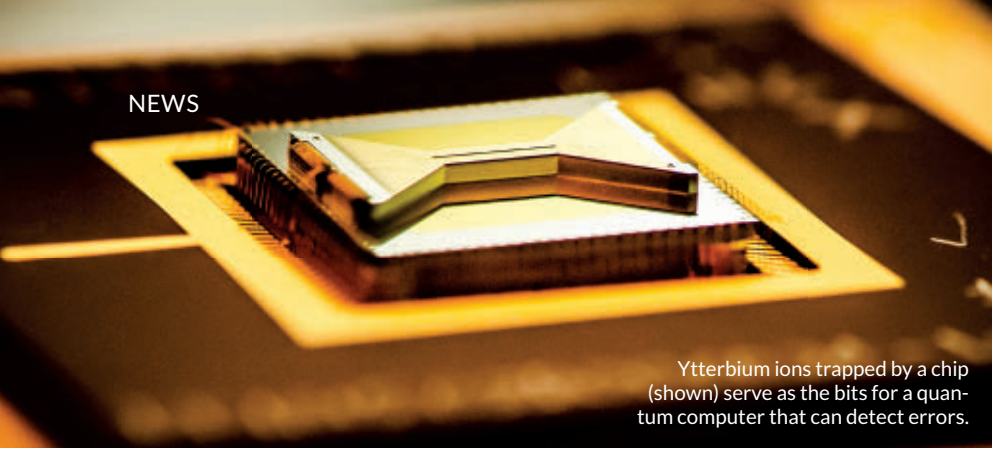
Surgeons then implanted a more permanent device into Sarah's brain in June 2020. Scientists programmed the device to detect when gamma signals were high in Sarah's amygdala and respond with a tiny jolt to her VC/VS. This happened about 300 times a day. The stimulation was calibrated so Sarah didn't feel any zaps, but she said they left her feeling a little more energetic.

The research paper describes Sarah's improvements as the technology did its work in her head over two months; it's unclear how long the benefits might last, though she's now had the device implanted and active for over a year. "As time has gone on, it's been this virtuous cycle, a spiral upwards," Sarah said. "Everything has gotten easier and easier and easier."

The approach used by the researchers requires a lot of sophisticated imaging and machine learning technology. That complexity may prevent the treatment from becoming widespread, cautions neurologist Helen Mayberg of the Icahn School of Medicine at Mount Sinai in New York City.

Still, the results add to a variety of ways to detect and change problem-causing brain activity. And amid those various approaches is valuable information about how depression takes hold of a brain, and how brain stimulation can change that, says Mayberg, whose research has helped build and refine the field of deep brain stimulation for mood disorders. "What we all want to know is, how does this work?" ■

FROM TOP: JOHN LOK/UCSF 2021; MAURICE RAMIREZ/UCSF 2021



Ytterbium ions trapped by a chip (shown) serve as the bits for a quantum computer that can detect errors.

MATTER & ENERGY

A quantum computer spots its errors

Scientists create a 'logical qubit' that detects mistakes

BY EMILY CONOVER

Mistakes happen — especially in quantum computers. The quantum bits, or qubits, that make up the machines are notoriously error-prone, but now scientists have shown that they can fix the flubs.

Computers that harness the rules of quantum mechanics show promise for making calculations far out of reach for standard computers. But without a mechanism for fixing the computers' mistakes, the answers that a quantum computer spits out could be gobbledygook (*SN: 6/20/20, p. 18*).

Combining the power of multiple qubits into one can solve the error woes, researchers report in the Oct. 14 *Nature*. Scientists used nine qubits in a quantum computer to make a single, improved qubit called a logical qubit. Unlike the individual qubits from which it was made, the logical qubit can be probed to check for mistakes.

"This is a key demonstration on the path to build a large-scale quantum computer," says quantum physicist Winfried Hensinger of the University of Sussex in Brighton, England, who was not involved in the work. But that path remains a long one. To do complex calculations, researchers will have to dramatically scale up the number of qubits in the machines, he says. Now that scientists have shown that they can keep errors under control, "there's nothing fundamentally stopping us [from building] a useful quantum computer."

In a logical qubit, information is stored redundantly. That allows researchers to check and fix mistakes in the data. "If a piece of it goes missing, you can reconstruct it from the other pieces, like Voldemort," says quantum physicist David Schuster of the University of Chicago, who was not involved in the work. (The *Harry Potter* villain kept his soul safe by concealing it in multiple objects called Horcruxes.)

In the new study, four auxiliary qubits interfaced with the logical qubit to identify errors in the logical qubit's data. Future quantum computers could make calculations using logical qubits in place of the original, faulty qubits,

GENES & CELLS

Identical twins share DNA tags

Chemical markers could reveal how an embryo splits

BY JONATHAN LAMBERT

Identical siblings are used to sharing a lot, including DNA with their twin. Now, research suggests identical twins also share a common signature of twinhood with all other identical twins — not in their DNA, but on it.

This signature is part of the epigenome, chemical markers that dot spots along DNA and influence the activity of genes without altering their sequence. Identical twins largely share a specific set of these marks that persists from birth to adulthood, researchers report September 28 in *Nature Communications*. These shared epigenetic tags could be used to better understand how identical twins form and to identify people who were conceived as an identical twin but lost their sibling in the womb or were separated at birth.

Despite humans' age-old fascination with identical twins, the biological process that generates them, known as monozygotic twinning, "is an enigma," says Jenny van Dongen, an epigeneticist at Vrije Universiteit Amsterdam. Researchers know that identical twins form after a fertilized egg, called a zygote, somehow splits into two embryos during development. But why this cleavage happens remains unknown, van Dongen says.

For twins and non-twins alike, early development happens amid a flurry of epigenetic changes that turn many genes on or off as an embryo takes shape. Some of these changes may account for slight differences between identical twins (*SN: 8/25/12, p. 14*). To better understand what makes a zygote split, "it makes sense to look at epigenetics," van Dongen says.

She and colleagues looked for epigenetic differences at over 450,000 sites along the genomes of nearly 6,000 identical twins and fraternal twins. At 834 spots along the genome, identical twins were strikingly similar, the team found. Shared epigenetic marks were concentrated in certain parts of the genome, including centromere and telomere regions on chromosomes. Some marks were near genes involved in early developmental processes, including those that regulate how tightly cells stick to one another.

These epigenetic signs popped up in twins young and old, from places as far-flung as Finland to Australia, and were found in different cell types. The shared marks are so uniquely common to identical twins that the researchers were able to devise a test that can determine, with up to 80 percent accuracy, whether an individual is an identical twin. That includes individuals who don't know that they lost their twin during pregnancy and

KAI HUDEK/JQI

repeatedly checking and fixing any errors that crop up.

To make their logical qubit, the researchers used a technique called a Bacon-Shor code, applying it to qubits made of ytterbium ions hovering above an ion-trapping chip inside a vacuum; the ions are manipulated with lasers. The team also designed sequences of operations so that errors don't multiply uncontrollably.

Thanks to those efforts, the new logical qubit had a lower error rate than that of the most flawed components that made it up, says study coauthor and quantum physicist Christopher Monroe of the University of Maryland in College Park and Duke University.

But the researchers didn't complete the full process that scientists envision for error correction. While the computer detected errors that arose, it didn't correct the mistakes before continuing on with computation. Instead, the computer fixed errors after it had finished. Ideally, scientists would detect and correct errors multiple times on the fly. ■

twins who were separated at birth.

The findings "open up a lot of avenues of inquiry," says developmental psychologist Nancy Segal of California State University, Fullerton. For example, identical twins are predisposed to a variety of conditions, from left-handedness to certain congenital disorders. Perhaps for some portion of people, these conditions are related to being an unknown identical twin, she says.

Whether this epigenetic signature is a cause or consequence of monozygotic twinning remains unclear, van Dongen says. It's possible that some of the epigenetic changes tell a zygote to split.

Epigeneticist Robert Waterland of Baylor College of Medicine in Houston suggests that the marks "could be like a persistent molecular scar." An embryo splitting could disrupt normal processes in a way that leaves a permanent mark, though more studies are needed to know for sure, he says. ■

PEIXIN ZHANG

LIFE & EVOLUTION

Dinosaurs got big during rainy spell

Environmental shifts are linked to ancient volcanic eruptions

BY MEGAN SEVER

The biggest beasts to walk on Earth had humble beginnings. The first dinosaurs were cat-sized, lurking in the shadows, just waiting for their moment. That moment came when four major pulses of volcanic activity changed the climate in a geologic blink of an eye, causing a roughly 2-million-year-long rainy spell that coincided with dinosaurs rising to dominance, a new study suggests.

Clues found in sediments buried deep beneath an ancient lake basin in China link the volcanic eruptions with climate swings and environmental changes that created a globe-spanning humid oasis in the middle of the hot and dry Triassic Period, researchers report in the Oct. 5 *Proceedings of the National Academy of Sciences*. During this geologically brief rainy period between 234 million and 232 million years ago, called the Carnian Pluvial Episode, dinosaurs started evolving into the hulking and diverse creatures that would dominate the landscape for roughly the next 165 million years.

Previous research has noted a jump in global temperatures, humidity and rainfall during this time period, as well as a changeover in land and sea life. But the studies lacked detail on what caused the changes, says paleobotanist Jason Hilton of the University of Birmingham in England. So he and colleagues turned to a core of lake-bottom sediments drawn from the Jiyuan Basin for answers.

The core had four distinct layers of sediments with bits of volcanic ash that the team dated to the Carnian Pluvial Episode and mercury, a proxy for volcanic eruptions. "Mercury entered the lake from a mix of atmospheric pollution, volcanic ash and also being washed in from surrounding land that had elevated levels of mercury from volcanism," Hilton says.

Layers in the core that correspond to the Carnian Pluvial Episode also showed different levels of carbon isotopes, indicating four massive releases of carbon dioxide into the atmosphere. Meanwhile, microfossils and pollens changed from species that prefer drier climates to ones that tend to grow in humid climates.

Pollens, spores and algae (sampling shown) found in sediment from when dinosaurs began bulking up point to an environment that changed from arid to humid.

Together, the evidence suggests that the Carnian Pluvial Episode was actually four distinct periods of environmental change, each triggered by volcanic eruptions that were capable of impacting the global carbon cycle, says coauthor Jacopo Dal Corso, a geologist at the China University of Geosciences in Wuhan. The eruptions injected huge amounts of CO_2 into the atmosphere, boosting temperatures and rainfall, Dal Corso says. As the rains created wet environments, humidity-loving flora became predominant and large dinosaurs began to thrive.

That volcanism might have come from the Wrangellia Large Igneous Province eruption in British Columbia and Alaska, the team suggests. If true, then the Wrangellia event must have occurred in pulses rather than one sustained eruption.

The findings mark the "first time that mercury and carbon isotope data are so well correlated across the Carnian Pluvial Episode," says igneous petrologist Andrea Marzoli of the University of Padua in Italy. But "the link to Wrangellia is still weak, simply because we don't know the age of Wrangellia."

Forensic geologist Alastair Ruffell of Queen's University Belfast in Ireland agrees and says that more evidence is needed to understand what the Carnian Pluvial Episode "actually looked like on the ground." ■

LIFE & EVOLUTION

Wetland jaguars lead strange lives

Most jaguars are landlubbing loners, but not in Brazil's Pantanal

BY JAKE BUEHLER

In a tract of central Brazilian wetland, jaguars spend their days wading through chest-deep waters searching for fish. When not hunting, the big cats playfully grapple with each other back on land. This life, recently documented by scientists, is unlike that of any other known jaguar population in the world.

The findings reveal a degree of flexibility in diet and lifestyle previously unseen among the big cats. The observations may also provide key context about the jaguar's role in food webs, helping scientists better understand the effect of environmental changes on the species, researchers report October 6 in *Ecology*.

Jaguars (*Panthera onca*) are usually territorial loners that hunt on land, living in a wide array of habitats, from North American deserts to Central and South American grasslands and tropical rainforests. The cats are also found in the Pantanal, an immense tropical wetland that covers parts of Brazil, Bolivia and Paraguay.

Ecologists Manoel dos Santos-Filho of the Universidade do Estado de Mato Grosso in Cáceres, Brazil, and Carlos Peres of the University of East Anglia in Norwich, England, knew of rumors of large numbers of jaguars sighted in the remote northern reaches of the wetland in Brazil's Taiamã Ecological Station.

After relaying these anecdotes to Taal Levi, a wildlife ecologist at Oregon State University in Corvallis, together the researchers started a project to better understand the jaguars in this reserve.

Taiamã is seasonally flooded, with no roads or trails, so the team had to access the reserve by boat, setting up motion-activated cameras along waterways to gather data on jaguar numbers. The area's abundance of jaguars, however, was obvious immediately.

"You set your foot out of the boat, and there's a jaguar footprint there already," says Charlotte Eriksson, a wildlife scientist also at Oregon State. "There are scratches on trees. There are jaguar scats. There's just an unbelievable presence of this apex predator wherever you go, which is something I've never experienced anywhere before."

The team operated 59 cameras from 2014 to 2018 and collected more than 1,500 videos of jaguars, covering parts of both the dry and rainy seasons. The researchers also captured 13 jaguars and fitted them with GPS or radio-tracking collars to gain insight into the animals' population density, movements and social interactions.

From the data, the team estimates that the reserve hosts the highest density of jaguars ever recorded: 12.4 animals per 100 square kilometers, nearly double or triple some of the next highest estimates elsewhere. Jaguars were also the most common mammal spotted on camera.

Jaguars lie by the water in their wetland home in the northern Pantanal in Brazil.

C. ERIKSSON, DANIEL KANTEK

Video footage showed jaguars carrying large fish out of the water. Of 138 analyzed scat samples, 46 percent contained fish remains and 55 percent held the remains of reptiles, such as caimans. Just 11 percent had mammal remains. The team thinks that the Taiamã felines have the most fish-dependent diet of all big cats.

The cameras and tracking collars also showed that the jaguars spend a lot of time near each other, sometimes traveling, fishing and playing together. This is odd for jaguars, at least based on what scientists know about the cats elsewhere.

The profusion of aquatic prey in the flooded preserve — protected from human encroachment — may be responsible for the jaguars' superlative density and rich social lives. So much food may be available, Eriksson says, that there is "no real need to fight over it."

Another possibility is that prey concentrated along the river margins is accessible in only certain areas, Levi says. This may encourage jaguar territories to dissolve, since obtaining access to multiple fishing spots requires getting along with other jaguars. Brown bears, for example, congregate in great numbers to feed at salmon spawning grounds, despite the bears' typically solitary nature, Levi says.

The abundance of jaguars and their social behavior is not surprising, given the available food resources, says Todd Fuller, a conservation biologist at the University of Massachusetts Amherst. Still, he finds the new information exciting. The study helps bring researchers' understanding of jaguar ecology and conservation closer to what's known about most other large cat species, and "that is a very good thing," he says.

Jaguars in the Pantanal face many threats, and the cats are declining across Brazil, Eriksson says, suffering from drought, fire and agricultural expansion. Evaluating how jaguars respond to such changes is paramount. In 2020, half of the study area burned, and Eriksson is now assessing fire's impact on the jaguars and their periodically submerged home. ■

Watch jaguars fish and play together at **bit.ly/SN_jaguar**

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HUMANS & SOCIETY

Footprints point to an early arrival in the Americas

Fossil tracks suggest humans reached by 23,000 years ago

BY FREDA KREIER

Footprints left behind by prehistoric people may be some of the strongest evidence yet that humans arrived in the Americas earlier than once thought.

Sixty-one "ghost tracks" — so-called because they pop up and disappear across the landscape — suggest that people romped through what's now New Mexico 23,000 to 21,000 years ago, geoscientist Matthew Bennett and colleagues report in the Sept. 24 *Science*. If true, the fossil findings would be definitive proof that humans were in North America during the height of the Ice Age.

When people reached the Americas is highly contested. Many scientists have thought that humans traveled across the Bering land bridge that connected Asia to North America around 13,000 years ago, after the ice sheet that once blanketed much of North America started to retreat. But a slew of more recent discoveries suggest that humans arrived much earlier (*SN: 8/15/20, p. 6*).

Human footprints preserved in New Mexico may be between 23,000 and 21,000 years old.

At White Sands National Park in New Mexico, Bennett, of Bournemouth University in Poole, England, and colleagues used several methods to calculate the ages of the tracks, including radiocarbon dating of aquatic plant seeds embedded in and between the footprints.

"One of the beautiful things about footprints is that, unlike stone tools or bones, they can't be moved up or down the stratigraphy," Bennett says. "They're fixed, and they're very precise."

But some archaeologists aren't yet convinced of the footprints' age. Loren Davis of Oregon State University in Corvallis says he would like to see other validation techniques confirm the dates before "breaking out the champagne."

"This is the kind of stuff that makes you rewrite textbooks," Davis says. "For the good of the field, we need really high standards." If verification confirms the age, he says, the discovery will "show us that people have this amazing ability to survive and thrive during a time when global conditions were extreme."

The tracks were created over two millennia mostly by children and teenagers wandering through a patchwork of waterways. The footprints were found alongside those of mammoths and other large animals that flocked to water in the largely arid landscape. ■

HUMANS & SOCIETY

Ancient Siberians traded far and wide

Dog DNA suggests Arctic communities weren't so isolated

BY FREDA KREIER

Ancient communities in the Arctic traded with the outside world as early as 7,000 years ago, DNA from the remains of Siberian dogs suggests.

A genetic analysis shows that Arctic pups thousands of years ago interbred with dogs from Europe and the Near East. Along with previous archaeological finds, the results suggest that Siberians long ago were connected to a trade network that may have extended as far as the Mediterranean and the Caspian seas, researchers report in the Sept. 28 *Proceedings of the National Academy of Sciences*.

Dogs rarely wander far from their humans, so researchers can "use dogs to understand human movement, like migrations and even trade interactions," says Kelsey Witt, a geneticist at Brown University in Providence, R.I., who was not involved in the study.

Over the last 9,500 years, Arctic dogs have been valuable commodities, used for sledding, hunting, herding reindeer, clothing and food. Because the region is remote, scientists thought local dogs — and their owners — had been isolated for much of that time, an idea supported by the fact that ancient Siberians didn't exchange much DNA with people outside of the region, says Tatiana Feuerborn, an archaeologist at the University of Copenhagen.

But archaeological evidence, including the discovery of glass beads and other foreign goods entombed alongside 2,000-year-old dogs near the Yamal Peninsula in Russia, has suggested that these communities were trading with cultures beyond the Arctic.

After reading about the archaeological evidence, Feuerborn wanted to see if she could use ancient dogs to confirm whether a trade network existed.

Feuerborn and colleagues analyzed DNA from the remains of 49 Siberian dogs, ranging from 11,000-year-old bone fragments to fur hoods used by Arctic explorers in the early 20th century. Siberian dogs began mixing with dogs from the Eurasian steppes, the Near East and even Europe as early as 7,000 years ago, the team found.

The result suggests that Siberians did bring in dogs from outside the Arctic, Feuerborn says. This trade network could have helped transmit new ideas and technologies, such as metalworking, and may have facilitated Siberian society's transition from foraging to reindeer herding. ■

DAVID BUSTOS/NATIONAL PARK SERVICE, BOURNEMOUTH UNIV.

SCIENCE & SOCIETY

This year's Nobel Prizes awarded

Climate modeling, touch research and more honored

The 2021 Nobel science prizes celebrate research that has untangled the complexity of nature and society.

The physics award knitted together work illuminating intricate physical systems. Half the prize went to climate scientists Syukuro Manabe of Princeton University and Klaus Hasselmann of the Max Planck Institute for Meteorology in Hamburg, Germany, for their work on simulations of climate and predictions of global warming.

Manabe studied how rising carbon dioxide levels change temperature. A simple model, or mathematical representation, of climate in a 1967 study he coauthored simulated a single column of the atmosphere in which air masses rise and fall as they warm and cool, which revealed that doubling the amount of atmospheric carbon dioxide increases temperature by over 2 degrees Celsius.

Manabe's work laid the foundation for climate modeling. "He really did construct the models from which all future climate models were built," John Wettlaufer of Yale University, a member of the Nobel Committee for Physics, said in an interview after the October 5 prize announcement. Hasselmann's work tackled a specific puzzle that affected climate models: how to incorporate short-term variations in weather, as well as longer-term shifts in climate.

The other half of the prize went to physicist Giorgio Parisi of Sapienza University of Rome, who studied the roiling fluctuations within disordered systems, such as a type of material called a spin glass. In spin glasses, atoms behave like magnets, due to a quantum property called spin. But the atoms can't agree on which direction to point those magnets, resulting in a disordered arrangement. Parisi came up with a mathematical description for such spin glasses.

Efforts to study the complexities of real-life economic events in ways that mimic controlled lab studies earned three economists the Nobel Memorial Prize in Economic Sciences. David Card of the University of California, Berkeley, Joshua Angrist of MIT and Guido Imbens of Stanford University were instrumental in developing "natural experiments." These investigations rely on naturally occurring differences between groups that either do or don't experience specific conditions. In this way, social scientists can study, say, how differences in income affect health or how immigration influences employment rates.

Natural experiments are important because social scientists often can't assign people at random to treatment and control conditions.

The chemistry prize honored scientists who improved chemical reactions that are often slow, convoluted and wasteful. Benjamin List of the Max-Planck-Institut für Kohlenforschung in Mülheim an der Ruhr, Germany, and David MacMillan of Princeton developed catalysts that revolutionized how chemists build new molecules, making the process faster and more environmentally friendly.

To build new molecules, chemists combine chemical building blocks via reactions that are accelerated by catalysts. Catalysts have often been hard to use on a large scale, and some metal catalysts are toxic and expensive. Another complicating factor is that chemical reactions often produce two mirror-image versions of a molecule. Because those versions can have different effects, it's crucial to control which version is made.

While List was studying a reaction that links two molecules together through carbon bonds and has a large protein called an enzyme as its catalyst, he found that only a small part of the enzyme actually catalyzes the reaction. That bit could do the work of the larger enzyme while also producing one version of the final product more often than the other. Meanwhile, MacMillan designed small organic molecules that mimic the catalytic action of metals in a simpler way while also favoring the production of one of two possible final products of a reaction that forms carbon rings. These discoveries set off an explosion of research into finding more of these catalysts, which has aided drug discovery, among other uses.

The physiology or medicine prize recognized two scientists who identified sensors on nerve cells that detect heat, cold and pressure. Molecular physiologist David Julius of the University of California, San Francisco used capsaicin, the compound that makes chili peppers spicy, to discover a protein that allows people to feel a chili's burn.

The protein, a receptor called TRPV1, is an ion channel, a molecular gate nestled in a cell's membrane that opens or closes to control the flow of charged atoms or molecules into or out of the cell. When TRPV1 encounters capsaicin or heat, it opens, allowing calcium ions into the cell. That ion flood triggers electrical signals that go to the brain to warn of hot stuff.

Julius also used the winter-fresh compound menthol to uncover TRPM8, a cold-sensing receptor. Neuroscientist Ardem Patapoutian of the Scripps Research Institute in La Jolla, Calif., simultaneously discovered that receptor.

Patapoutian also discovered PIEZO1, which opens in response to mechanical pressure. That receptor, along with the related protein PIEZO2, helps people feel touch. — *Bruce Bower, Emily Conover, Carolyn Gramling, Freda Kreier, Jonathan Lambert and Tina Hesman Saey*

2021 Nobel laureates

PHYSICS

Syukuro Manabe
Princeton University

Klaus Hasselmann
Max Planck Institute for Meteorology

Giorgio Parisi
Sapienza University of Rome

ECONOMIC SCIENCES

David Card
University of California, Berkeley

Joshua Angrist
MIT

Guido Imbens
Stanford University

CHEMISTRY

Benjamin List
Max-Planck-Institut für Kohlenforschung

David MacMillan
Princeton University

PHYSIOLOGY OR MEDICINE

David Julius
University of California, San Francisco

Ardem Patapoutian
Scripps Research Institute

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EARTH & ENVIRONMENT

Earth is reflecting less sunlight

Dimming from 1998 to 2017 resulted in more warming

BY SID PERKINS

The amount of sunlight that Earth reflects into space, measured by the dim glow best seen on the dark portions of a crescent moon's face, has decreased in recent years. Whether the decline is a short-term blip or an ominous sign for the climate is up in the air, scientists say.

Our planet, on average, reflects about 30 percent of the sunlight that shines on it. But a new analysis bolsters previous work suggesting that Earth's reflectance has declined, says Philip Goode, an astrophysicist at Big Bear Solar Observatory in California. From 1998 to 2017, Earth's reflectance dropped about 0.5 percent, Goode and colleagues report in the Sept. 8 *Geophysical Research Letters*.

Using ground-based instruments at Big Bear, the team measured earthshine — the light that reflects off the planet, to the moon and then back to Earth. Because earthshine is most easily gauged when the moon is a slim crescent and the weather is clear, the team collected only 801 useful data points.

Much of the decrease occurred during the last three years of the two-decade study period, Goode says. Satellite data, he and colleagues note, hint that the drop stems from higher sea surface temperatures along the Pacific coasts of North and South America, which reduced low-altitude cloud cover and exposed the underlying, much darker and less reflective seas.

"Whether or not this is a long-term trend is yet to be seen," says Edward Schwieterman, a planetary scientist at the University of California, Riverside.

Decreased cloudiness over the eastern Pacific isn't the only thing trimming Earth's reflectance, or albedo, says Shiv Priyam Raghuraman, an atmospheric scientist at Princeton University. Many studies point to a long-term decline in ice on land, Arctic sea ice and tiny pollutants called aerosols — all of which scatter sunlight back into space and cool Earth.

With ice cover declining, Earth is absorbing more radiation. That extra radiation in recent decades has warmed the oceans and melted more ice, which can contribute to even more warming via a feedback loop, Schwieterman says.

Altogether, Goode and colleagues estimate, the decline in Earth's reflectance from 1998 to 2017 means that each square meter of the planet's surface is absorbing, on average, an extra 0.5 watts of power. For comparison, greenhouse gases and other human-related sources of warming over the same period boosted power input to Earth's surface by about 0.6 watts per square meter. That means the decline in Earth's reflectance has, over that 20-year period, almost doubled the warming effect Earth experienced. ■

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Aviators training during World War I recovered from influenza in a hangar at Eberts Field in Arkansas during the 1918 pandemic. The infectious disease moved swiftly through crowded military camps.

ScienceNews 100

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When Diseases Spread

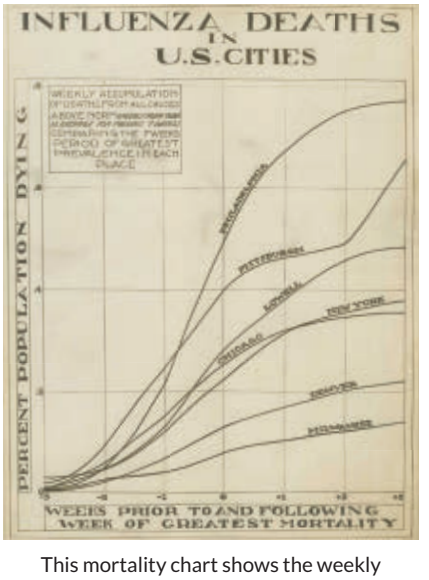
A century of science has helped us fend off infectious diseases, but we could learn more from past experience **By Aimee Cunningham**

The emergency hospital, a partially demolished building hastily enclosed with wooden partitions, was about to open. It was the fall of 1918 in Philadelphia, and influenza was spreading fast. With many of the city's doctors and nurses serving in World War I, 23-year-old Isaac Starr and his third-year classmates at the University of Pennsylvania School of Medicine needed to help tend the sick. They'd had just one lecture on influenza. Their first job was to assemble the hospital beds, about 25 to a floor.

Starr's shift was 4 p.m. to midnight. The beds soon filled with patients who had fevers, he recalled in a 1976 essay for *Annals of Internal Medicine*. Many who developed influenza recovered. But Starr witnessed some patients become starved for air, their skin turning blue. Soon, they were "struggling to clear their airways of a blood-tinged froth that sometimes gushed from their nose and mouth," he wrote. "It was a dreadful business."

There were no effective treatments. Patients, desperate for breath, became delirious and incontinent and would die within days. "When I returned to duty at 4 p.m., I found few whom I had seen before," Starr wrote. "This happened night after night." In October, around the pinnacle of the pandemic, roughly 11,000 Philadelphians perished.

Some who died in the makeshift hospital stuck with Starr. There was Mike the piano mover, who in a frenzy left his bed and was about to leap from a window before medical staff grabbed him. Mike died shortly after. There was the young woman, "flushed with fever," whose large family kept vigil at her bedside, hoping for a recovery that never came.



This mortality chart shows the weekly accumulation of deaths above normal during the 1918 influenza pandemic. Philadelphia was one of the hardest hit U.S cities.

An estimated 50 million people worldwide died of influenza during the 1918 pandemic. The century since has seen many vaccines and treatments become available to combat infectious diseases. But beyond those medical feats, the story of epidemics remains a story about people: people who become sick, people who die, people whose lives are upended, people who care for others. And ultimately, people who remember what happened and people who forget.

The public memory of the 1918 pandemic, which lasted into 1919, faded quickly in the United States, with few historical accounts or memorials to victims in the aftermath. One of the first major histories of the pandemic, by Alfred Crosby, didn't arrive until 1976, the same year Starr published his reflections on serving in an influenza ward. Crosby's book was eventually reissued with the fitting title *America's Forgotten Pandemic: The Influenza of 1918*.

Since 1918, we have faced many epidemics, but COVID-19 has been the first to rival the great flu in how it has changed everyone's daily lives. "We are living through a historic pandemic," says Anthony Fauci, director of the National Institute of Allergy and Infectious Diseases in Bethesda, Md.

But a hundred years' worth of advances in virology, medical understanding and vaccine development has made a difference. It was 11 months from the discovery of the SARS-CoV-2 virus to "having a vaccine that you could put in people's arms," Fauci says, "a beautiful testimony to the importance of investing in biomedical research."

The COVID-19 pandemic is also a stark reminder of what hasn't changed. "Pandemics just surface all the muck," says internist, medical humanities scholar and historian of medicine Lakshmi Krishnan of Georgetown University in Washington, D.C. Ever present but often

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ignored societal inequities become unavoidable. The disproportionate weight of COVID-19 disease and death on Black, Latino and Native American communities in the United States — "we better not forget," says Fauci. "We really need to address the social determinants of health that lead to these very, very obvious disparities."

Yet outbreak after outbreak, our collective memory falters. The urgency of the predicament eventually fades. The families mourning the loss of loved ones, people struggling with unmet medical needs, with stigma, become small islands of remembrance ever threatened by vast seas of forgetfulness and indifference.

Sometimes forgetfulness comes from a lack of reckoning. The United States moved on from the 1918 pandemic without addressing what was lost. Sometimes the success of vaccines obscures their power. The fear that surrounded polio subsided in the United States after the country rolled up its sleeves for polio vaccines. The dread of many other childhood illnesses, such as diphtheria and measles, has also diminished, leaving some to take prevention measures for granted.

To look back at infectious diseases since 1918 is to observe what we've learned about the viruses, bacteria and fungi with which we share our world, and observe the strides made in lessening their harms. But it's also a call to listen to the stories of how infectious diseases have shaped people's lives.

Outbreaks "have occurred throughout history and they occur now," Fauci says. "And they will continue to occur."

Vaccine victories

On February 24, 1947, Eugene Le Bar, an American merchant, boarded a bus in Mexico City. During the trip, his head began to ache and he broke out with a rash. He arrived in New York City on March 1 still not feeling well. Four days later, he was admitted to the hospital. His stay overlapped with a mumps patient named Ismael Acosta and a little girl, almost 2, who had croup.

Le Bar deteriorated while doctors searched for a diagnosis. He died March 10. Acosta and the little girl had been discharged, but returned later in March with rashes. The results of tests for those two led to a review of Le Bar's autopsy. The diagnosis was smallpox, a disease that kills about 30 percent of those sickened and leaves survivors disfigured by prominent scars.

More victims turned up. A little boy with whooping cough who had been at the hospital developed a rash. So did Acosta's 26-year-old wife, Carmen, who died days later. Soon the number of people with smallpox reached 12. New York City embarked on a massive vaccination campaign.

At the time, Anthony Fauci was 6 years old, growing up in Brooklyn. He remembers his parents talking about a huge event that would be happening in the city. "We all had to get vaccinated, and vaccination means somebody would get a little needle and prick it multiple times in your arm." (The smallpox vaccine wasn't given as a shot; instead, a drop of vaccine was placed on the skin and a needle poked the skin repeatedly to usher the vaccine into the body.) Fauci and his family were among the millions of New Yorkers immunized that spring, bringing the smallpox outbreak to a close without another person added to the count.

A smallpox outbreak in New York City in 1947 spurred a huge vaccination effort. That April, people waited in two long lines at the Morrisania Hospital in the Bronx to be vaccinated.

BETTMANN/GETTY IMAGES

Throughout history, smallpox was one of the most feared infectious diseases. A British historian, writing about the 1694 death of Queen Mary II from smallpox at age 32, described the disease as "always present, filling the church-yards with corpses, tormenting with constant fears all whom it had not yet stricken, leaving on those whose lives it spared the hideous traces of its power."

Smallpox is also a starring character in the story of vaccines. At the end of the 18th century, the English physician Edward Jenner extracted fluid from a sore caused by cowpox on a dairymaid's hand and inoculated a young boy with it, a test of the belief among some farmers that getting sick with cowpox protected against smallpox. The experiment propelled forward the concept of vaccination. By giving the immune system a preview of the pathogen, the body's defenses were prepared for the main event.

What followed exemplifies the fullest power of vaccination. After a worldwide campaign, smallpox was the first infectious disease to be declared eradicated from the globe, in 1980 (*SN: 11/03/79, p. 310*). A scourge that had plagued humankind for at least 3,000 years was consigned to the history books.

Other vaccine-preventable diseases — especially those that afflict children — harm many fewer around the world today than in the near past. During the 20th century in the United States, after vaccines became widely used for nine diseases, including polio, measles and *Haemophilus influenzae* type b, cases declined by 95 to 100 percent. Yet there can be "a lack of appreciation for what vaccines have done in terms of getting rid of or managing many infectious diseases," says virologist A. Oveta Fuller of the University of Michigan in Ann Arbor.

For many people today, an understanding of polio only comes from history books (*SN: 1/20/51, p. 42*). But others who

grew up when summers meant polio outbreaks have sharp recollections.

Paul Offit, a pediatric infectious disease specialist at Children's Hospital of Philadelphia, was 5 years old in 1956. After surgery on his foot, he stayed for about six weeks in a Baltimore hospital's chronic care facility. It was primarily a polio ward. He was surrounded by children whose limbs were suspended in traction or whose bodies were swallowed in iron lungs.

"It was a lonely, frightening experience," Offit says. Parents were allowed to visit only one hour a week. He could see "how vulnerable and helpless and alone all of those children were." Offit's bed was next to a window, which gave him a view of the building's front door. He'd stare at the entrance, "waiting for someone to come save me."

Offit later trained at that same hospital as a medical student. The ward he had languished in as a child was now a suite of offices. The room looked the same, even the molding, "and that window was still there," Offit says. "I remember walking up and looking out that window and seeing the same thing I saw 20 years earlier and just fighting back tears."

Memorial Day weekend in the United States used to herald a season of polio fear, as cases rose in summertime. Children were barred from swimming pools and crowds. Fauci's parents wouldn't allow him and his sister to go to the beach at Coney Island. "All of us as kids knew somebody who'd been paralyzed," says David Morens, Fauci's senior scientific adviser, who grew up in the 1950s.

Vaccines provided an exit from this recurring nightmare. The two vaccines developed to thwart polio each drew on different advances. First came Jonas Salk's "killed" polio vaccine, approved in 1955 (*SN: 4/16/55, p. 242*). Made with poliovirus that had been treated with formaldehyde, the virus could no longer cause harm, but the body could still mount an immune response against it. About seven decades earlier, Louis Pasteur had demonstrated that rabies virus could be inactivated to develop a rabies vaccine.

The second vaccine, Albert Sabin's oral polio vaccine, became available in 1961 (*SN: 12/14/63, p. 370*). Often delivered on a sugar cube, Sabin's easily digested vaccine was the inspiration for the song "A Spoonful of Sugar" in the movie *Mary Poppins*. Sabin's approach was to weaken the poliovirus by making it replicate in nonhuman cells. Forced into an unfamiliar environment, the virus made genetic changes that diminished its ability to cause disease. This method, called attenuation, had first been used about 25 years earlier to create a yellow fever vaccine.

Vanishing ailments

Life before and after polio vaccines was like night and day. In 1952, polio paralyzed more than 21,000 people in the United States. Thirteen years later, that number had plummeted to 61. By 1979, polio was eliminated in the country. With new immunizations, one by one, common childhood ailments all but vanished in the United States: measles, rubella, chicken pox, and meningitis caused by bacteria.

When Kathryn Edwards trained in pediatrics in Chicago in the mid- to late 1970s, "we were really in the grips of *Haemophilus influenzae* meningitis." (*H. influenzae*, formerly *Bacillus influenzae*, is the misnamed bacterium that had once been suspected of causing influenza.) She remembers seeing four or five children at a time hospitalized with this dangerous swelling of the membranes covering the brain and spinal cord, says Edwards, an infectious disease pediatrician and vaccine researcher at Vanderbilt University School of Medicine in Nashville. Some children with *H. influenzae* meningitis were left with brain damage, while about 5 percent died. Edwards still remembers a young patient lost to the disease the last night of her training.

The first vaccine against *H. influenzae* type b, the type that most commonly caused meningitis and other severe infections, became available in the United States in 1985. More effective vaccines came a few years later, evaluated by Edwards and colleagues. Again the impact was unmistakable. Before 1985, close to 20,000 children, most of them under age 5, developed severe infections from *H. influenzae* type b each year, including 12,000 with bacterial

FROM LEFT: TALLAHASSEE DEMOCRAT COLLECTION/FLORIDA MEMORY, STATE LIBRARY AND ARCHIVES OF FLORIDA; FOOD COLLECTION/ALAMY STOCK PHOTO

Nurse Grace Kyler cares for two young boys wearing leg braces, their limbs weakened by polio (left). If the disease impaired the muscles in the chest, patients would be placed in an iron lung (right), which forced air in and out of their lungs so they could breathe.

meningitis. By 1994 and 1995, the incidence of severe disease had fallen 98 percent in children age 4 or younger. With the availability of vaccines against *H. influenzae* and other pathogens, "the practice of pediatrics is much different now than when I began 40 years ago," Edwards says.

The scope of infectious diseases that children face worldwide is slowly changing too. From 2000 to 2018, 23 million deaths globally were prevented by measles vaccination. But there are still millions of children around the world missing out on basic immunizations that are routine in the United States. The COVID-19 pandemic has worsened the problem: An estimated 23 million children worldwide did not receive childhood vaccines in 2020; that's about 3.7 million more than in 2019.

Virologist Jonas Salk, shown here vaccinating a young girl, developed the first polio vaccine while at the University of Pittsburgh. When results of a large clinical trial attesting to the vaccine's safety and efficacy were announced on April 12, 1955, U.S. church bells rang and people celebrated in the streets.

The work of developing vaccines against COVID-19 began shortly after researchers worked out the genetic sequence of the new coronavirus, SARS-CoV-2, in January 2020. Previous studies of the coronaviruses behind Severe Acute Respiratory Syndrome, or SARS (*SN: 3/29/03, p. 198*), and Middle East Respiratory Syndrome, or MERS (*SN: 5/31/14, p. 6*), had identified a viral protein that would effectively ramp up an immune response.

And the basic research that would underpin a new vaccine technology, which would be used for two of the first COVID-19 vaccines, had been going on for decades. The approach is based on messenger RNA, or mRNA, which carries out of the cell nucleus the instructions for making a protein. The vaccines have the guide for the viral protein; the body makes that protein and produces antibodies against it. Some of the crucial work, modifying the instructions for the viral protein so the body wouldn't see the guide as an invader, came from RNA biologist Katalin Karikó, immunologist Drew Weissman and colleagues working at the University of Pennsylvania Perelman School of Medicine in the mid- to late 2000s.

COVID-19 vaccines were created and tested in the shortest timeline for any vaccines yet. But that efficiency wasn't matched in the distribution. While there haven't been enough shots available globally (*SN: 3/27/21, p. 6*), the United States, a country awash in supply, has struggled to immunize everyone eligible. Some people haven't been vaccinated because they can't take time off work to recover from side effects or are worried they'll have to pay for the shots. Others don't see COVID-19 as a threat and don't see the need for the vaccine.

COVID-19 has killed millions of people worldwide. Yet perhaps it would be more terrifying if it primarily threatened children. The horror of polio was that it could leave children paralyzed for the rest of their lives, Offit says; it was as though children had been injured in war.

Michigan's Fuller thinks that seeing the harm that polio could do to children helped make Americans eager for polio vaccines. During the COVID-19 pandemic, "because we were all isolated, we didn't see each other really suffering or dealing with the effects of this virus," she says.

When virologist Katherine Spindler of the University of Michigan was growing up, she had measles, mumps and rubella. The vaccines for those afflictions "came along too late for me," Spindler says. She still remembers the name of her older brother's classmate who died in eighth grade of an infectious disease. The routine immunizations that are now regular parts of pediatrician appointments mean that most of us "don't know what it's like to have polio or to die from measles."

Spindler found getting the COVID-19 vaccine "so meaningful," thinking about all of the science that came together to develop it. People have e-mailed her with questions about the vaccine. One woman who had an appointment but wasn't sure she wanted to keep it wrote several times. Spindler spent a few hours responding. Finally, she got an e-mail back with a picture of the woman in her car getting

Big impact Vaccines that came into wide use in the 20th century against diphtheria, polio, measles and other diseases drastically reduced or, in the case of polio, eliminated the illnesses by the end of the century in the United States. Smallpox was globally eradicated by 1980.

Disease	Annual cases pre-vaccine*	Annual cases in 1998
Smallpox	48,164	0
Diphtheria	175,885	1
Pertussis	147,271	6,279
Polio	16,316	0
Measles	503,282	89
Mumps	152,209	606
Rubella	47,745	345
Haemophilus influenzae type b	20,000	54

**Annual pre-vaccine cases are from the 3–5 years before vaccine approval, except for mumps and smallpox. Mumps cases are reported the first year after the vaccine was licensed. Smallpox cases are from the early 1900s, when the vaccine was not yet in widespread use.*
SOURCE: NATIONAL IMMUNIZATION PROGRAM, CDC/*MMWR* 1999

HULTON ARCHIVE/GETTY IMAGES

the shot. "Tears came to my eyes," Spindler says. "One person vaccinated feels like such a victory."

The aftermath

At the start of the COVID-19 pandemic, Lakshmi Krishnan and S. Michelle Ogunwole were internists at Johns Hopkins Hospital in Baltimore. Patients were dying. There wasn't enough personal protective equipment for staff. So much about COVID-19 was still unknown. "It was terrifying," says Krishnan, now at Georgetown University. Some of her colleagues were writing their wills.

And the patients were largely alone. Ogunwole, also a health disparities researcher at Johns Hopkins University School of Medicine, remembers an older Black woman who had been hospitalized with COVID-19 for months. She was well enough to move out of the intensive care unit but was extremely debilitated because she hadn't walked in so long, Ogunwole says. A tube in her windpipe made talking difficult as well.

The woman's family was not there. "There was nobody to speak for her," Ogunwole says. It made Ogunwole think of her own mother, "an incredibly vibrant person ... the life of the party." If it was her mom in that bed, no one would have known who she is. That she likes to dance for no reason. That she picks up a different sport every year.

Ogunwole felt her patient's sorrow and loss. Millions are reckoning with the pandemic's cost to their physical and mental health. The toll is not unlike that of tuberculosis, AIDS, fungal diseases, childhood infectious diseases or the many other outbreaks and epidemics of the last century.

We should know by heart how lives — and whose lives — are changed by infectious disease outbreaks. But time and again, there's a clamor to leave outbreaks behind us. And the trauma and the inequities linger. The question this time, says historian Nancy Bristow of the University of Puget Sound in Tacoma, Wash., is, "Can we do a better job of continuing to hear the stories of those who have been affected?"

The stories of children who have lost one parent or both, for example. For her book *American Pandemic: The Lost Worlds of the 1918 Influenza Pandemic*, Bristow interviewed Lillian Kancianich, born in a small town in North Dakota. Kancianich's mother died of influenza when Kancianich was a baby. The story was that her mother was out sweeping the porch on Armistice Day and then was never seen again, Bristow says.

Kancianich bounced among extended family members' houses for two years before she was able to call one home. She told Bristow that as a child, when asked what she wanted to be when she grew up, her answer was, a stepmother. "The loss of that parent changed her life completely," Bristow says.

These stories have continued. In roughly the first year of the COVID-19 pandemic, an estimated 1 million children worldwide experienced the death of a mother, a father or both, researchers reported in July in the *Lancet*. The number is staggering, and yet it is a fraction of the estimated 17 million children who have lost one or both parents to AIDS in roughly the last three decades, according to the United States Agency for International Development. Ninety percent of those children live in sub-Saharan Africa.

Nearly 105,000 children in the United States are facing life without one or both parents due to COVID-19, the study in the *Lancet* found. "Evidence from previous epidemics shows that ineffective responses to the death of a parent or caregiver, even when there is a surviving parent or caregiver, can lead to deleterious psychosocial, neurocognitive, socioeconomic and biomedical outcomes for children," the authors wrote.

An earlier study on parental death due to COVID-19 in the United States took race and ethnicity into account. While Black children make up only 14 percent of children in the United States, they made up 20 percent of those who had lost a parent, researchers reported in April in *JAMA Pediatrics*.

When Krishnan was treating patients early in the pandemic, she remembers noting, "It's all my Black and brown patients that are getting upgraded to the intensive care unit." Research has revealed a disproportionate impact among Black, Latino and Native Americans in terms of infection, hospitalization and death.

"COVID has unveiled disparities in health," but the pandemic didn't create them, Fuller says. "This is not new."

At the turn of the 20th century, Black Americans' death rates were higher than white Americans for tuberculosis, pneumonia and, in children, diarrheal disease and diseases of malnutrition, W.E.B. Du Bois wrote in 1906, "an indication of social and economic position." Racism and segregation restricted access to health care, housing and wealth for Black Americans.

The accounts from 1918 in Black newspapers in Philadelphia and Chicago "gave the impression that the epidemic did not substantially disrupt life in black communities," wrote Vanessa Northington Gamble in *Public Health Reports* in 2010.

The U.S. military banned Black nurses during World War I. These nine Black nurses, who cared for soldiers with influenza at Camp Sherman in Ohio, along with nine Black nurses assigned to Camp Grant in Illinois, were the first called to serve after the ban was lifted two days after the war ended on November 11, 1918.

SPECIAL COLLECTIONS AND UNIVERSITY ARCHIVES, UNIVERSITY OF MASSACHUSETTS AMHERST LIBRARIES

A memorial displays the names of victims of COVID-19 on yellow hearts outside of the U.S. Capitol in Washington, D.C., on May 5, 2021.

DREW ANGERER/GETTY IMAGES

Yet it was clear that the number of Black people who did have flu "overwhelmed the medical care facilities that were available to them," says Northington Gamble, a physician and medical historian at George Washington University in Washington, D.C. White hospitals wouldn't accept Black patients or would send them to the basement or other segregated areas. Black hospitals didn't have the capacity for everyone who needed care. So Black communities came together to provide for their own, she says.

When every one of the 75 beds at Frederick Douglass Memorial Hospital in Philadelphia filled up, its medical director, with no support from the city's board of health, managed to open an emergency annex for Black patients. Black women volunteers in Chicago made house visits to tend to the sick.

Black nurses also cared for Black influenza patients in their homes. Bessie B. Hawes, a 1918 graduate of the Tuskegee Institute's nursing program, described her experience caring for a family of 10, "dying for the want of attention," in a rural area of Alabama. "As I entered the little country cabin, I found the mother dead in bed, the father and the remainder of the family running temperatures of 102 to 104°. Some had influenza and others had pneumonia.... I saw at a glance that I had much work to do.... I milked the cow, gave medicine, and did everything I could to help conditions."

One of the legacies of the 1918 pandemic is "this long-standing tradition of the Black community of standing up and taking care of itself," says Northington Gamble. The tradition continues, she says, with the work of organizations including the Black Doctors COVID-19 Consortium, created to make it easier for Black communities in the Philadelphia area to receive COVID-19 testing and vaccination.

When Black people became ill with influenza in the 1918 pandemic, they were more likely to die than white people with influenza, researchers reported in 2019 in the *International Journal of Environmental Research and Public Health*. That higher likelihood of death "could be attributed to several factors still present today: higher risk for pulmonary disease, malnutrition, poor housing conditions, social and economic disparities, and inadequate access to care," Krishnan, Ogunwole and their colleague Lisa Cooper of Johns Hopkins University wrote last year in *Annals of Internal Medicine*.

The societal systems that foster racial discrimination and lead to health inequities must be addressed, Ogunwole says. "There is no amount of resilience that overcomes that."

The suffering of the 1918 pandemic was overshadowed by the end of World War I, Bristow says. The war was publicly memorialized with monuments and a holiday. "The pandemic goes unspoken," she says, because it doesn't fit with the victorious narrative of the war. Only a few fictional works that drew upon the 1918 pandemic were published in the following decades.

But those books — such as the 1939 *Pale Horse, Pale Rider*, by Katherine Anne Porter, who survived an influenza illness but whose fiancé died — as well as private letters reveal deep loss, Bristow says.

"It's very clear that the trauma stayed with people, even if there's not public grieving, and that's what's so sad about it," she says. "There was no public acknowledgment of all of this loss." The country marched ahead, and people "were expected to hop in line and march along too."

Krishnan, a historian of medicine, says we must preserve a record of the COVID-19 pandemic. A hopeful sign that stories of how people felt, lived, loved and died won't be lost are the many oral history projects spearheaded by universities and libraries. "We cannot forget," Krishnan says, "because it will happen again." ■

Explore more

- Nancy K. Bristow. "'It's as bad as anything can be': Patients, identity and the influenza pandemic." *Public Health Reports*. 2010.
- Vanessa Northington Gamble. "'There wasn't a lot of comforts in those days': African Americans, public health and the 1918 influenza epidemic." *Public Health Reports*. 2010.

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A jumping spider's world

Jumping spiders have an exceptional way of sensing the world. Behavioral scientists are fascinated by the differences — and similarities — in how we view things.

THOMAS SHAHAN

Tiny creatures offer big insights into sensory landscapes beyond our perception

By Betsy Mason

Imagine that the world is shades of gray and a little blurry, almost as if your lousy peripheral vision has taken over. This fuzzy field of view extends so far that you can make out dim shapes and motion behind you as well; no need to turn your head. The one bright spot is an X-shaped splash of color that moves with your gaze. At the center of this splash, everything is crisp and clear — a small window of sharp, colorful detail in a gauzy grayscape.

Add some blades of grass the size of redwood trees, and you've got an inkling of what the world looks like through the eight eyes of a jumping spider. It might be a bit like watching a poorly focused black-and-white movie on a 3-D IMAX screen that wraps around the room, while you hold a spotlight shining high-definition color wherever you point it. In other words, it's really, really strange, at least compared with our two-eyed human perspective.

Jumping spiders, which are the family Salticidae, are best known for their hilariously flamboyant mating dances, their large front eyes that make for adorable close-ups and their itty-bitty size — some of the more than 6,000 known species of jumping spiders are smaller than a sesame seed.

But scientists are discovering that there's much more to these diminutive arachnids. Researchers are getting a sense of what it's like to be another animal by doing innovative experiments to go

Watch jumping spiders dance for a mate at **bit.ly/SN_JumpingSpider**

deeper into these spiders' lives, probing their ability to see, feel and taste.

"Part of why I study insects and spiders is this act of imagination that is required to really try to get into the completely alien world and mind and perceptual reality of these animals," says visual ecologist Nathan Morehouse of the University of Cincinnati.

Eye of the spider

Unlike bees and flies, which have compound eyes that merge information from hundreds or thousands of lenses into a single, pixelated mosaic image, the jumping spider has camera-type eyes, similar to those of humans and most other vertebrates. Each of the spider's eyes has a single lens that focuses light onto a retina.

The principal eyes — the big forward-facing ones that just beg us to anthropomorphize — have incredibly high resolution for creatures that are usually between 2 and 20 millimeters long. Their eyesight is sharper than any other spider's and is the secret behind their ability to stalk and pounce on prey with impressive precision. Their sight is comparable to that of much larger animals like pigeons, cats and elephants. In fact, human visual acuity is only about five to 10 times better than a jumping spider's.

"Given that you can fit a lot of spiders in one single human eyeball, that is pretty remarkable," says animal behavior researcher Ximena Nelson, who studies jumping spiders at the University of Canterbury in Christchurch, New Zealand. "In terms of size-for-size, there's just no comparison whatsoever to the type of spatial acuity that jumping spider eyes can achieve."

But that sharp vision covers only a small portion of the spider's field of view. Each of the two principal eyes sees a narrow, boomerang-shaped strip of the world. Together they form an "X" of high-resolution color vision. An adjacent pair of smaller, less sharp eyes scans a wide field of view in black and white, watching for things that need the attention of the big high-resolution eyes.

On the side of the spider's head are two more pairs of lower-resolution eyes that any human parent would envy. They let the spider monitor what's happening behind it, a nearly 360-degree view that's a real advantage for a small animal that is both hunter and prey. Indeed, a jumping spider might consider our 210-degree field of view rather pitiful.

But in other ways, a jumping spider's visual world is not so different from ours. The animal's principal eyes and first set of secondary eyes together do basically the same job as our two eyes with our high-acuity central vision and low-resolution peripheral vision. Like the spider, we focus our attention on a relatively small area and largely ignore the rest until something catches our attention.

"I totally think of them as completely analogous," Nelson says. "The jumping spider's solution is exactly the solution we've adopted. They've just adopted it in a much smaller manner."

A jumping spider (left) is perched on a foam ball and tethered in place with a plastic stick and removable adhesive. The spider watches videos while a specialized eye tracker records where the spider's principal eyes are looking. The eye tracker uses infrared light to record a reflection of the X-shaped view of the spider's high-resolution principal eyes. That view (top) is superimposed on a video watched by the spider. While the principal eyes focus on a cricket silhouette, the researchers add shapes like a growing or receding oval in view of the secondary eyes, to see if the spider will shift its focus.

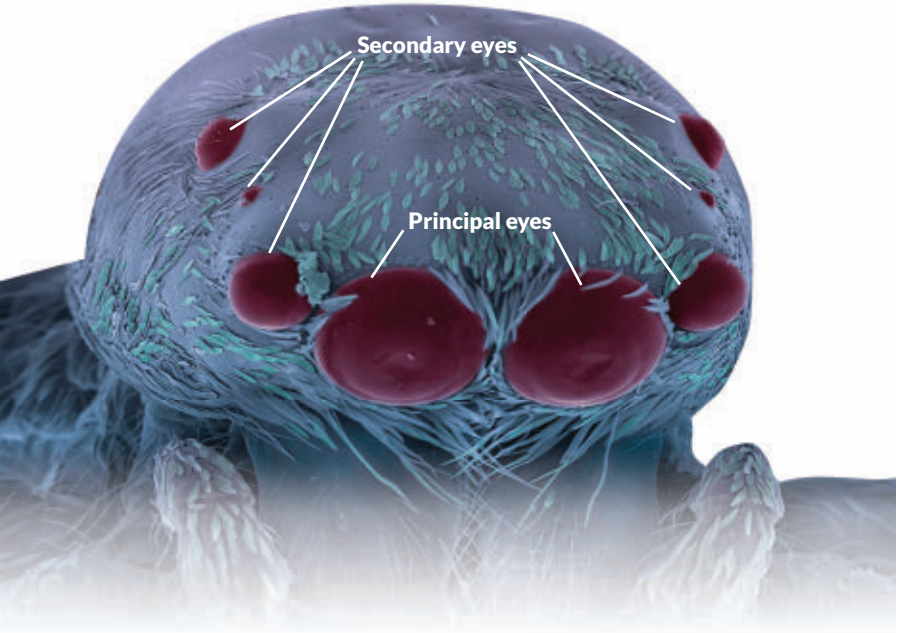
Giving the side eye

Each of the jumping spider's four pairs of eyes has a different job and behaves independently, but they all work together. This cooperation opens up intriguing research possibilities for behavioral ecologist Elizabeth Jakob of the University of Massachusetts Amherst. "I'm really interested in how the eyes collaborate," she says.

Jakob uses an ophthalmoscope modified to create a spider eye tracker. With removable adhesive, she tethers a female *Phidippus audax* to the end of a small plastic stick. Then, she hangs the stick with its spider in front of the eye tracker, the spider perched on a little ball facing a video screen. Once the spider is in position, Jakob plays videos. As the spider watches, she records how the principal eyes react.

The tracker shines an infrared light at the retinas of the principal eyes while a video camera

FROM TOP: DANIEL DAYE; E. JAKOB



A jumping spider's eight eyes, magnified above with a scanning electron microscope, combine for a nearly 360-degree view of the world. The large, forward-facing principal eyes see in color and have the highest resolution known for such a small animal.

records the reflected, X-shaped field of view. The reflection is later superimposed on the video the spider viewed, revealing exactly what the spider's principal eyes were focused on. For a human, watching the combined video is like peering through a portal into the spider's visual world.

Jakob teases out the relationships between the eyes by showing various images to different eye pairs. In a study published April 15 in the *Journal of Experimental Biology*, Jakob and her colleagues tried to determine which kinds of objects seen by the secondary eyes would prompt a spider to swing the principal eyes over for a sharper look. This test probes more than just how the eyes work together; it gets at what's important to a jumping spider.

"It's just so interesting to see what captures their attention," Jakob says. "To just get this little window into their mind."

First, a silhouette of a cricket — an appealing meal for a jumping spider — appears on the screen. You can tell when the spider's principal eyes have locked onto the cricket because the boomerangs start wiggling, rapidly scanning the silhouette while slightly twisting one way and then the other. The spider's principal eyes can do this sort of visual gymnastics because the retinas are at the back of two long, independently movable tubes, each controlled by six muscles.

To find out what might draw the spider's focus away from the cricket, Jakob adds other images to an area of the screen that is within the field of view of the secondary eyes. Any interest in a black oval? Nope. Maybe a black cross? Or another cricket? Not impressed. How about a black oval that is shrinking? Still no. What if the oval is getting bigger? Bingo: The boomerangs quickly flit over to the expanding oval to get a better look.

A jumping spider's principal eyes can concentrate on preparing to pounce on dinner, while the other eyes notice and ignore any number of less relevant things. But if those secondary eyes spot something that's getting bigger, well, that could be an approaching predator that requires immediate attention. It's a nifty design — one that could make an easily distracted human jealous.

"We're swimming in a sea of potential stimuli all the time," Jakob says. One way to filter that information is to prioritize, focusing attention on some things over others. "This is certainly familiar to any human trying to focus on reading one thing."

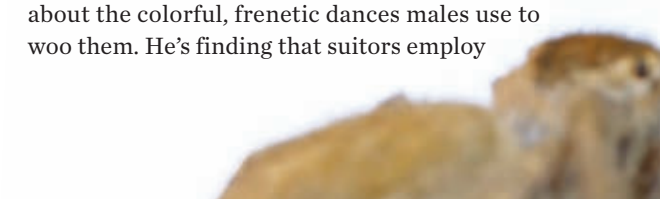
Spotlight on color

Among mammals, humans and many other primates have exceptional color vision. Most people can see three colors of light — red, blue and green — and all the various combinations of hues in between. Many other mammals typically see just some shades of blue and green light. Many spiders may also have a crude form of color vision, but for them it's usually based on green and ultraviolet light, which extends their vision into the deep violet end of the spectrum beyond what humans can see, and covers the blue and purple hues in between.

But some jumping spiders see even more. While at the University of Pittsburgh, Morehouse led a team that discovered that certain species have a filter squashed between two layers of green-sensitive photoreceptors that allows these spiders to detect red light in a small area at the center of their principal eye field of view. This adds red, orange and yellow hues to their world, which, along with the UV, gives them an even wider rainbow of colors than humans.

Seeing red can be handy since it's often used as a warning, in nature as well as in the human-engineered world of red lights and stop signs. For jumping spiders, the ability to see red may have evolved as a way to avoid toxic prey. But once this new world of color was available to the spiders, they put it to good use. "The evolution of color vision seems to be followed by the rapid use of the new colors that they can see in courtship," Morehouse says.

Using Jakob's eye tracker, Morehouse is testing female jumping spiders to see what interests them about the colorful, frenetic dances males use to woo them. He's finding that suitors employ



STEVE GSCHMEISSNER/SCIENCE SOURCE

a combination of movement and color that seems specifically designed to capture and hold a female's attention by playing to her various eyes. She can only see color within the boomerang-shaped view of her principal eyes, and the red, orange and yellow hues only at the center. Unless he can grab the attention of her secondary eyes with movement, she won't turn her principal eyes toward him and may never see his fabulously colored features. And for him, this could be a matter of life and death, because an unimpressed female may decide to make a meal of him instead.

The males of one species Morehouse studies, *Habronattus pyrrithrix*, have a dazzling red face and beautiful lime-green front legs. Yet the females seem most impressed by the orange knees on the males' third set of legs. When a male first spots a female, he raises his front legs like he's directing a plane into its gate and skitters side to side, hoping to catch the attention of her secondary eyes. When she turns his way, he comes closer and starts flicking the wrist joints at the end of his raised front limbs. You can almost hear him saying, "Hey lady, over here!"

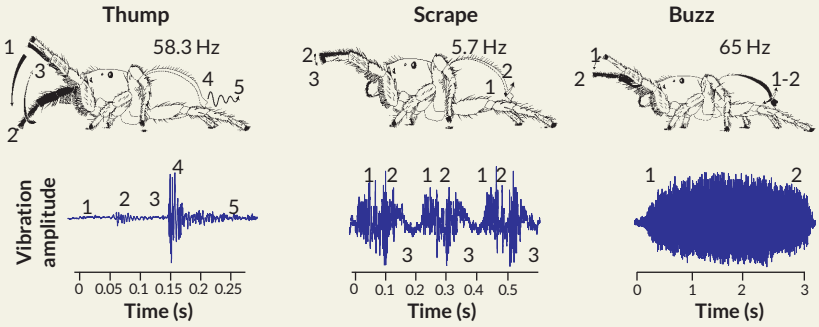
Once he's drawn her attention, out come the orange knees. "They move them up behind their back into view in a kind of a peekaboo display," Morehouse says.

To find out exactly what it is about a male's display that turns a female's head, Morehouse uses a bit of subterfuge. He doctors videos of males dancing, then plays the videos to a female perched in an eye tracker to see how each of the changes affects her attention. If the male has an orange knee hiked up, but it's not moving, she's less interested. If the knees are moving but the orange color is removed, she'll look but quickly lose interest. He's got to have both the right look and the right moves.

"He's using motion to influence where she's looking, and then he's using color to hold her attention there," Morehouse says.

Behavioral ecologist Lisa Taylor of the University of Florida in Gainesville, likens the males' tactics to those of human advertisers. "It feels like a lot of the tricks that marketers use to influence our decisions," Taylor says. "Understanding the psychology of spiders sometimes feels similar to understanding the psychology of humans."

Good vibrations Male jumping spiders work hard to get and keep a potential mate's attention. By tapping his front legs and oscillating his abdomen at various speeds, measured in hertz, or Hz, a male can produce three types of seismic signals that researchers can pick up using laser vibrometry.



Can you feel it?

The leg-waving, knee-popping spectacle of the male courtship display is meant to capture female attention. But this dance is only one part of the show, behavioral ecologist Damian Elias of the University of California, Berkeley discovered.

Many spiders use vibrations to communicate, and there had been a few reports that jumping spiders were among them. When Elias investigated further, he found that male jumping spiders accompany their moves with a remarkably elaborate serenade of vibrations, sent through the ground to the females, beyond human perception.

"It was a complete surprise to me," Elias says. When he shared what he had found with other arachnologists, "they were just blown away."

To eavesdrop on the spiders' seismic songs, Elias uses a laser vibrometer, similar to technology used in the aeronautics industry to measure vibration of airplane components. He tethers a female spider onto a nylon surface stretched like a drumhead and then adds a male. When the male spots the female, he starts his song and dance, drumming his legs on the surface and vibrating his abdomen.

The vibrometer measures the vibration of the surface and translates it into airborne sound that humans can hear, revealing an acoustic barrage of thumps, scrapes and buzzes. Elias simultaneously records video of the courtship at 1,000 frames per second so he can slow it down to see how the sound and motion sync up. It's like

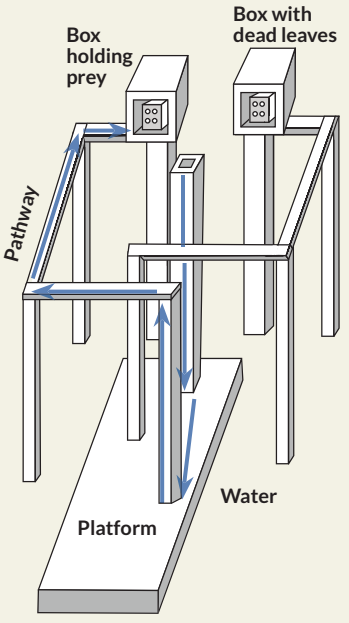
As part of his showy courtship dance, a male *Habronattus pyrrithrix* waves his front legs as if to say, "Look at me," then lifts the bright orange knees of two back legs. The female (foreground) is transfixed. Within minutes, he's won her over.

FROM TOP: D. ELIAS *ET AL*/*J. EXP. BIOL.* 2003; DANIEL ZUREK AND N. MOREHOUSE/MOREHOUSE LAB

Fly tigers

One of the things jumping spiders use their unusually good vision for is, well, jumping. Instead of building webs to passively snare meals, the spiders prefer to hunt. Their ability to quickly and accurately pounce on insects and other spiders earned them the moniker "fly tiger" more than 500 years ago during the Ming dynasty in China.

Scientists are learning just how apt the nickname is. At least one group of jumping spider species plans out strategic attacks involving elaborate detours to reach a target — the kind of clever hunting behavior typically ascribed to large-brained mammals like actual tigers.



"Some of the things that they do could keep you awake at night," says arachnologist Fiona Cross of the University of Canterbury in Christchurch, New Zealand. Cross and renowned jumping spider expert Robert Jackson, also at Canterbury, have tested this group of species, including the clever *Portia fimbriata*, with all sorts of challenges in the lab. In one study, the team placed a spider atop a tower on a platform (shown above) surrounded by water, knowing that jumping spiders avoid water whenever possible. From the perch, the spider could see two other towers: one topped with a box containing prey and one with a box of dead leaves. Both were accessible from the platform by a raised walkway with multiple turns. After surveying the scene, most spiders climbed down the tower and chose the correct path to the target — even when that required initially heading away from the target, losing sight of the prey, and first passing the start of the incorrect walkway.

This feat suggests that the spiders are capable of planning, Cross and Jackson argued in 2016 in the *Journal of the Experimental Analysis of Behavior*. The spiders came up with a strategy, and executed it. — *Betsy Mason*

a miniature drum solo, perfectly matched to the spider's flicks and kicks.

"We don't have access to that without technology," Elias says. "It's kind of unlocking this secret world."

The jumping spider's sensory world is filled with vibrations coming through the ground. But because those vibrations feel different depending on what the spider is standing on, things can change quickly as he hops from leaf to rock to soil.

For humans, who sense sound vibrations through the air rather than the ground, Elias imagines it might be something like taking two steps and suddenly listening through water, and then another two steps and you're surrounded by foam, and then back to air. The spiders' entire sensory world is constantly changing, yet they adapt without missing a beat.

Now, take that alien auditory world and add the fact that jumping spiders also have chemical sensors at the tips of their legs. "They're moving around, tasting everything that they're walking on," Elias says.

Very little is known about this aspect of the jumping spider's sensorium, but the latest research out of Taylor's Florida lab, published July 29 in the *Journal of Arachnology*, suggests that male spiders may be hoping to taste traces of potential mates. Most jumping spiders don't build webs to capture prey; they stalk and pounce instead. But the spiders are constantly laying down a line of silk as they move about, a sort of safety rope in case they fall or need to make a quick escape.

In the new study, a male *H. pyrrithrix* could sense a female's silk line when he stepped on it. Taylor's lab is now testing whether a male spider can detect the difference between a silk trail that will lead him to a virgin female who might be willing to mate with him and a dragline left by a female who has already mated and might prefer to eat him.

"The more we learn, the more complicated it gets," Taylor says. Jumping spiders "are so highly visual, and there's so much vibrational stuff going on, and then the chemistry. It's hard to imagine that it wouldn't just be super overwhelming."

Somehow, jumping spiders manage the sensory deluge quite well — they live just about everywhere on Earth. You've most likely seen one, possibly in your own house. Despite being so small, they are easy to identify if you know what you're looking for — or what *they're* looking for.

"Next time you see a spider in the middle of a wall, and you look at it, and it turns back and looks at you, that's a jumping spider," University of Canterbury's Nelson says. "It's detected your movement towards it with its secondary eyes, and it's checking you out."

That spider might just be imagining what the world looks like to a human. ■

Explore more

- Margaret Bruce *et al.* "Attention and distraction in the modular visual system of a jumping spider." *Journal of Experimental Biology.* April 2021.
- Fiona R. Cross *et al.* "Arthropod intelligence? The case for *Portia*." *Frontiers in Psychology*. October 14, 2020.

Betsy Mason is a freelance science journalist based in the San Francisco Bay Area.

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Jon Graff was a lifelong *Science News* reader who greatly admired the communications skills of its writers and editors. During his life, Jon helped devise the secure methods we use every day to make online credit card transactions. He also loved taking long trips in the Southwest on his beloved green bike.

When Jon looked back over his life as he grew older, he thought about the things that mattered to him most—his biking friends, his seminal work as a cryptographic architect and decades of reading *Science News*.

Sadly, Jon died in January 2021 at the age of 77. Before he died, Jon made a bequest intention to create an endowment—The Jon C. Graff Fund for *Science News*—whose income will benefit both the Society for Science and *Science News* journalism in perpetuity.

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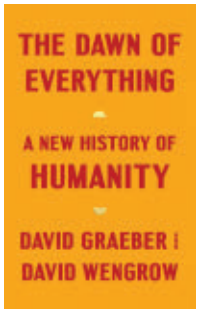

The Dawn of Everything
David Graeber and David Wengrow
FARRAR, STRAUS AND GIROUX, $35

BOOKSHELF

A new book challenges classic views of history

Concerns abound about what's gone wrong in modern societies. Many scholars explain growing gaps between the haves and the have-nots as partly a by-product of living in dense, urban populations. The bigger the crowd, from this perspective, the more we need power brokers to run the show. Societies have scaled up for thousands of years, which has magnified the distance between the wealthy and those left wanting.

In *The Dawn of Everything*, anthropologist David Graeber and archaeologist David Wengrow challenge the assumption that bigger societies inevitably produce a range of inequalities. Using examples from past societies, the pair also rejects the popular idea that social evolution occurred in stages.

Such stages, according to conventional wisdom, began with humans living in small hunter-gatherer bands where everyone was on equal footing. Then an agricultural revolution about 12,000 years ago fueled population growth and the emergence of tribes, then chiefdoms and eventually bureaucratic states. Or perhaps murderous alpha males dominated ancient hunter-gatherer groups. If so, early states may have represented attempts to corral our selfish, violent natures.

Neither scenario makes sense to Graeber and Wengrow. Their research synthesis — which extends for 526 pages — paints a more hopeful picture of social life over the last 30,000 to 40,000 years. For most of that time, the authors argue, humans have tactically alternated between small and large social setups. Some social systems featured ruling elites, working stiffs and enslaved people. Others emphasized decentralized, collective decision making. Some were run by men, others by women. The big question — one the authors can't yet answer — is why, after tens of thousands of years of social flexibility, many people today can't conceive of how society might effectively be reorganized.

Hunter-gatherers have a long history of revamping social systems from one season to the next, the authors write. About a century ago, researchers observed that Indigenous populations in North America and elsewhere often operated in small, mobile groups for part of the year and crystallized into large, sedentary communities the rest of the year. For example, each winter, Canada's Northwest Coast Kwakiutl hunter-gatherers built wooden structures where nobles ruled over designated commoners and enslaved people, and held banquets called potlatch. In summers, aristocratic courts disbanded, and clans with less formal social ranks fished along the coast.

Many Late Stone Age hunter-gatherers similarly assembled and dismantled social systems on a seasonal basis, evidence gathered over the last few decades suggests. Scattered discoveries of elaborate graves for apparently esteemed individuals and huge structures made of stone, mammoth bones and other material dot Eurasian landscapes (*SN: 10/28/17, p. 7*). The graves may hold individuals who were accorded special status, at least at times of the year when mobile groups formed large communities and built large structures, the authors speculate. Seasonal gatherings to conduct rituals and feasts probably occurred at the monumental sites. No signs of centralized power, such as palaces or storehouses, accompany those sites.

Social flexibility and experimentation, rather than a revolutionary shift, also characterized ancient transitions to agriculture, Graeber and Wengrow write. Middle Eastern village excavations now indicate that the domestication of cereals and other crops occurred in fits and starts from around 12,000 to 9,000 years ago. Ancient Fertile Crescent communities periodically gave farming a go while still hunting, foraging, fishing and trading. Early cultivators were in no rush to treat tracts of land as private property or to form political systems headed by kings, the authors conclude.

Even in early cities of Mesopotamia and Eurasia around 6,000 years ago, absolute rule by monarchs did not exist. Collective decisions were made by district councils and citizen assemblies, archaeological evidence suggests. In contrast, authoritarian, violent political systems appeared in the region's mobile, nonagricultural populations at that time.

Early states formed in piecemeal fashion, the authors argue. These political systems incorporated one or more of three basic elements of domination: violent control of the masses by authorities, bureaucratic management of special knowledge and information, and public demonstrations of rulers' power and charisma. Egypt's early rulers more than 4,000 years ago fused violent coercion of their subjects with extensive bureaucratic controls over daily affairs. Classic Maya rulers in Central America 1,100 years ago or more relied on administrators to monitor cosmic events while grounding earthly power in violent control and alliances with other kings.

States can take many forms, though. Graeber and Wengrow point to Bronze Age Minoan society on Crete as an example of a political system run by priestesses who called on citizens to transcend individuality via ecstatic experiences that bound the population together.

What seems to have changed today is that basic social liberties have receded, the authors contend. The freedom to relocate to new kinds of communities, to disobey commands issued by others and to create new social systems or alternate between different ones has become a scarce commodity. Finding ways to reclaim that freedom is a major challenge.

These examples give just a taste of the geographic and historical ground covered by the authors. Shortly after finishing writing the book, Graeber, who died in 2020, tweeted: "My brain feels bruised with numb surprise." That sense of revelation animates this provocative take on humankind's social journey. — *Bruce Bower*

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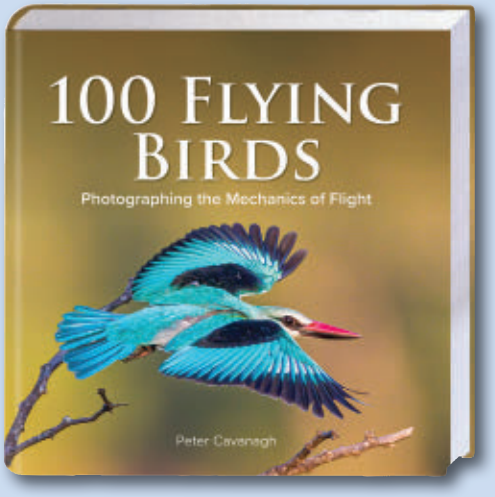

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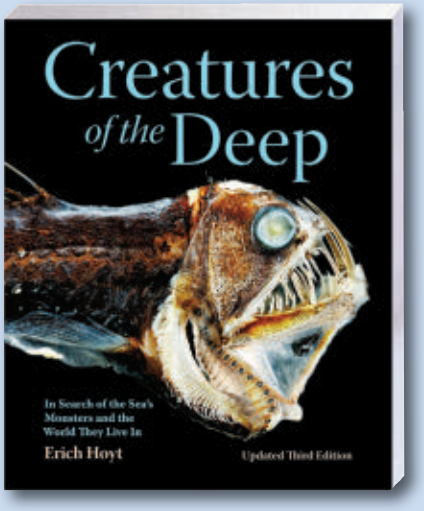

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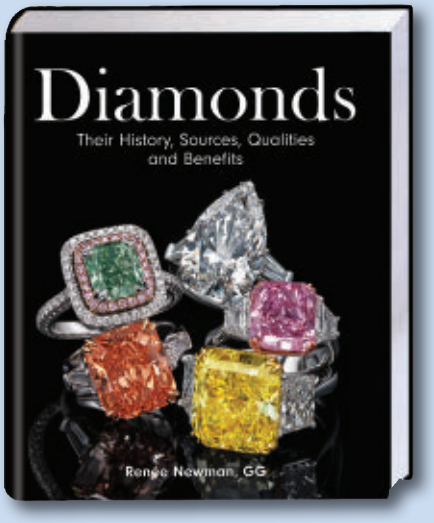

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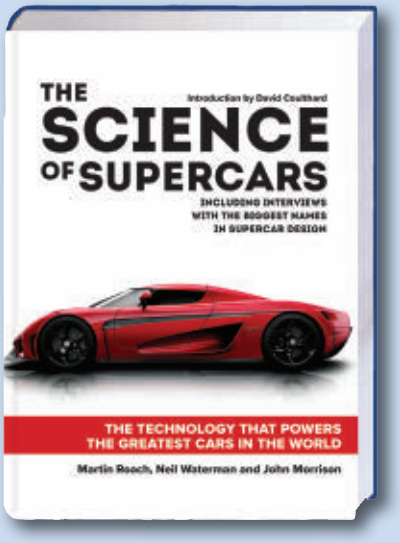

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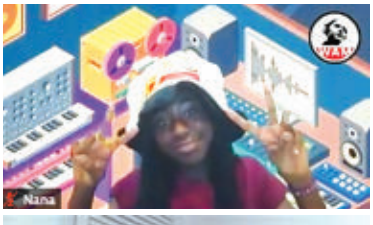

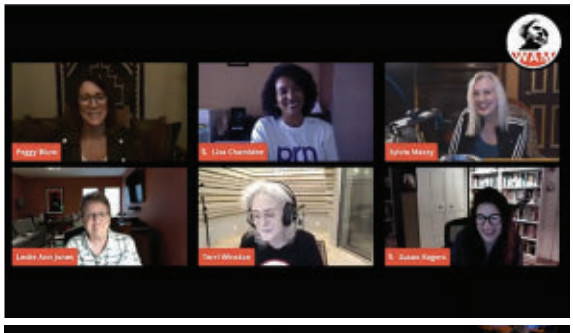

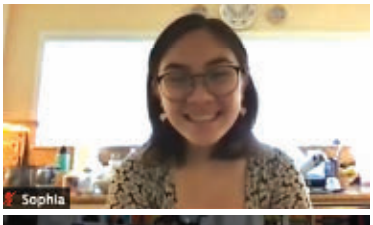

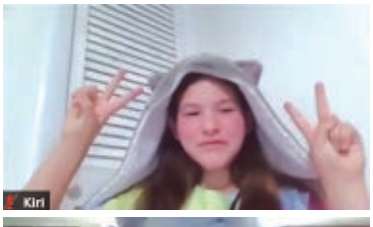

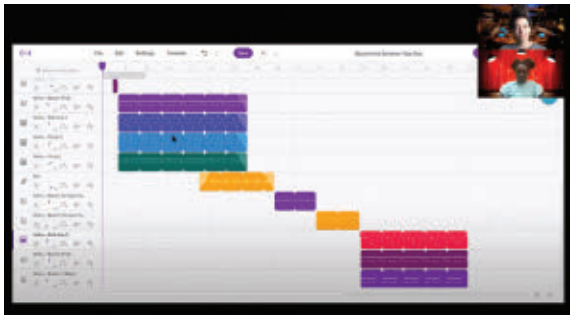

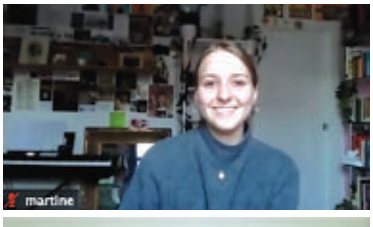

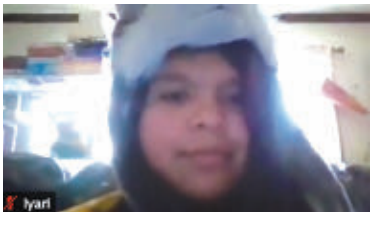

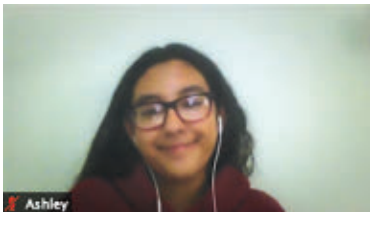

Women's Audio Mission (WAM), a nonprofit dedicated to the advancement of women and girls in music production and the recording arts, provided creative technology training to more than 4,000 women, girls and gender-expansive individuals all over the globe in 2020. WAM's online programming, which serves individuals throughout the United States and in more than 30 countries, featured top music technologists and engineers that have worked with musicians, such as Beyoncé, Janelle Monáe and Selena Gomez.

WAM is a multiyear recipient of the Society for Science's STEM Action Grant program, which bolsters and improves outcomes for groups that have been historically left behind in STEM education and careers, including Black and Latino individuals; women and gender-expansive persons; people who are hard of hearing and visually impaired; and students from low-income backgrounds. In 2021, WAM received $5,000 from the Society to continue expanding the organization's award-winning Girls on the Mic program, an after-school training and mentoring program.

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SOCIAL MEDIA

Pondering perspectives

Sujata Gupta's story on psychological richness (see "What makes a good life?" right) caught the attention of *Science News* reader **Margaret Atwood**. The acclaimed poet, essayist and novelist shared **Gupta's** story with her millions of followers on Twitter, writing: "Perspective-changing experiences, good or bad, can lead to richer lives."

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Fuse and fizzle

*Laser-sparked nuclear fusion reactions released nearly as much energy as was used to ignite them, **Emily Conover** reported in "Physicists near a nuclear fusion feat" (SN: 9/11/21, p. 11).*

Reader **Christopher** asked how scientists contained the fusion reaction.

Fusion reactions don't need to be contained because they fizzle out on their own, **Conover** says. Shortly after the laser blast ends, so do the reactions. This is one of the benefits of fusion, she says. Since the reactions stop on their own, unlike the fission reactions currently used to generate nuclear energy, there's no risk of a runaway reaction leading to a meltdown.

What makes a good life?

*Happiness and meaning are long-posited avenues to the "good life." Psychological richness spurred by perspective-changing experiences may be a third path, **Sujata Gupta** reported in "Roads to the good life" (SN: 9/11/21, p. 24).*

Reader **Ellen Leff** wondered whether people's approaches to the good life change with age.

Paths to the good life may evolve over time, **Gupta** says. Younger people tend to desire a life of happiness, while older people lean toward psychological richness, a 2020 study published in *Affective Science* suggests. But that difference was found primarily in people in the United States. More research is needed to determine if the trend holds for people in other countries. Personality traits tend to be stable across time, **Gupta** says. People open to novel experiences, the trait most strongly linked with richness, will probably continue pursuing such experiences as they age. Theoretically, those people may report higher richness at the end of life than people who are less open to novel experiences.

A weigh with words

*Flickers in a black hole's accretion disk can help scientists measure its mass, **Lisa Grossman** reported in "How black holes eat hints at their mass" (SN: 9/11/21, p. 12).*

The story inspired reader **David Morse**, a published author, to craft a poem:

Black holes feed on everything: kitchen scraps; whole galaxies. / Scientists are trying to weigh those vast star-suckers by what / they leave behind: a white-hot disc of gas and cosmic dust / that twinkles like a campfire in the night, but a billion times / brighter than our sun. Astronomers count that pulse, use Einstein's / theory of relativity to calculate the weight. I can't do the math, / only know this from afar, that scientists somewhere are counting / light to weigh the unweighable by its blinking residue. I can't help / but see Albert himself peering past that droopy white moustache / like a green grocer testing a balance scale with his thumb, in / a world where nothing so personal exists, where green grocers / are all sucked into those big box stores, our sun a dying star.

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PS Form **3526**, July 2014

Spider moms have been caring for their young for a long time

Millions of years before *Tyrannosaurus rex* walked the Earth, sap engulfed a spider guarding her precious egg sac.

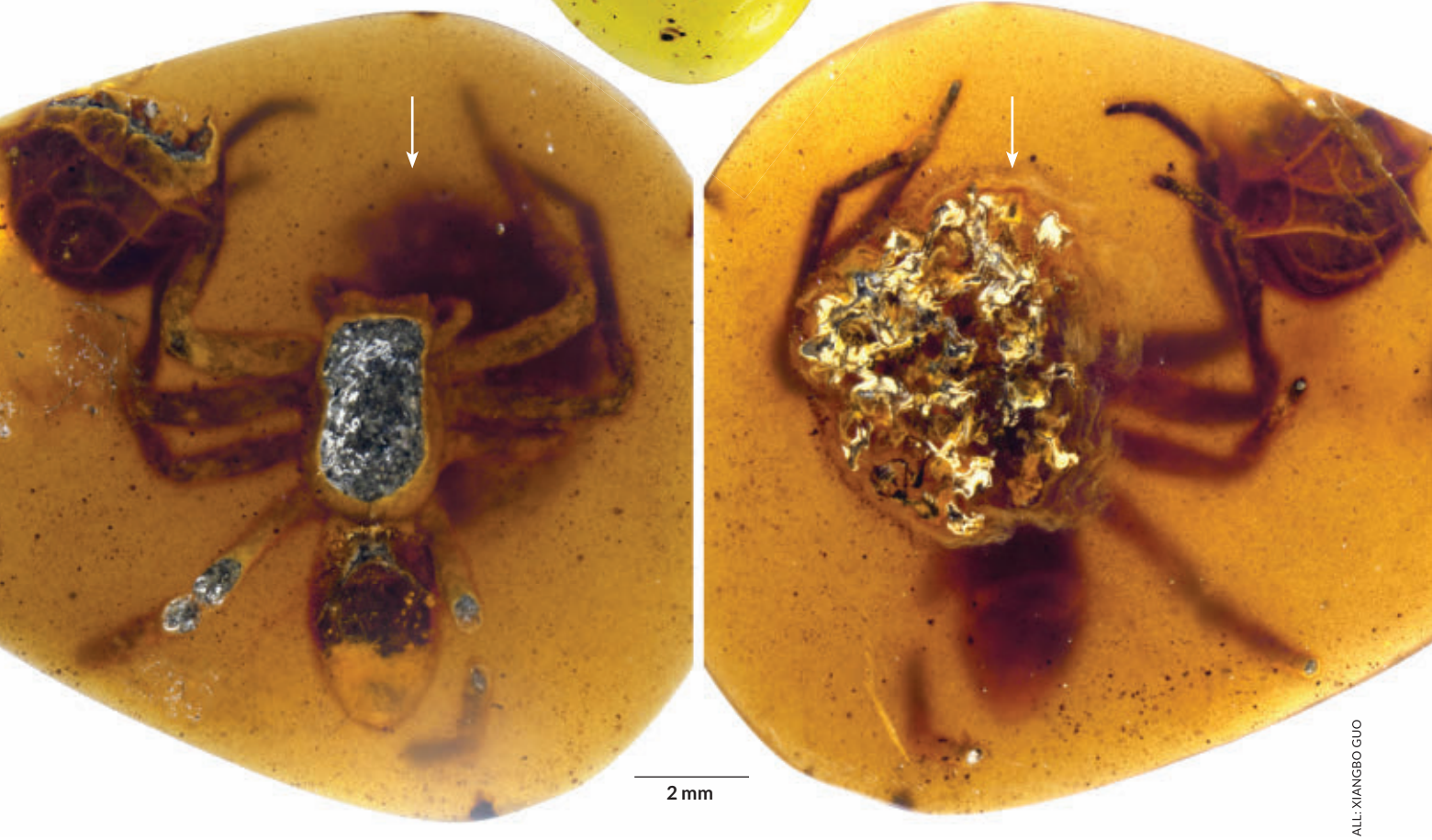
Her corpse, preserved alongside her offspring in amber for 99 million years, is the oldest physical evidence for maternal care in spiders, says Paul Selden, an invertebrate paleontologist at the University of Kansas in Lawrence. This fossil (shown at bottom; left is from above and right is from below) is one of four recently analyzed specimens that, together, show that some ancient spiders guarded their egg sacs and may even have raised their young, Selden and colleagues report in the Sept. 29 *Proceedings of the Royal Society B*.

Guarding eggs and other forms of maternal care are common among modern spiders. Some species even nurse their young or serve themselves up as their children's first meal (*SN: 5/2/15, p. 4*). Because maternal care is so widespread, researchers suspect that spiders developed this behavior not long after they evolved around 400 million years ago.

But this "is the first time we've seen evidence for this behavior in fossils," Selden says. The female spider and her unborn offspring (egg sac indicated with arrows) belong to a now-extinct family of spiders called Lagonomegopidae, distinguished by their large, reflective eyes.

Along with guarding their eggs, female spiders may have stuck around after the eggs hatched. Three of the chunks of amber contain dozens of week-old spiders (one chunk shown at center with a spiderling circled). Spiders are usually solitary creatures, so the presence of multiple spiderlings side by side suggests that they didn't disperse soon after hatching, perhaps choosing instead to stay near their mother.

The study "unequivocally" shows that these spiders were guarding their egg sacs during the mid-Cretaceous Period, says Linda Rayor, an entomologist at Cornell University who studies maternal care in spiders. But how long mom or the spiderlings stuck around remains unclear. "Future researchers need to keep their eyes open for females with larger and older offspring," Rayor says. — *Freda Kreier*



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