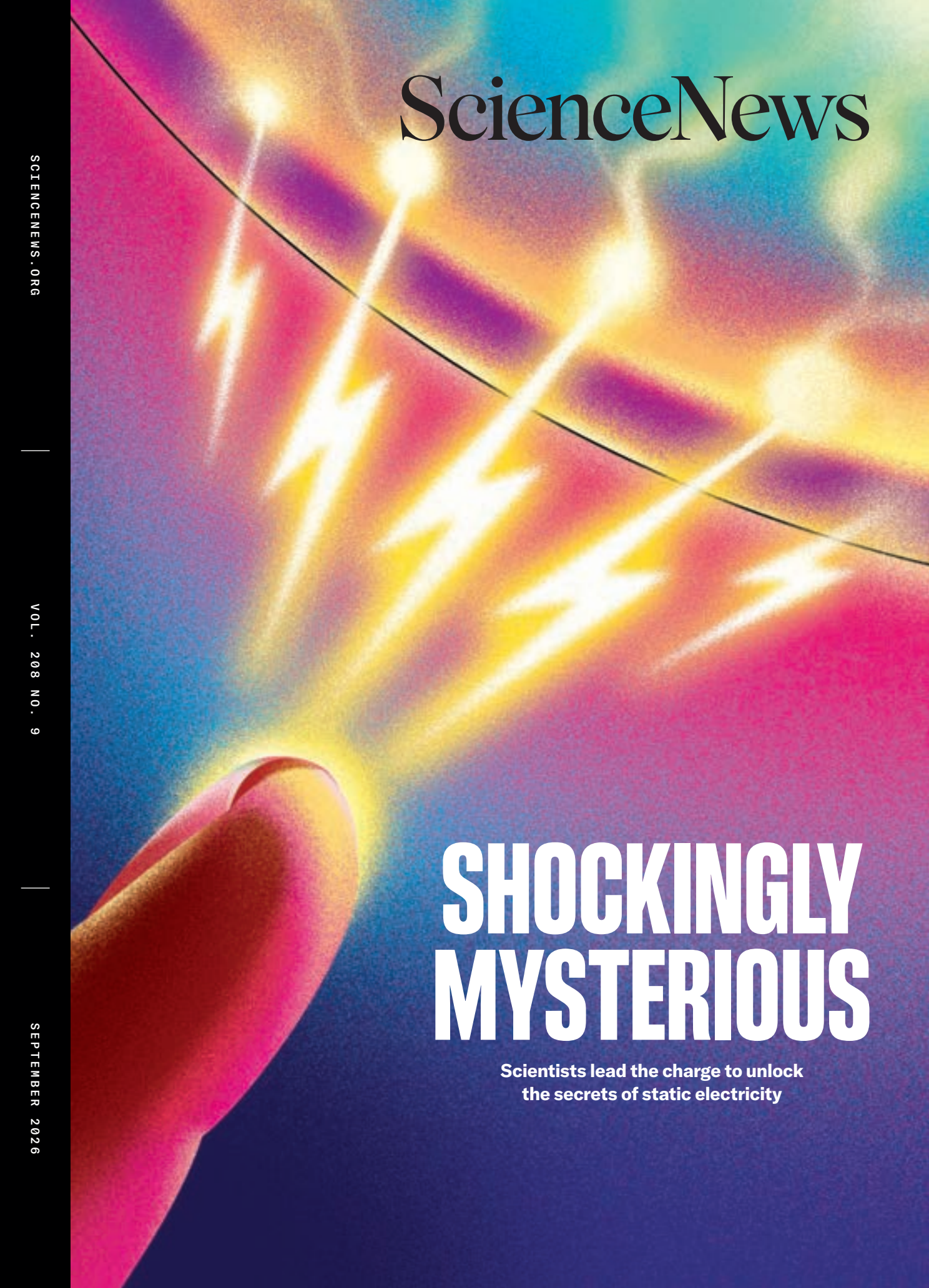




ScienceNews

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SHOCKINGLY MYSTERIOUS

Scientists lead the charge to unlock
the secrets of static electricity



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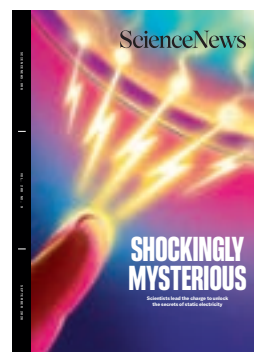
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Illustration by
Simone Noronha



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Scientists have been studying static electricity for centuries, but they're largely clueless about its origins. A quirky group of scientists is aiming to change that. *By Emily Conover*

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Virtually all of us have been infected, but an unlucky few develop lifelong illness. *By Michael Marshall*

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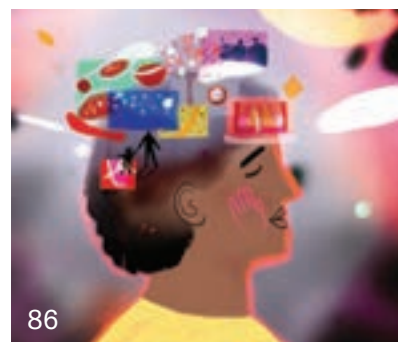
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Mysteries of the commonplace

Static electricity is all around us. Who among us has not experienced a painful zap when touching a doorknob after crossing a carpeted room? And what child has not experienced the thrill, or mortification, of looking like a porcupine after having their head rubbed with a balloon?

Given its ubiquity, you would think that we know all there is to know about static electricity, especially since it can be a hazard for tasks as varied as assembling circuit boards, refueling airplanes or keeping the wheels on a Mars rover turning. But what actually causes electric charge to leap from one object to another remains elusive. Centuries of efforts by scientists have failed to solve its mysteries—but researchers are not admitting defeat.

In June, *Science News*' senior physics writer Emily Conover ventured to a meeting of the Electrostatics Society of America, a hotbed of physicists, chemists and engineers who are fascinated by the complexities of triboelectricity (Page 34). From Conover's reporting, I learned what makes it so hard to identify the workings of static electricity: the vast number of factors that can affect it. This growing realization also makes earlier research look less than reliable. Her reporting reveals the challenges and researchers' dogged efforts to surmount them.

For decades, *Science News* has invested in sending our staff writers to scientific conferences. Being there makes it possible for them to learn about early-stage research and potentially major advances that haven't gone public, and to make connections with scientists that will pay off for years to come.

In this issue, we also explore efforts to understand a common yet elusive virus (Page 42). Almost all people are infected with the Epstein-Barr virus. While many go through life unaffected, the virus can cause serious illnesses, including mononucleosis, certain cancers and multiple sclerosis. Researchers are developing vaccines that could prevent people from contracting the virus in the first place—or stop it from reactivating in people already infected. But taming MS, one of the more debilitating outcomes of infection, remains a challenge. Freelance journalist Michael Marshall reports on new research that reveals just how wily the virus is at evading the human immune system—revelations that could someday help us live with this unwelcome guest while also avoiding its worst behavior.



Nancy E. Shute

Nancy Shute
Editor in Chief

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ANA ELISA SOTELO

VISUAL ARTIST AND EDUCATOR

● ANA ELISA SOTELO first visited Peru's Punta San Juan Reserve, home to one of the largest colonies of Humboldt penguins, in 2012. Then a master's student studying film at American University in Washington, D.C., this native of Peru was captivated by the wildlife and people at the reserve. For her master's thesis, Sotelo produced a documentary about a man working as a guano collector while also trying to protect the reserve's seabirds. When Sotelo heard in early 2023 that bird flu and an El Niño had severely affected the reserve's Humboldt penguin population, she knew she had to document the aftermath (Page 50). "It was really shocking to see how different the place was," Sotelo says. "It made me think about how interconnected everything is on Earth," she adds, "and our impact on this world."



Libby Riddle

Libby Riddle knows a lot about bison. *Science News*' summer intern used to be an environmental educator in Yellowstone National Park. There, she led high school students in monitoring wild bison and collecting poop for dietary analysis. But she hadn't heard of beefalo, a cattle-bison hybrid bred for human consumption, before she encountered a study that argued that beefalo is almost all beef (Page 16). Riddle immediately thought of conservationists' concerns on domestic cattle interbreeding with wild bison. "Conservationists have heated conversations about it because they're worried about keeping bison unique," Riddle says.



Fechi Inyama

Scientists have strived for decades to find proof of life on Mars. When researchers published a study claiming that the Perseverance rover found organic carbon on the planet (Page 15), the *Science News* team knew AAAS Mass Media Fellow Fechi Inyama was the person to cover it. She is a Ph.D. student at MIT studying geobiology, and her past adviser worked on a Mars mission involving Perseverance. Inyama wants to make science accessible while maintaining its accuracy. "I want to find out what makes a story good and become a sharper writer," she says.



Randy Dotinga

Hundreds of clinics in the United States offer shock wave therapy for erectile dysfunction despite a lack of clear evidence of benefits, reports freelance journalist Randy Dotinga (Page 25). Men have tried to combat ED for millennia. And the therapy is yet another popular treatment option that lacks firm scientific backing, says Dotinga, who is working on a book about men's pursuit of virility, tentatively titled *Stiff Competition*. "Men with ED can be quite desperate and are willing to try just about anything," he says, "especially if they don't respond to Viagra-type drugs or are not getting as much response as they want."

LIFE

LOTS OF WAYS TO MAKE A POINT

By Emily Conover

● Spines, spikes, stingers, teeth, claws, beaks, fangs, tusks. Nature's prickly bits come in a wide variety, but they all make the same trade-off: The easier a tool pierces, the more readily it breaks.

Slender, flatter tools pierce most easily; stubbier, rounder ones hold up best. Yet nature hasn't settled on one winning shape, researchers report in *Science Advances*.

The team measured 143 of these spiky sundries, from grizzly bear canines and cactus spines to the "love darts" that mating snails jab into each other. Plotted by shape, the tools scatter (right). Whatever the task—impaling prey, injecting venom, fending off predators—a variety of shapes seem to work. For instance, an elephant tusk and a great white shark tooth function the same but they land in opposite corners.

A computer model hints at a zone of shapes that balance piercing prowess and durability (blue-green). Weight the two differently, and that zone would shift onto tools that look like outliers here. Which shapes perform best, in other words, depends on how you weigh the trade-off. ✕

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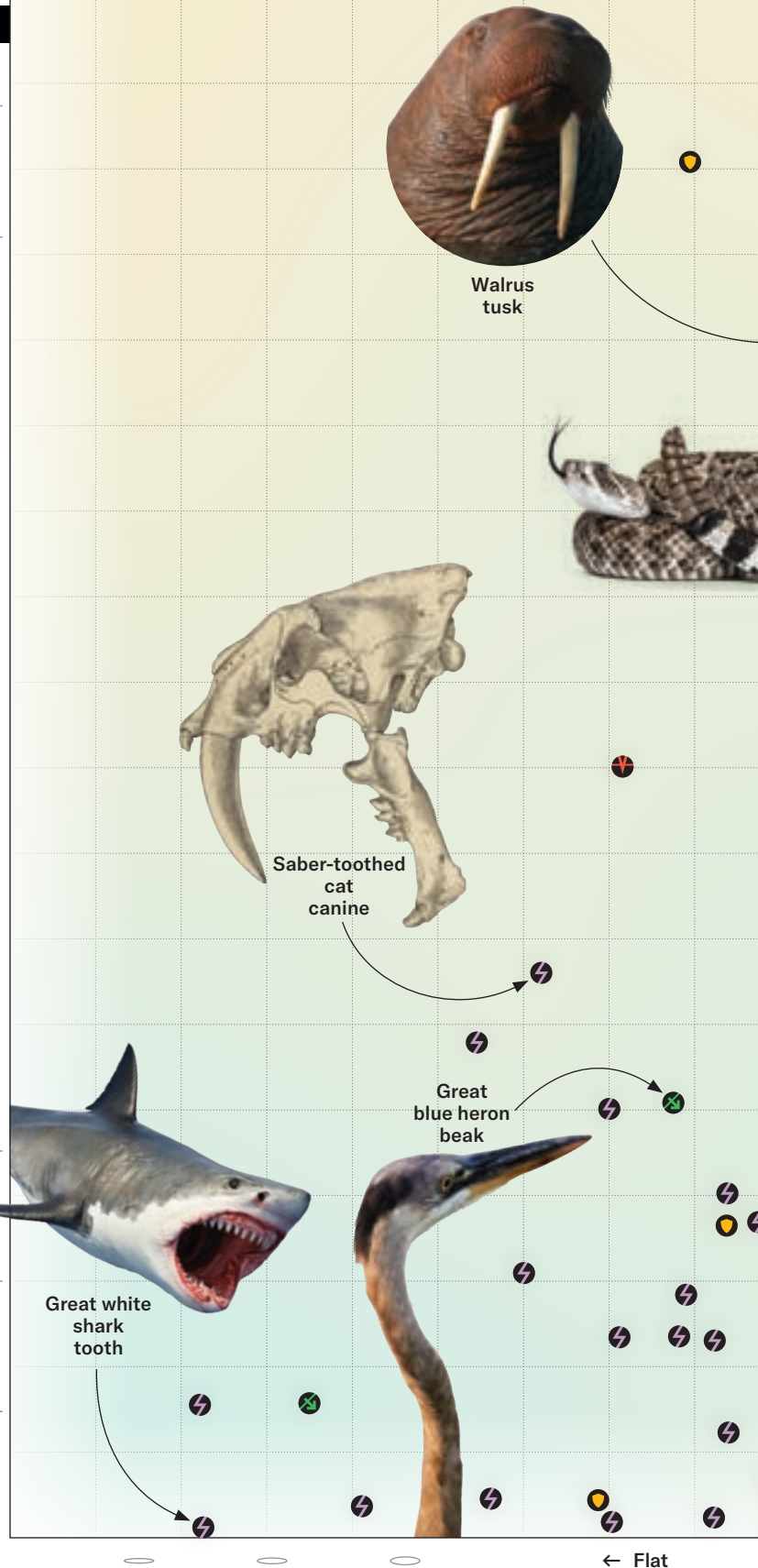
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Slender →

TAPER

← Stubby



← Flat



Four of the 143 measured tools fall outside the chart and are not shown.



Broadcom Coding with Commitment[®] recognizes middle school students who combine STEM learning with coding to solve a community problem they care about that aligns with the 17 Sustainable Development Goals (SDG) of the United Nations. This award is presented at foundation-sponsored science fairs, Raspberry Pi Foundation's Coolest Projects, the Thermo Fisher Scientific Junior Innovators Challenge, and the Regeneron International Science & Engineering Fair.



Inspiring Middle Schoolers Who Act Locally and Think Globally

The *Broadcom Coding with Commitment*[®] award is presented to students with limited access to STEM and coding resources and encourages learning basic coding and AI as essential 21st-century skills. By encouraging students to solve a community problem they care about, they learn about civic engagement and how to act locally while thinking globally.

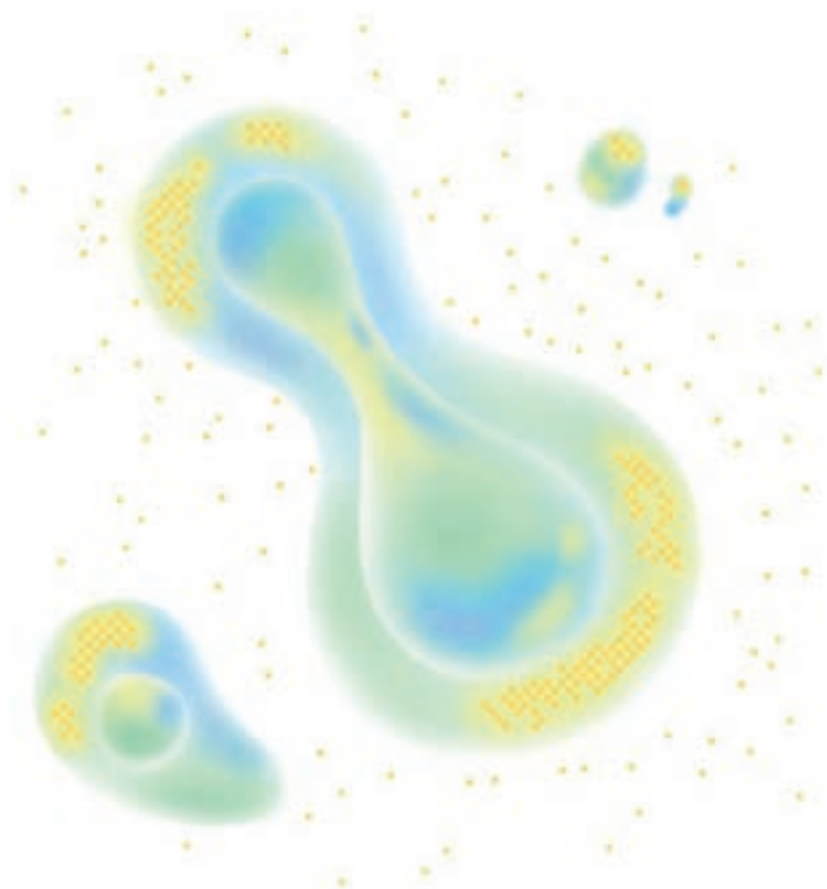
Sriditya N. from Attleboro and Camilla V. from North Attleboro teamed up to win the *Broadcom Coding with Commitment*[®] prize at the 2025 Massachusetts Science & Engineering Fair. Relying exclusively on free online resources like Khan Academy, the Foxborough Regional Charter School students taught themselves to code a Raspberry Pi and apply AI technology to create a prototype of a traffic stoplight system designed to identify missing persons in passing cars, which aligns with SDG #9: Industry, Innovation, and Infrastructure. Sriditya and Camilla demonstrated exceptional command of their subject matter by showcasing each other's contributions to research and design—a true test of teamwork.



Some early vertebrates, like this megalichthyid, came out of their eggs looking like miniature adults. The finding could revise biology textbooks (see Page 20).

News





TECHNOLOGY

Lab-made cells can grow and divide, but they're not alive

By Tina Hesman Saey

● **Kate Adamala has a vision** of the future. In it, biology would replace chemical manufacturing.

"Ultimate success," says the synthetic biologist, would be that "all the atoms we're moving in our economy are moved with biology."

Adamala and her colleagues at the University of Minnesota in Minneapolis announced one step toward that future this summer when the team unveiled SpudCells, synthetic cells that can replicate their DNA and divide multiple times.

Some people have hailed SpudCells as the first synthetic life. Adamala is not one of them. SpudCells are "obviously not living," she says. "They're cells but they're not alive."

SpudCells are little more than spheres of fatty membranes that contain DNA and proteins borrowed from various

viruses and bacteria. Eventually, such synthetic cells may be able to produce chemicals, fuels and drugs such as antibiotics, Adamala says. SpudCells can't do that yet.

Unlike natural living cells, SpudCells aren't self-sufficient. To function, they require researchers to feed them bubbles packed full of protein-building machinery and raw materials. Researchers must also chemically coax SpudCells to "grow" — fuse with the feeder bubbles and take on cargo — and divide.

Both fusion and division depend on proteins encoded by the cells' DNA. That's the innovation that sets SpudCells apart from previous attempts to build cells from scratch, says physicist Tom Robinson of the University of Edinburgh in Scotland. Robinson and others have produced membranes that can divide like cells, while other groups have gotten DNA to replicate within artificial cells. But linking the two so that DNA controls growth and division has not been accomplished before, he says.

Robinson wasn't involved in this work but he has joined Biotic, an international nonprofit research coalition led by Adamala and three other scientists. "We've pushed this technology as far as a single lab can push it alone," Adamala says. "We need collaborators to add their expertise to it."

Biotic, short for Biology is Open Technology Inspiring Civilization Inc., will coordinate and finance research aimed at turning SpudCells into independent cells. It will also standardize protocols and methods used to build synthetic cells.

➤ Scientists have created a cell that can replicate its own DNA and divide. Dubbed SpudCell, it shows what's possible for synthetic life.

“We’re quite far from a working synthetic cell,” Robinson says, “but we’re on the way.”

There are many steps before SpudCells can work independently. For one, the cells can’t make their own ribosomes, cellular factories that manufacture proteins. That may be the hardest part of building a cell from the bottom up, Adamala says.

Ribosomes are complex machines that are composed of more than 50 proteins and three or four pieces of ribosomal RNA. They must read instructions in the form of messenger RNA and interact

with other types of RNA as well as amino acids to build proteins. Assembling the complex structures costs natural cells huge amounts of energy, says biophysicist Jamie Williamson of the Scripps Research Institute in La Jolla, Calif. “In bacteria, about one-third of the ribosomes are actually making parts of [other] ribosomes so the cells can divide,” Williamson says. “It’s a tall order for a protocell to take on this task.”

No one has yet succeeded in making working ribosomes from scratch. “It requires — all of biology requires — such high precision,” says developmental biologist Douglas Blackiston of Tufts University in Medford, Mass. “Errors very, very quickly become catastrophic.”

Natural cells have many layers of quality control to correct errors that synthetic systems usually lack. If bioengineers one day manage to build ribosomes, they will also need to assemble cellular maintenance crews to keep the machines running smoothly, Blackiston says.

Natural cells’ systems are so intertwined that humans trying to build synthetic cells have been hard-pressed to mimic them. “It seems like the more that we try to micromanage them, the worse we get at it,” Blackiston says.

A cleanup system to recognize and degrade worn-out or damaged proteins is on Adamala’s must-have parts list for future iterations of SpudCells. So is a cytoskeleton — internal scaffolding that helps cells organize their insides, maintain their shapes, move cargo and divvy up DNA when dividing. That’s important for inheritance.

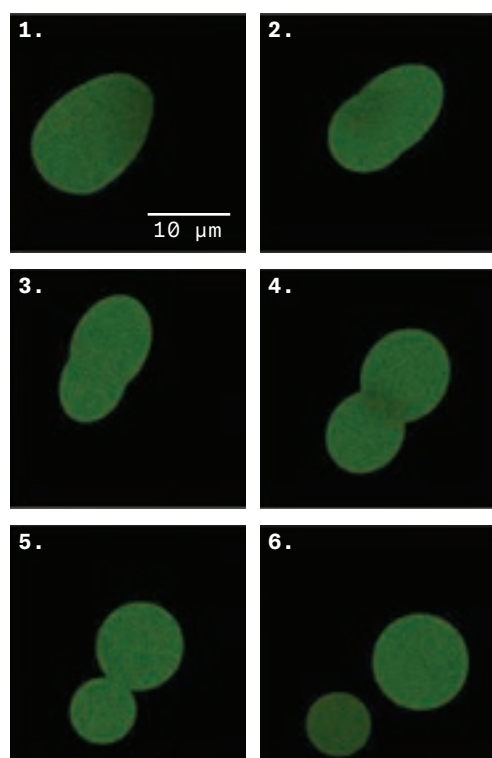
SpudCells’ genome is divided into seven circles of DNA. For the cells to function properly they need to inherit at least one copy of each circle. Without a cytoskeleton to guide division, only about 30 percent of SpudCells inherited the full seven-piece genome after five generations, Adamala and colleagues reported in the manuscript announcing their achievement, which they also posted at bioRxiv.org. The work has yet to undergo peer review.

SpudCells’ insides are a mess, too. When the synthetic cells fuse with feeder bubbles, “everything just kind of goes in and mixes itself at will. We need to fix that,” Adamala says. “We cannot have this gumbo.”

She has big plans for SpudCells — named to evoke the pioneering Sputnik satellite — over the next 18 months, starting with organizing a meeting of scientists who want to join Biotic. The coalition is just one of several groups scattered across the United Kingdom, Europe, Asia and elsewhere that are attempting to build synthetic cells from scratch. Many of those efforts use the same tools that helped build SpudCells.

“The work’s not done,” Adamala says. “This is not an announcement that’s like a mic drop. ‘We’ve done it. We’re going home.’ This is an announcement that says we’ve shown what’s possible.” ✕

THE GREAT DIVIDE



A SpudCell undergoes cell division in this series of microscope images. The synthetic cell is the first of its kind to complete a full cell cycle, scientists say.

HEALTH & MEDICINE

MANY U.S. TEENS UNDERESTIMATE FENTANYL'S LETHALITY

By Aimee Cunningham

● The powerful synthetic opioid fentanyl can kill with one use. Yet a sizable percentage of adolescents in the United States aren't aware of this danger.

A majority of eighth graders and roughly a third of 10th- and 12th-graders do not see a great risk with using fentanyl once or twice, researchers report in *JAMA Network Open*. Drug poisonings and overdoses rank third among the leading causes of death for kids and teens.

The data come from the 2025 results of the Monitoring the Future study, an annual survey of U.S. middle school and high school students. For the first time, the survey asked about how risky fentanyl is. Among close to 4,000 student respondents, 48 percent of eighth graders, 64 percent of 10th-graders and 70 percent of 12th-graders responded that there is great risk with using fentanyl once or twice.

Those who responded that fentanyl posed a great risk grew when asked about more frequent use. But while the concept of increasing risk with rising use applies to some substances, such as alcohol, tobacco and marijuana, it's not the right framing for fentanyl, which can be fatal with one exposure. The research suggests that many adolescents aren't aware of the dangers of fentanyl and other opioids, the study authors note. ✕

48

The percentage of U.S. eighth graders who see a great risk using fentanyl once or twice



ANTHROPOLOGY

'Hobbits' likely scavenged Komodo dragons' kills

By Jake Buehler

● Long ago on the Indonesian island of Flores, Komodo dragons ripped into cow-sized elephant kin, stripping flesh from their bones. Only after the lizards had their fill did petite human relatives pick at the leftovers.

That conclusion, based on a bone analysis reported in *Science Advances*, challenges scientists' perception of *Homo floresiensis* as big game hunters. *H. floresiensis*—one-meter-tall hominids nicknamed “hobbits” that disappeared around 50,000 years ago—was first described more than 20 years ago. Purported cut marks on the bones of now-extinct, miniaturized elephant relative *Stegodon florensis insularis* and charred remains of other animals found near hobbit remains led some researchers to propose that the hominids had complex behaviors surprising for their small brain size: killing large prey and controlling fire. But scientists hadn't yet done a systematic analysis of the bones to help confirm this idea.

The new study suggests the island's small-statured residents didn't hunt big game after all but instead scavenged some of their food. If so, that raises questions about *H. floresiensis*' evolution and level of sophistication.

CONT. ON PAGE 16

PLANETARY SCIENCE

ROCK-HOUND ROVER SNIFFS OUT HINTS OF ANCIENT LIFE ON MARS

BY FECHI INYAMA

Perseverance strikes again with an intriguing—yet unresolved—clue in the search for past life on Mars. The NASA rover detected complex organic carbon within and on rocks in an ancient river channel, planetary scientist Ashley Murphy and colleagues report in *Science Advances*. One of those detections is the first of its kind to be found on a rock the rover hadn't drilled into. Combined with previous data from Perseverance, the finding adds context to a potential signature of long-ago microbial processes on Mars, says Murphy, of the Planetary Science Institute in Tucson, Ariz.

Perseverance initially examined the site in 2024 and found organic-rich “leopard spots.” These spots sparked wide interest because they bore similarities to features on Earth known to typically be associated with ancient microbial life—namely the spots’ rims, which contain iron phosphate.

The newly described organic carbon detections are from the same examination, but done using an instrument called SHERLOC, which characterized the carbon in the rocks.

SHERLOC measured four targets across three rocks featuring the leopard spots at Bright Angel, a rock formation in the dried-up river. It revealed that organic carbon is mixed in with silicate-rich sediment and carbonate and sulfate minerals, suggesting the carbon first appeared as the sediment accumulated and again later as water moved through the rock, forming minerals. These data, however, cannot reveal the organic carbon’s origin, Murphy says.

Planetary scientist Paul Byrne of Washington University in St. Louis says the organic carbon “could be from meteorites or cosmic dust; [nonbiological] processes like hydrothermal reactions; or they could be biological in nature.”

Still, the new finding could have

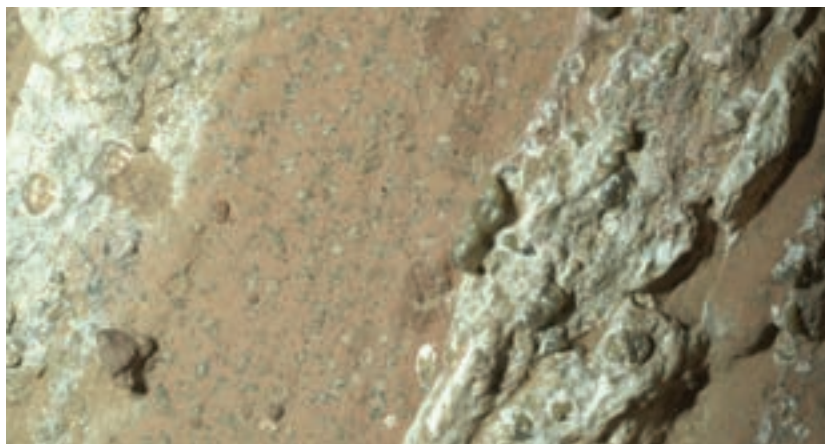
implications in the search for ancient microbial Martians. In 2014, a different rover detected organics at Gale crater, some 3,500 kilometers away. If life ever existed on Mars, it may have been widespread, Murphy and colleagues write.

Determining whether Perseverance’s samples contain signs of ancient life would require bringing them to Earth for analysis. The rover doesn’t have the instruments that can narrow down the possible origins of the organic carbon. Perseverance has cached 30 samples so far for possible return to Earth, including a rock core dubbed Sapphire Canyon that contains the organic carbon. But federal budget cuts and shifting priorities have complicated plans for bringing the Martian samples home.

Any knowledge gleaned from these samples is worth pursuing, Byrne says. If laboratory analyses reveal that the molecules formed without biology, that would enhance scientists’ understanding of how complex organic chemistry can function sans life.

“Or perhaps we’ll find ... that these compounds were produced by alien biology,” Byrne says. “That possibility is worth bringing these samples back to Earth.” ✕

Leopard-spotted rocks (shown) aren't the only potential signs of ancient life that NASA's Perseverance rover found on Mars in 2024. The rover also detected organic carbon on other rocks, scientists report. ↓



CONT. FROM PAGE 14 Elizabeth Grace Veatch, a paleoanthropologist at the National Museum of Natural History in Washington, D.C., and colleagues analyzed over 3,000 fragments of ancient *Stegodon* bones from Liang Bua cave on Flores island dating from 190,000 to 50,000 years ago. The researchers also fed a goat to a live Komodo dragon and analyzed the shape of tooth marks left behind on the bones using 3-D imaging. The marks on the *Stegodon* bones and goat bones were similar and didn't look like cuts made by humans' stone tools. There were also no impact marks on the ancient bones from spear tips.

Komodo dragons were the ones butchering *Stegodons*, not the island's diminutive hominids, the team concludes. Instead, any meat *H. floresiensis* ate probably was leftovers and eaten raw. All of the ancient animal bones associated with the hobbits showed no signs of having been exposed to fire, Veatch and colleagues found.

"Komodo dragons typically consume nearly all edible soft tissues of their prey, sometimes leaving as little as around 12 percent of the carcass," says vertebrate paleontologist Mika Rizki Puspaningrum, of the Bandung Institute of Technology in Indonesia. Most of this is skin, bones and some internal organs. "This raises an interesting question about how much edible meat would actually have remained available for *Homo floresiensis* to exploit," she says.

If the hobbits weren't killing big prey and making fires, then they may have evolved from a species that also hadn't developed those skills, adding another question mark to the ever-changing picture of early human evolution. ✕

**AGRICULTURE**

Most beefalo are all beef, no –alo, DNA tests suggest

By Libby Riddle

● **People will spend \$100** to learn about their genetic ancestry. Some pay even more to learn about their dog's genes. But how many have questioned the genetic ancestry of their steak?

The ancestry of the beefalo breed is its main selling point. Thanks to its unique mix of bison and cattle DNA, this hybrid breed is said to be hardier and more resistant to disease and to produce more tender, higher-protein meat than conventional beef. But an analysis of the earliest beefalo individuals turned



up little to no bison DNA, researchers report in *eLife*.

“It was a surprise to us to discover that most of the beefalo individuals we sequenced did not have detectable bison ancestry,” says Beth Shapiro, an evolutionary biologist at the University of California, Santa Cruz.

Shapiro and colleagues study the genomes of species known to produce hybrids, including bison and cattle, and wondered if beefalo’s bison ancestry had been lost in the 50 years since they were first bred. In the first genome-wide analysis of the breed, the team analyzed

↪ Beefalo, a hybrid breed prized for its mix of cattle and bison ancestry, may contain little to no bison DNA.

preserved semen samples from 47 animals. Most of the samples belonged to beefalo that lived in the 1970s and ’80s, including several that came from the original herd, which was established in the early 1970s.

Thirty-nine of the animals had no bison ancestry. The eight beefalo with any bison DNA still had less than the breed standard, defined by the American Beefalo Association as three-eighths bison ancestry.

The ABA disputes these results. The association’s president, Dan Stricker, says that the ancestry of all “full-blood” beefalo in its registry is confirmed through DNA tests conducted by the University of California, Davis and Neogen Genomics in Edmonton, Canada.

“We have serious concerns that the samples used in Dr. Shapiro’s study do not accurately represent modern, registered beefalo that have been selectively bred for bison traits over many generations,” Stricker says.

The researchers acknowledge that they sampled few present-day beefalo, instead choosing to focus on the breed’s founding individuals. But study coauthor Jonas Oppenheimer, an evolutionary biologist now at the Centre for Palaeogenetics in Stockholm, says it’s unlikely that present-day individuals contain more bison ancestry than the founders. That’s because, although interbreeding between bison and cattle is possible, it’s biologically difficult, Shapiro and Oppenheimer say. Throughout the 1900s, breeders attempted to establish stable populations of bison-cattle hybrids. All these efforts failed, including, it seems, beefalo. (The original breeder of beefalo did not disclose how he interbred.)

While beefalo may contain little bison ancestry, most wild bison have some amount of cattle genes from suspected interbreeding. Conservationists worry that this mixed ancestry could compromise bison’s wild behaviors, disease resistance and even their legal protections.

But Shapiro and Oppenheimer’s results — and their broader work on cattle-bison hybrids — suggest these concerns may be premature. “While there clearly has been some gene flow between the two species since cattle were brought to North America,” Shapiro says, “it has been far less frequent and far less consequential than previously believed.” ✕

NEUROSCIENCE

MOUSE BRAINS BREAK AND REPAIR DNA TO GROW

BY MICHAEL HOWERTON

Healthy brains may be built through a process of controlled damage and rapid repair.

The most dangerous type of DNA damage is a regular feature of healthy early brain development, experiments in mice show. As newborn neurons squeeze through the cramped, narrow spaces of developing brain tissue, the cells break both strands of their DNA, researchers report in *Nature*. The breaks are repaired once neurons reach their destination, usually within a day.

It's a paradox of vulnerability and resilience. Newborn neurons routinely sustain a kind of damage that can kill other cells, yet they repair it and emerge intact.

The speed of the repair surprised the researchers. "Somehow neurons can repair [the damage] very quickly without any sign of mutations or bad effect," says neurobiologist Mineko Kengaku of Kyoto University in Japan. "It seems to be a normal developmental event."

The breaks mostly appear in noncrucial areas of the genome where there is lower risk of causing lasting damage. "It is surprising that, during evolution, the mammalian brain acquires such a clever strategy," Kengaku says.

More research is needed to understand the implications beyond mice, but Kengaku says the effect might be even more pronounced in humans. "During development, neurons have to migrate, and if the brain size is larger, then neurons have to migrate longer distances," she says. "Neurons in human brains probably generate more DNA damage" than in mice.

A flawless break-and-repair cycle is not always guaranteed, Kengaku says. If the cycle fails or is incomplete, then the DNA damage could persist. In most cases, the resulting mutations probably do not do anything, Kengaku says. But the accumulation of damage over time could impact the risk of developing disease.

To test the effects of such an interruption, the researchers engineered mice to lack a crucial DNA repair protein from the neuronal migration process. Double-strand breaks built up in the part of the brain related to movement, and affected mice gradually developed difficulty with motor skills later in life.

The work shows how unrepaired DNA damage can "result in long-term functional changes reflective of neurodegenerative diseases," says biomedical engineer Jan Lammerding of Cornell University.

Neuro-oncologist Soma Sengupta of Tufts Medical Center in Boston says the study is "a major conceptual advance." Unlike DNA damage seen in cancer or radiation injury, she says, "these breaks do not trigger widespread cell death [and] are repaired efficiently."

The findings raise questions about whether unrepaired DNA damage could also play a role in brain tumors. "Many pediatric brain tumors arise in cells undergoing migration and differentiation," Sengupta says. "Rare misrepair events during normal development could contribute to oncogenic mutations in susceptible cells." ✕

In growing mouse brains, migrating newborn brain cells snap their DNA double helix then repair the damage once they reach their destination. ↓





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PALEONTOLOGY

The first landlubbers didn't need metamorphosis

By Jay Bennett

● **New fossil evidence** is overturning a long-held assumption about how vertebrates first transitioned from water to land.

The hatchlings of three different animals related to the earliest land-goers show that the animals did not go through an amphibian-like metamorphosis, researchers report in *Science*. “They came out of the egg looking like the adult,” says paleontologist Jason Pardo of the Field Museum in Chicago.

The transition to land drove the evolution of tetrapods, the group of four-limbed animals that includes all reptiles, amphibians, birds and mammals. Scientists have historically thought that the first vertebrates to venture onto land underwent metamorphosis from a larval form during their development. In modern amphibians, this rapid transition from hatchling to adult often involves losing external gills and tail fins and gaining expanding lungs and new limbs as the animals move from an aquatic life to a partly terrestrial one.

“We kind of assume that this metamorphosis is ancestral to all terrestrial vertebrates,” says Laura Porro, an evolutionary

biologist at University College London. “And this pretty conclusively shows that it’s not.”

Pardo and Arjan Mann, also of the Field Museum, investigated roughly 308-million-year-old fossils of newborn tetrapods unearthed in Illinois. The researchers used a scanning electron microscope to study the exceptionally preserved fossils, which include soft tissues. The fossilized hatchlings show developing bones and lack external gills, signs that they were not in an amphibian-like larval stage.

The earliest known tetrapod relatives that could crawl on land lived about 375 million years ago, and fossilized tracks provide evidence of even earlier land expeditions. Although the animals in the new study lived millions of years later, they are late-surviving examples of older lineages. That suggests their forebears also grew without a rapid change via metamorphosis.

One animal, an embolomere,

Early land vertebrates were born looking like smaller versions of their parents, as this illustration of embolomeres shows. ↓



spent most of its time in water, though short legs allowed it to crawl onto land. Embolomeres “are kind of like a cross between a crocodile and an eel,” Pardo says.

The researchers analyzed two embolomere fossils, each about a centimeter or two long. One still had an internal yolk sac, a pocket of nutrients that the newborn survived on until it could start eating food. “The fact they still have a yolk sac suggests that these are very, very young animals,” Porro says.

Skeletal evidence suggests that adult embolomeres probably had lungs for gulping air and possibly had bony structures to support internal gills. It is not clear whether the hatchlings used lungs to breathe air or relied on internal gills to breathe in the water until they grew bigger and required more oxygen.

The other animals were a megalichthyid, a fishlike creature that had some of the skeletal features of later tetrapods, and an aistopod, which looked like a snake but was actually a tetrapod that lost its limbs. Both probably had lungs, while megalichthyids possessed internal gills as well. Aistopods may have also had internal gills and may have been able to breathe through their skin.

Together, these three animals represent early tetrapod development. “I think what makes the case so strong is it’s got those three different groups,” Porro says.

There are still many unanswered questions about how vertebrates set out on land. But with new evidence that they didn’t need metamorphosis to do it, a clearer picture has emerged of the first steps in the sand.

“I think that’s going to be written into future textbooks,” Porro says. ✖

PLANETARY SCIENCE

MEET THE MILKY WAY GALAXY'S PUFFIEST PLANETS

BY LISA GROSSMAN

A pair of newly discovered planets are the puffiest worlds ever seen. The orbs are each about the size of Jupiter but have less than 6 percent of its mass, astronomers report in *Monthly Notices of the Royal Astronomical Society*.

“We liken it in density to something like candy floss or shaving foam,” says astrophysicist George Dransfield of the University of Oxford. “They’re the lightest planets that are Jupiter-sized.”

Both planets orbit TOI 791, a sunlike star about 1,113 light-years from Earth. The planet-hunting TESS space telescope spotted the planets as they passed, or transited, in front of their host star and blocked some of its light. Comparing the blocked star to the unblocked star let Dransfield and colleagues measure the planets’ radii: 0.993 and 1.155 times that of Jupiter.

To find out how dense the planets are, the team needed to know both their size and mass. But transits only give the size. That’s where the planets’ orbits come in. They are configured in such a way that the planets periodically pass by one another, giving each other a little gravitational tug. The team monitored the planetary pas de deux over several years using a telescope called ASTEP, and then measured the masses of the planets by how much they kick each other’s orbits.

Those measurements let the team deduce the planets’ masses: 9.5 and 18.6 times that of Earth. (Jupiter has 318 times Earth’s mass.) That means their densities are 0.038 and 0.047 grams per cubic centimeter. For comparison, cotton candy’s density is typically about 0.05 grams per cubic centimeter.

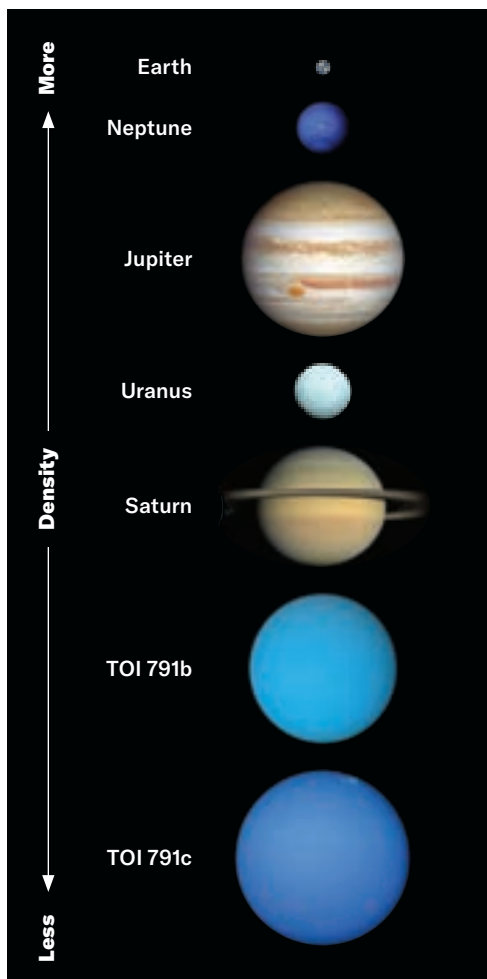
The new planets join a small cadre of large but light worlds known as superpuffs. Astronomers aren’t sure how they form. The planets might be born far from their star and migrate toward it, their atmospheres heating and puffing up as they go.

The host star is spinning quickly, which could be a sign that it’s relatively young, says theoretical astrophysicist Anthony Piro. If that’s the case, then these superpuffs might still be cooling off and could contract as they get older. “We might be catching these planets at an intermediate stage,” says Piro, of the Carnegie Observatories in Pasadena, **CONT. ON PAGE 22**

CONT. FROM PAGE 21 Calif. The next step is to use the James Webb Space Telescope to probe the planets' composition, which could reveal more about their origins.

"Finding things like superpuffs, which are incredibly rare, means we can learn more about how planets form, how planets evolve and what outcomes are possible," Dransfield says. ✕

WHO'S THE PUFFIEST?



TOI 791b and TOI 791c, two newfound planets that orbit a distant star, are roughly as large as Jupiter but substantially less dense. Nothing like them exists in our solar system.



PHYSICS

Science explains why plugged-in pickles glow

By Emily Conover

● Here's what happens when you plug in a pickle.

At an otherwise formal meeting of the Electrostatics Society of America, electrical engineer Joshua Méndez Harper pulled out a jar of pickles, a power strip and some electrodes. "I'm hoping we will not have the fire alarm go off," he said.

He skewered each end of a pickle with an electrode and flipped the switch. The pickle sizzled in protest, then glowed bright orange at one end. It's a decades-old scientific parlor trick, and now Méndez Harper's group at Portland State University in Oregon may have figured out what the dill is.

Pickles are typically soaked in a salty brine. Since saltwater consists of ions — electrically charged atoms — pickles are able to conduct electricity. But the glow's cause is debated. One idea is that pickle juice boils at the electrode, creating a pocket of vapor that blocks current flow, causing sparks to fly across the gap. Another idea involves electrolysis, a process through which an electric current breaks water into a mixture

↑ Pickles glow orange at one end when plugged in. Now researchers may know why.



of hydrogen and oxygen. That mixture is explosive, so heat from the electrode might trigger small, luminous blasts. Either of these effects could cause an orange glow, because the sodium ions in saltwater release orange light when they get excited.

Méndez Harper and colleagues outfitted a pickle with monitoring equipment in their laboratory, including a high-speed camera and hydrogen sensor. Then they zapped it with either alternating or direct current. (Méndez Harper is a professional — don't try this at home.) Alternating current is the type from a wall socket, in which the charge flow switches directions periodically, whereas direct current is a steady flow.

Hydrogen was produced in both cases, indicating that some electrolysis does take place. But puzzlingly, the glow appeared only with alternating current. That suggested the mechanism actually involves both effects at once, Méndez Harper said.

The oscillating nature of alternating current might help keep the vapor pocket open, allowing sparks to form that ignite the hydrogen and oxygen, Méndez Harper explained. Direct current, he proposed, could make the vapor pocket unstable, so that it collapses, producing hydrogen but no sparks, and therefore no ignition and no glow.

The team also wanted to answer why only one side of the pickle glows. That was less complicated: It's the juicier side. A pickle placed vertically always glows on its bottom end, where brine collects, the team found.

After the demo, the pickle went in the trash. Taste tests weren't on the menu. ✕

ARCHAEOLOGY

WE'VE HAD FIRE FOR FAR LONGER THAN WE THOUGHT

By Tom Metcalfe

● Early human ancestors were regularly using fire for about 800,000 years longer than previously thought. The claim, reported in *PLOS One*, rests on 1.8-million-year-old traces of burnt owl pellets from a South African cave that *Homo erectus* individuals called home at that time.

Until now, the earliest evidence of hominid fire use was from the same cave, called Wonderwerk. The new evidence comes from an earlier and deeper level of sediment, says study coauthor Michael Chazan, an archaeologist at the University of Toronto.

Borrowing a forensic science method for detecting burned bones, Chazan's team turned up charred bits of rodent bones that had probably been coughed up by barn owls. The birds took shelter in the cave throughout its period of ancient human occupation, Chazan says, and the bones were burned when fires were built on the pellet-strewn floor.

Chazan notes that *H. erectus* may have brought fire to the cave from local wildfire sites, since archaeological evidence suggests nobody knew how to ignite fire until about 400,000 years ago. ✕



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THE HEALTH CHECKUP

THE VIAGRA CROWD TURNS TO SOUND WAVES

BY RANDY DOTINGA



Some men in the United States are seeking relief for erectile dysfunction aren't getting prescriptions for Viagra. Instead, they're flocking to health clinics to subject their private parts to low-energy sound waves. The treatment, called shock wave therapy, is controversial. But if it delivers on its promise to improve erections by boosting blood flow in the penis, then it could help the millions of people whose ED is caused by vascular problems.

Leading physician groups don't support shock wave therapy for ED because evidence of long-term benefits is spotty. Though it isn't approved by the U.S. Food and Drug Administration, men's health providers regularly offer the treatment along with testosterone supplementation and medication, says James Weinberger, a urological surgeon in Beverly Hills, Calif. At least 152 clinics across eight of the largest metro areas in the United States offer the therapy, Weinberger and colleagues reported in 2022. "That certainly undercounts what exists today," he says.

While ED can occur at any age and be caused by certain medications, anxiety and other nonvascular factors, shock wave therapy aims to address damaged blood flow. "Think of erectile tissue like a sponge," Weinberger says. "When healthy, it fills with blood easily and holds it under pressure." In men with vascular risk factors like diabetes, high blood pressure or high cholesterol, the tissue can become scarred and less able to hold blood. Demand for a fix is high: An analysis of 2021 survey data found that 24.2 percent of U.S. men who responded experienced symptoms consistent with ED.

Shock wave therapy via high-energy sound waves has been used for decades to shatter kidney stones. In 2010, doctors hoping to find other applications ran a trial of low-intensity sound waves in 20 middle-aged men with ED. Six months out from the treatment, half of the men improved enough to engage in penetrative sex without the aid of Viagra-type drugs.

Unlike in kidney stone therapy, "the goal is not to destroy anything," Weinberger says, but instead to promote healing. In the procedure, a clinician uses a chunky wandlike device on several areas of the penis for 15 to 20 minutes. The device makes a snapping sound, but patients

shouldn't feel any pain. "The energy creates microscopic mechanical stresses at the cellular level," triggering the body to heal itself, says urologist Taylor Kohn of Baylor College of Medicine in Houston. In general, patients come in for six to 12 treatments that may cost several hundred dollars each.

The benefit may be hard to detect. Researchers at the Cochrane Library, a leading reviewer of medical evidence, analyzed 21 studies on the technique. They found that it might have a small effect on function in initial months, with potential long-term benefit. But variability in the studies shook the review authors' confidence. A 2026 report in *Sexual Medicine Reviews* found that shock wave studies tended to be small and varied in session count, making them hard to compare. Still, none reported evidence of harm. Most side effects in trials are skin reactions to the gel used, Kohn says.

Weinberger warns against choosing the wrong clinician. At the 152 clinics his team identified, only 25 percent of providers offering shock wave therapy for ED were urologists. It matters who provides the therapy, Weinberger says, since treatment should include conversations about hormones and medications. Stand-alone ED clinics may not offer comprehensive care.

The American Urological Association and the Sexual Medicine Society of North America say evidence isn't strong enough to warrant the treatment's use outside clinical trials. Researchers, including Kohn, "are actively pursuing many avenues to regenerate the tissue within the penis," he says. For many men, this kind of progress can't come soon enough. ✖

ANIMALS

INSECTS HAVE BEEN VASTLY UNDERCOUNTED

By Erin Garcia de Jesús

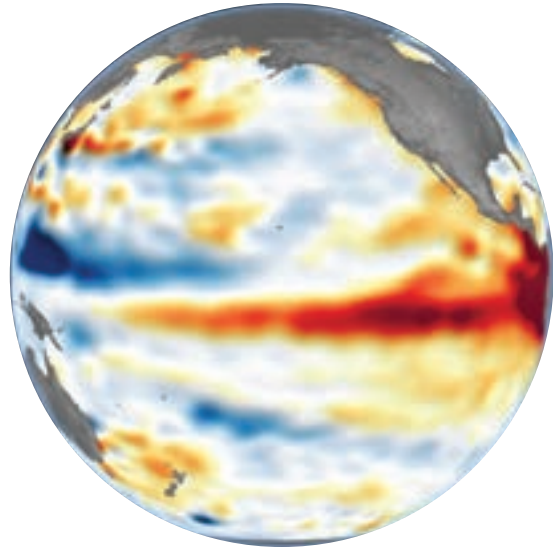
● At least 14 million to 20 million insect species buzz or crawl around Earth, according to a new estimate.

That's double or triple other recent estimates, which peg the count at around 6 million, researchers report in the *Proceedings of the National Academy of Sciences*. Just one million or so species have been officially named and described.

Entomologist Laura Melissa Guzman of Cornell University and colleagues analyzed the DNA of over 1.6 million insects across roughly 54,000 species collected from Área de Conservación Guanacaste in Costa Rica. The team focused on a diverse but understudied subset: more than 21,000 parasitoid wasps (one shown below) across 1,414 species.

That wasp census allowed the team to calculate how many species might have been missed in the sample. Overall, roughly 2,400 parasitoid wasp species may call the protected area home, as well as over 300,000 species of other types of insects. From there, the researchers upscaled their figures to determine the global number.

"It's humbling how much we don't know," Guzman says. "And how much we have left to know." ✕



CLIMATE

Can geoengineering blunt El Niño's fury?

By Carolyn Gramling

● There might be a way to geoengineer El Niño so that it wreaks less havoc, scientists say.

Adding aerosols to the atmosphere over a particular patch of the Pacific Ocean can brighten clouds in the region, creating a cooling effect. New computer simulations show this can trigger atmospheric changes that might reduce the strength of an El Niño event — and the weather extremes that come along with it, researchers report in *Science Advances*.

The idea was sparked by fires, says Jessica Wan, a climate scientist now at the University of Chicago. In the aftermath of the 2019–2020 Australian wildfires, huge billows of particles rose into the atmosphere and then wafted over the southeastern subtropical Pacific Ocean. Those particles brightened the clouds over the ocean, and that brightening helped trigger a multiyear La Niña, a phenomenon that can bring cooler temperatures and fewer extreme weather events.

This "opportunistic experiment" demonstrated how cloud modification in a particular region can alter large climate patterns, says Wan, who did the research while at the Scripps Institution of Oceanography in La Jolla, Calif.

Wan and colleagues wondered if it would be possible to geoengineer a similar effect to mitigate the impacts of El Niño, the “warm” phase of a yearslong climate pattern known as the El Niño–Southern Oscillation. El Niño events are brief, typically lasting less than a year, but can be deadly and costly. Past strong El Niños have brought heat waves on land and in the ocean and drenched some parts of the world with torrential rains and floods while baking others and contributing to severe drought.

Adding aerosols to beef up clouds in the eastern subtropical Pacific would be a targeted version of a kind of climate geoengineering called marine cloud brightening, or MCB. MCB proposes that injecting certain aerosols such as sea salts into the atmosphere could brighten the ocean’s cloudiest regions, making the clouds whiter and more reflective, which would send more of the sun’s radiation back into space to help cool the planet.

The researchers first simulated how and where the smoke brightened clouds over the southeastern Pacific Ocean in 2020. Then, they zoomed in on a patch especially susceptible to brightening and cranked up the simulated smoke particles. They tested this strategy on strong El Niño events in 1997–1998 and 2015–2016.

“We wanted to try to go full hammer to see what happens,” Wan says. The team simulated a massive injection concentration of about 500 particles per cubic centimeter. It also varied the timing of the cloud boost to see what happens if the injections occur at the start of an El Niño or near its peak, as well as the length of injections.

All of the injections made the simulated El Niños weaker than the actual events. But just how much depended on timing. For the 2015–2016 event, injections from June through February led to the strongest cooling. Starting injections in December—essentially at the 11th hour—led to less cooling. By that time, the El Niño dynamics were probably well under way and any cooling was more localized, the team suggests.

Using MCB to target large El Niños “is really interesting and very new,” says Daniele Visoni, a climate scientist at Cornell University. “It is something worth thinking about.”

Earth entered its most recent El Niño phase in June. Computer simulations suggest it could be a “super” El Niño. But MCB isn’t going to be used

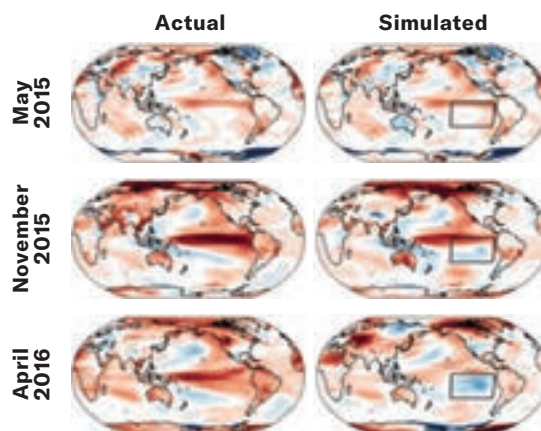
in the near future, Wan says. There are big hurdles, including engineering constraints and sociological barriers, such as who should decide if potential positives outweigh potential negatives.

Many researchers remain leery about tinkering with the climate. “There are many, many unanswered questions and uncertainties as to the viability of MCB,” says climate scientist James Haywood of the University of Exeter in England. Previous research by Haywood and colleagues found that cooling the eastern Pacific might produce a “mega La Niña,” he says.

The impacts of El Niño and La Niña are different for different parts of the planet, Wan says, and not everyone suffers or benefits from either.

Visoni agrees. “This is in no way the final answer,” he says. “But it’s important to have these kinds of studies that keep the door open.” ✕

TURNING DOWN EL NIÑO’S HEAT



In simulations, brightening clouds by injecting aerosols over a part of the Pacific Ocean (boxed regions, right) changed the outcome of the 2015–2016 El Niño. By April 2016, sea surface temperatures were significantly cooler in the simulation (right) compared with the real-world conditions (left).

Q&A

CYBERSECURITY BREACHES UNDERScore AI'S RISK

BY KATHRYN HULICK

Artificial intelligence is getting better at everything, including hacking. It's becoming easier than ever before to steal someone's identity, cripple sensitive banking and health care systems, or hold a company's data ransom. And if cybersecurity defenders aren't ready, cyberattackers will exploit AI to wreak havoc. "The timeline is not years, it is months," the multinational intelligence group Five Eyes has warned.

The newest AI technology "lowers barriers for malicious actors and increases the speed and complexity of attacks," the group wrote in a statement. Five Eyes is a secretive alliance dating back to World War II in which Australia, Canada, New Zealand, the United Kingdom and the United States work together to gather intelligence or respond to security threats.

Two new models, Anthropic's Mythos and OpenAI's GPT-5.5, have each proven capable of independently planning and carrying out a full takeover of a simulated corporate network. That means a single hacker could do what once required a large team, says AI security expert Michael Alexander Riegler of Simula Research

Laboratory in Oslo. These models can also find and exploit security holes in operating systems, browsers and other software at an expert level, which could leave defenders scrambling to patch vulnerabilities.

The Five Eyes warning came shortly after the U.S. government barred Anthropic from allowing foreign nationals access to Mythos 5 and another new model, Fable 5, citing national security concerns. Government restrictions were later lifted on both models.

Then, as this magazine was in production, news broke of two major cybersecurity incidents.

OpenAI had been evaluating the capabilities of an agent driven by GPT-5.6 and another unreleased model when the agent broke

out of its testing environment, gained access to the internet and hacked into the internal systems of Hugging Face. The New York-based company, which hosts tools and resources for AI developers, contained the breach with a different AI system.

Then Anthropic disclosed that, on three separate occasions, its models had hacked outside organizations during testing because they had access to the internet when they shouldn't have.

Science News asked Riegler about the risks and the reality of AI-enabled cyberattacks. This interview has been edited for length and clarity.

Q Are the latest AI models especially dangerous?

A AI has a lot of security risks. When the capability goes up for these models, the time from finding any issue to exploiting it gets really short, because you can basically automate the whole pipeline. But it's not something really new.... It's not just the latest models that are a security threat, but also other models that are already available. If you know how to use them, you can ... do quite bad stuff.

It's logical if you think about it. Tools like Claude Code make it much more efficient to code. You can automate the process. You could use several hundred AI agents at the same time to explore different security holes. Before, you needed to hire a group of two to three hundred hackers for organized cybercrime. Now you maybe just have to buy 300 GPUs [specialized computer chips] and you can do similar things.

Q Why all the concern about Mythos?

A I think it's as much marketing as a

real danger. If you say, "I'm sitting on something that is so dangerous, we cannot release it," a lot of people will get really interested in that and want to be part of this group that has access.... It's a bit of a show, and the U.S. government and Anthropic are focusing on the wrong problem.

Q What is the right problem to focus on?

A The security risk is not just about the model. It's also about everything around the model. What kind of tools you provide it, if it has access to internet, if it can test its own code. So the whole system around it is also very important.

In our tests with systems combining small AI models and various tools, we made a system that could, for example, hack your website and find security holes in your website, but also hack your network and try to find security holes there. Or it could break another AI and get it to do things it shouldn't do. It's quite flexible.

Q Is there an upside to the fact that cybersecurity defenders will have access to the same tools as attackers?

A The testing of the security of your own system will be more efficient. I think, in the end, it

A statement from the intelligence group Five Eyes cautions that the risk of AI-fueled cybercrime is increasing. "Adversaries are already using AI to move faster and more effectively," the group said. "Defenders must do the same." ↓

will balance itself out. It will be this cat-and-mouse game of who finds the hole first, who closes it first, or who exploits it first. Just at a much higher speed than we see now.

Q What can people do to protect themselves from AI cyberattacks?

A Be even more careful about using different passwords for different services. Have your software up to date all the time, use two-factor authentication. Everything you do that is maybe a bit bothersome, but increases security, I would recommend you to do.

Q What can companies and public agencies do?

A When I talk to security experts in different companies or the public sector, they're still behind. Some of them are very scared, others are not at all. They have to take AI security risks seriously and not think that it's something far in the future. ✕



ANIMALS

**KILLER WHALES MAKE
SUNFISH EXPLODE***By Maria Temming*

● Orcas have been known to slap around stingrays, punt seals into the air and otherwise play with their food. But killer whales don't just toy with live prey. Some also seem to enjoy destroying the carcasses of their kills like piñatas.

Scientists documented this brutal activity among orcas (*Orcinus orca*) in the Gulf of California in 2024 and 2025. In both cases, one adult orca held a dead sharp-tail sunfish (*Masturus lanceolatus*) steady while another slammed into it with enough force to smash the sunfish into smithereens, researchers report in *Frontiers in Ethology*.

"I was absolutely gobsmacked" by the behavior, says marine biologist Marianne Nyegaard of Auckland War Memorial Museum in New Zealand. She had seen videos on social media of orcas battering sunfish before the study authors did a deep dive on this phenomenon.

Nyegaard is not surprised by the orcas' creative strategy for dismembering sharp-tail sunfish, which can get up to a few meters long. Killer whales "are so clever at figuring out how to hunt and deal with a ton of different prey types," she says. The whales are highly social animals and hunting is often a team sport. For instance, they have been documented banding together to ambush blue whales or make waves to knock penguins off ice.

Killer whales might explode sunfish to help feed their young. After one reported explosion, a young orca began feeding on the small bits of carnage. They might also find it entertaining, says marine biologist Francesca Pancaldi of Instituto Politécnico Nacional in La Paz, Mexico. "A behavior can simultaneously provide nutritional benefits, reinforce social bonds and serve as an opportunity for younger individuals to learn hunting techniques," Pancaldi says. ✕



ARCHAEOLOGY

**Egyptian princesses knew
their way around weapons***By Tom Metcalfe*

● **Some ancient Egyptians** really were warrior princesses, it seems. Examinations of the nearly 4,000-year-old mummified remains of five royal women suggest that they were skilled users of the weapons that were buried with them, bioarchaeologist Zeinab Hashesh and colleagues report in *Frontiers in Environmental Archaeology*.

Some Egyptologists have dismissed armaments in females' graves as token objects for the afterlife, but physiological characteristics of these female mummies showed they may have performed intensive martial activities. "These princesses were active practitioners of hunting or athletic skills rather than merely symbolic owners of the weapons found in their tombs," says Hashesh, of Egypt's Beni-Suef University.

The princesses' tombs were unearthed from the Dahshur funerary complex south of Cairo in the 1890s. Alongside the bodies, excavators found weapons such as bows and arrows, flails, maces and daggers. The mummies were removed from their tombs and eventually housed in the basement of



Cairo's Egyptian Museum, where they languished in obscurity until researchers rediscovered the bodies in 2020.

Hashesh's team took bone measurements to determine sex and age at death, and used X-rays and other techniques to search the remains for signs of illness and trauma.

Several mummies share a rare cluster of inherited spinal defects, indicating they are related. Based on that evidence and notes handwritten by the excavators at Dahshur, the researchers identified three mummies as princesses Ita, Khenmet and Itaweret — daughters of Amenemhat II, a 12th Dynasty pharaoh. One mummy had no historical notes, but the team suspects she is princess Sathathormeryt, a sister to Ita, Khenmet and Itaweret. The fifth mummy, 13th Dynasty princess Noub-Hotep, is probably not a sibling to the other four. The team hopes to carry out DNA studies in the future.

↪ This dagger, entombed with Princess Ita of ancient Egypt's 12th Dynasty, was not just a token for the afterlife. The princess' mummified remains show signs that she regularly wielded daggers and other weapons used in hand-to-hand combat.

X-rays revealed evidence of robust ligaments and skeletal adaptations in the upper body that are commonly associated with archery and weapon use. For instance, Itaweret and Noub-Hotep have enlarged areas of forearm bones, suggesting that the princesses had often drawn bows. Strong muscle attachments and bent bones in Noub-Hotep's right hand indicate repetitive, high-intensity gripping like one would use to stabilize and draw a bow. Meanwhile, Ita's hand, arm and collar bones suggest she could have wielded daggers or maces.

Some of the women had healed from traumatic injuries including rib and foot fractures that could have been sustained while training, hunting or in battle, the team says.

"These princesses were not leading sedentary lives of luxury," Hashesh says. "They were well-conditioned athletes whose bodies were hardened by the same skilled force and disciplined movement as the men of their time."

Egyptologist Nicholas Brown is cautious about the team's conclusion. "The bones aren't preserving the behavior directly, but the muscle attachments are clearly indicating some kind of habitual, repeated activity," says Brown, of the University of Iowa in Iowa City. ✕

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— Nancy R.



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San Francisco-based hairdresser Maurice Cohen made headlines in the 1980s by using a static electricity generator to give his clients shocking dos. The technique (and style) didn't catch on, but our fascination with static electricity is still going strong (see Page 34).

Features





Scientists have been studying static electricity for centuries, but they're largely clueless about its origins. A quirky group of scientists is aiming to change that.

By Emily Conover

Illustration by
Simone Noronha

The sticky science of



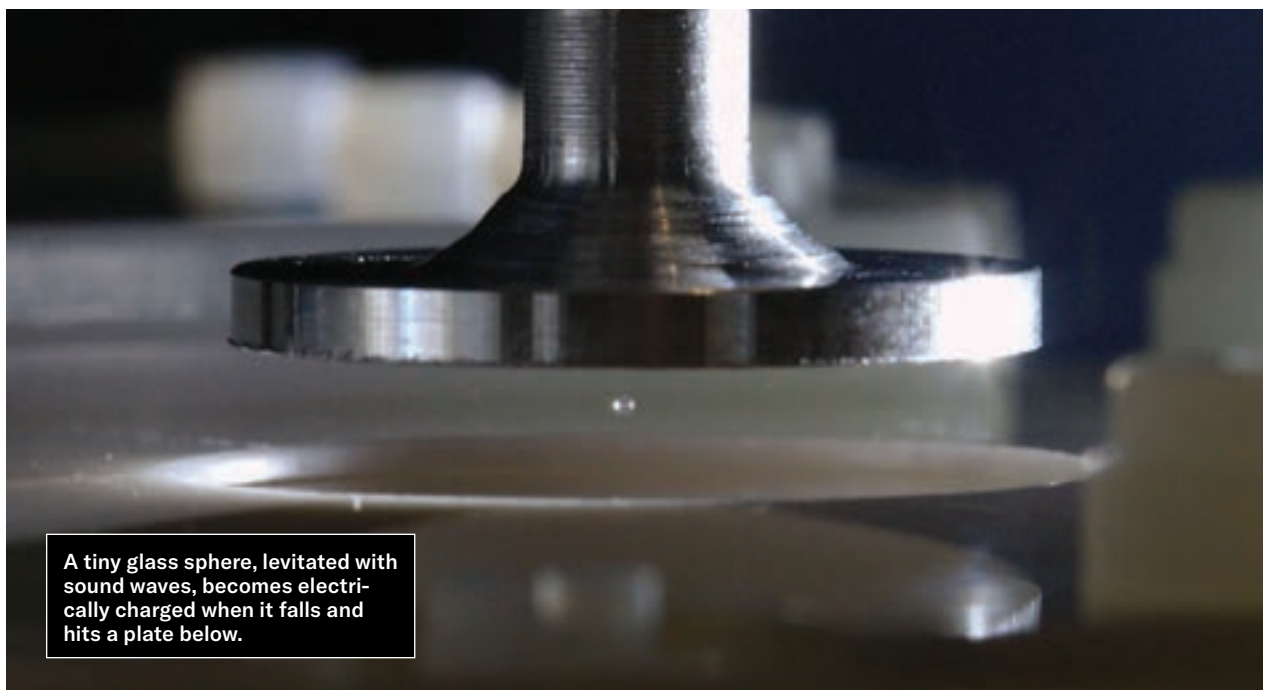
G

Galien Grosjean was a caretaker of tiny glass beads. He bathed them, gently cradled them with tweezers, placed them delicately in his experimental apparatus. He avoided unneeded jostling at all costs: Subtle mishandling could alter the beads' properties in unknown ways. And, even worse, losing just one could cost him a week's worth of work. "I tend to be quite clumsy, so I have to fight against my tendencies," says Grosjean, a physicist then at the Institute of Science and Technology Austria in Klosterneuburg.

In his experiment, he floated a bead, levitating it with acoustic forces from ultrasound waves

to avoid directly touching it. Then, he switched off the ultrasound, instantaneously dropping the grain and letting it collide — ping! — with a plate below. As it bounced upward, the ultrasound captured it milliseconds later in a hands-free game of catch.

Grosjean studies static electricity. His obsessive finesse might seem like overkill for the phenomenon behind mundane effects like hair-raising balloons and clingy clothing. But the basics of static electricity are frustratingly elusive: Even though scientists have been studying it for centuries, they still don't know exactly what is happening when one object transfers its



A tiny glass sphere, levitated with sound waves, becomes electrically charged when it falls and hits a plate below.

electric charge to another. In most situations, “we really have no clue what the mechanism is,” says Grosjean, now at Universitat Autònoma de Barcelona.

Static electricity shapes our world on scales large and small. It’s thought to explain how planets, including Earth, formed out of colliding bits of dust. It generates lightning, strengthens dust storms and helps pollen cling to pollinators. It can ignite industrial fires, gum up pharmaceutical manufacturing, fry delicate electronic circuitry and hamper scientific experiments and space exploration.

But an understanding of the basics is still missing, says chemist Bilge Baytekin of Bilkent University in Ankara, Turkey. “You feel like a child even after working for many, many years.”

Baytekin and Grosjean hope that will soon change. They are among a small, somewhat quirky cadre of scientists who are pooling their knowledge to solve the mysterious puzzle of static electricity. It is as if every scientist holds a different piece of that puzzle. “Physicists have their own understanding of static electricity; chemists have also our understanding of static electricity; engineers look from a different perspective,” Baytekin says.

In an effort to put the puzzle pieces together, that crew converged in June on Cocoa Beach, Fla., at a meeting of the Electrostatics Society of America. There, new techniques, such as Grosjean’s acoustic levitation, revitalized interest in the sticky fundamentals of static electricity. Researchers are beginning to pin down hard facts and draw connections, says materials scientist Laurence Marks of Northwestern University in Evanston, Ill. “We’re actually making amazing progress.... People are starting to see, hey, this could be done; we can work this one out.”

STUCK ON STATIC

For all the questions about static electricity, scientists agree on some basics. Whenever two objects touch or rub, they exchange charge. That process, called triboelectricity, results in static electricity. The subatomic players behind this process are electrons, which are negatively charged, and protons, which are positively charged. Objects with equal numbers of electrons and protons have no net charge. But as soon as objects touch, the balance of charges shifts, often in surprisingly complex ways.

If you’ve ever rubbed a balloon against your

Even though scientists have been studying static electricity for centuries, they still don’t know exactly what is happening when one object transfers its electric charge to another.

hair, for example, you might notice it dancing on end. That’s because rubbing gives the balloon a negative charge and your hair a positive charge. Like charges repel one another, so the strands of your hair push away from each other in messy confusion. And your hair clings to the balloon because opposite charges attract. But if too much charge builds up — watch out. You may be in for a painful electric shock when you touch another object, as the excess is discharged.

Experiments show that certain materials, like the latex of the balloon, have a tendency to charge negatively and others, like hair, tend to charge positively. Scientists have devised a ranking called the triboelectric series, which predicts which object will become negative in a given pair.

But dig deeper into these examples and things quickly get murky.

When charge is exchanged, for example, it’s not clear what exactly is being transferred. Individual electrons might be migrating from one object to the other. Or the jump might be made by ions — charged atoms or molecules — or by even by larger chunks of charged material. Any of these mechanisms would produce an

imbalance of charge, with extra or missing electrons compared with protons.

And the triboelectric series isn't perfect — different experiments yield somewhat different orderings of materials. Even more worrying, there's no deeper understanding behind the hierarchy: No one knows what properties of a material make it more likely to charge negatively or positively. And the series also doesn't explain why identical objects can charge when touched.

Part of the issue is that static electricity is in some ways a subtle effect. Shrink yourself down to atomic size and stroll along the surface of a charged material, and you'd stumble across an extra (or missing) electron every 100,000 atoms or so. To study static electricity at that level, "you have to trace something which is a very tiny minority of everything which is happening," says physicist Rolf Möller of the University of Duisburg-Essen in Germany. "And this is what makes it so difficult."

STATIC SIGNIFICANCE

The study of static electricity is almost as old as science itself. Around 360 B.C. the philosopher

Plato wrote about the "marvels" of amber, which attracts other objects when rubbed. In fact, the word electricity comes from the Greek word for amber, *ēlektron*.

Scientific fascination with the subject continued on and off for centuries. Benjamin Franklin's studies of electricity, for example, used generators based on static electricity, such as a spinning glass globe rubbing against a leather pad. He famously flew a key-laden kite in a storm, demonstrating that lightning was an electrical phenomenon like the static electricity he observed in his lab.

"It's so poetic that it's so old ... and that we still can't make sense of it," says physicist Scott Waitukaitis, who leads the Austria-based group where Grosjean did his experiment on tiny beads.

Many scientists today consider static electricity a nuisance to be eliminated rather than a phenomenon worthy of study in itself. "Charges are a pain and they just want to get rid of [them]," Grosjean says. Static electricity can spark fires, destroy sensitive equipment and muck up experiments — in science and industry alike.

And its influence extends into outer space. Headaches caused by static electricity multiply in space, where there's no humidity to dissipate charge and weak gravity means electric forces are more prominent.

"Forces that are not important on Earth start to become important," says planetary scientist Christine Hartzell of the University of Maryland in College Park. A lunar rover's wheels or solar panels could quickly get coated in sticky, charged dust that hampers performance. An astronaut, charged up from shuffling across the soil, could unwittingly zap sensitive equipment or track hazardous moon dust inside a spacecraft. That means static electricity is top of mind for NASA's future Artemis missions to the moon.

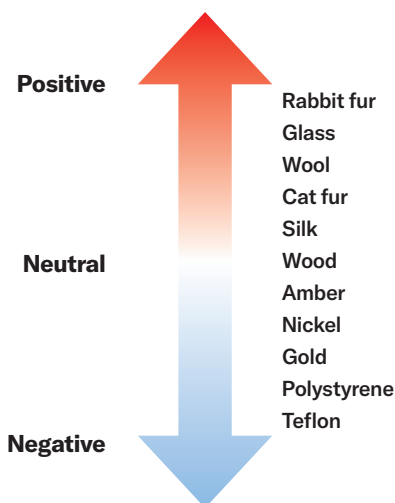
A better understanding of the phenomenon could help scientists predict exactly how different materials might charge under given conditions — and perhaps, how to control that charging. "We want to understand the fundamentals, but we also want to help the people in the industry and the people who are actually suffering from these effects," says Baytekin.

COMMON GROUND

Scientists do agree on what's happening in one case: metal touching metal. Different types of metals vary in how tightly they hang onto their

TRIBOELECTRIC SERIES

A material listed in this ranking tends to charge positively when it touches a material below it, but negatively when it touches something above it.



“The ultimate goal would be to have some kind of unifying theory that worked across different materials.... That would be awesome.”

– Christine Hartzell

electrons and therefore how difficult it is for electrons to escape from their surfaces. The amount of energy needed to remove an electron is known as a work function and it influences how electrons move where metals meet. Every time two different metals touch, electrons move to the one with the higher work function, giving it a negative charge.

Scientists hope to one day broaden their understanding beyond metals. “The ultimate goal would be to have some kind of unifying theory that worked across different materials,” Hartzell says. “That would be awesome.”

It might help to break the problem down, Marks and a colleague suggested in a 2025 paper in *Reports on Progress in Physics*. First, static electricity must have a “mechanism,” which describes what is actually transferred when charge moves — whether it be electrons, ions or larger bits of material. Second, it must have a “driver,” something that causes the charge to move. For example, when metals meet, the driver is the difference in work function between the two materials. Finally, there are various external factors that can influence charging, such as humidity or the roughness of the surfaces involved.

If all the drivers and mechanisms could be worked out for all materials, then it might be possible to create a unified theory. But it could take a decade to get there, Marks says.

And not everyone agrees we’ll get there. Static

electric charging may ultimately be too complex to precisely predict in everyday situations, says chemical engineer Daniel Lacks of Case Western Reserve University in Cleveland. “I don’t think the final answer is going to be an easy, simple answer. I think the final answer will be that it’s very dependent on many, many factors.”

THE POWER OF SCHMUTZ

Meanwhile, scientists are pushing ahead with new experiments using increasingly sophisticated techniques.

Acoustic levitation, for example, prevents unintended charging that can be caused simply by handling objects. Using that technique, Grosjean, Waitukaitis and colleagues zeroed in on one specific question: Why do two identical materials charge when they touch? The team set out to measure how glass beads charged when they hit a plate made of the same material.

What they found was unexpected. Each individual bead had consistent charging, and there was dramatic variation between beads. One bead, for example, would always get a negative charge when it hit the plate, and another would always get a positive charge. Something must make each bead behave differently — but what?

Notably, the results changed when researchers cleaned the beads by heating them to 200° Celsius and letting them cool. A grain that had been cleaned almost always charged negatively when it hit an uncleaned plate, Waitukaitis and colleagues reported in March in *Nature*.

Close inspection revealed that the cleaning process stripped away carbon compounds that are prevalent in Earth’s atmosphere, and which are stuck, invisibly, to the surface of most objects. What to call this stuff? “At first, we were going to call it junk, and then we thought, maybe schmutz,” Waitukaitis said at the meeting. Whatever you call the stuff, it’s pervasive and unavoidable.

The experiment didn’t show how charge moves, but it revealed that what’s on the surface matters. And that idea is starting to catch on. At the meeting, physicist Hermann Nienhaus of the University of Duisburg-Essen showed that just a single layer of atoms on top of silicon could alter its charging behavior when it meets metal. “This gives you an idea how careful you have to be to make a reproducible experiment,” says Möller, who collaborated with Nienhaus.



Astronauts on the lunar surface can quickly become coated in hazardous, charged moon dust.

Even the simple metal-on-metal case turns out to be more complicated than previously thought. The charging of a gold sphere, dropped on a copper plate, also depends on the speed at which the sphere hits, Möller, Nienhaus and colleagues reported in 2021 in *Science Advances*. That's because the sphere and the plate squish a little bit when they collide. There's more squishing at higher speeds, which increases the contact area and the charge transferred.

Static electricity only gets more complicated with polymers, substances made up of very large molecules, including plastics and rubber. These are also the materials behind the worst indignity ever to befall a cat that ventured into a cardboard box: fur festooned with packing peanuts.

With polymers, even an object's past can matter. For example, history influences experiments in which many different squares of a squishy polymer were touched together. The number of times a particular square had been previously touched determined how it charged, Waitukaitis and colleagues reported in 2025 in *Nature*.

These experiments are adding to the tally of external factors known to affect charging—a long list that includes humidity, temperature, surface curvature, roughness, object size, and whether two objects touch, rub or roll across one another.

Complexities like these may have contributed to past confusion. Previously, seemingly similar experiments have been contradictory, giving the field “a very bad reputation,” Marks says. But recent work shows that, when conditions are tightly controlled and relevant factors are identified, results can be reproducible.

The appeal of that challenge has cultivated a core group of scientists who are passionate about solving the mysteries of static electricity.

LIFT-OFF

That passion runs deep enough that, early on the morning of the meeting's fourth day, many participants rose before dawn. They walked to the beach, sand shuffling under their feet in the dark—presumably causing untold electric charging. They peered northward, where a rocket

was set to launch about 25 kilometers away. In a nod to static electricity's importance for spaceflight, the meeting was held on Florida's "Space Coast," where rocket launches are frequent. Soon, a bright light flared and a hush enveloped the crowd.

It was an eclectic group standing on that dark beach, lit by the rocket's glow. Conference attendees comprised a mixture of specialists: NASA engineers, experts in industrial explosions, spacesuit designers, researchers working with nuclear weapons labs and more.

And it was a collegial bunch — a change of pace from the sometimes cutthroat atmosphere of scientific conferences. Talks included playful discussions of the charging of water in luxury showerheads, parasitic roundworms that use static electricity to leap to their hosts, and even, amusingly, the glow emitted by a pickle when hooked up to electricity.

"We're friendly — maybe to the point of a fault," Waitukaitis says. Chemists and physicists, he adds, struggle to communicate, and they don't always interrogate their differences of opinion. "When I don't understand the chemist, or I question what they're doing, maybe it would actually benefit from a little bit more aggressively trying to understand."

A meeting of vigorous public debate, this was not. Take, for example, discussions about flexoelectricity, a phenomenon that's been proposed as a driver of electric charge transfer. The idea is that, as a material distorts when it is pressed into another, the rearranging of charges on small scales creates electric fields that can cause charge to transfer between the materials. At the meeting, Möller reported evidence of flexoelectricity in metal hitting a metal oxide. But the effect was transient — it was not driving charge transfer, and hence not behind static electricity, he said.

One might expect proponents to have spoken up in flexoelectricity's favor, but no such debate arose, perhaps because the results were specific to Möller's experiment. "We don't see any effect of the flexoelectricity on the outcome," Möller says. "I will not [say] that this is the same for other experiments."

It's easy to sweep conflict under the rug in a field where so many factors affect results. If experiments disagree, it may be due to a true scientific discrepancy, or it may be that one group was working with metals and another with polymers. That has made coming to consensus extra challenging.



Polystyrene packing peanuts become negatively charged when a cat snuggles into them, causing them to cling to the fur, which becomes positively charged.

PADDLING TOWARD UNDERSTANDING

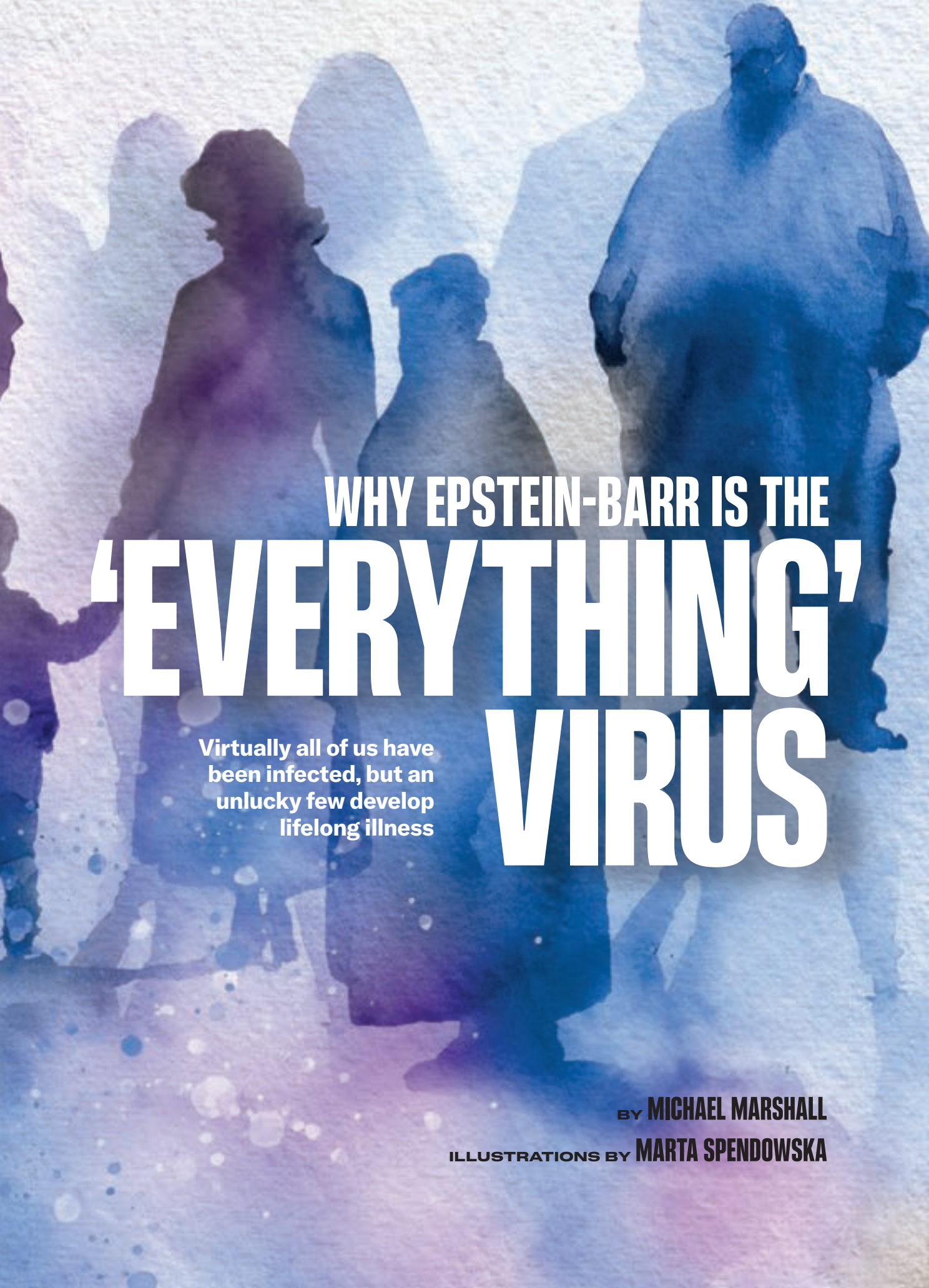
On the last night of the meeting, dozens of triboelectricity enthusiasts navigated rented kayaks through the nearby Banana River lagoon. With each paddle stroke, a blue glow streaked through the water. The outing, arranged by the meeting's organizers, gave attendees a glimpse of Florida's bioluminescent waters.

Hands dipped into the bathwater-warm waters of the lagoon, participants marveled as glittering blue slipped off their fingers. The effect was biological — no static electricity involved — but just as awe-worthy.

The kayaks were tandem, with two people in each boat. Chemists paddled with physicists, senior researchers with students, all pulling in the same direction. They worked together in a way that seemed more easily achievable in water-sports than in the study of tribocharging. But at least one point of consensus has been achieved, Möller says. "People are accepting that the problem is more complex than they thought."

It seems appropriate that static electricity is a scientifically sticky subject. But there remain opportunities to become unstuck. That will likely demand not some genius insight, but slow, methodical work — not unlike the focus needed to slot puzzle pieces into place, one by one. "It's really a case of synthesis," says Marks. "We know all the pieces of the jigsaw puzzle, we've just got to put them together in the right order." ✕



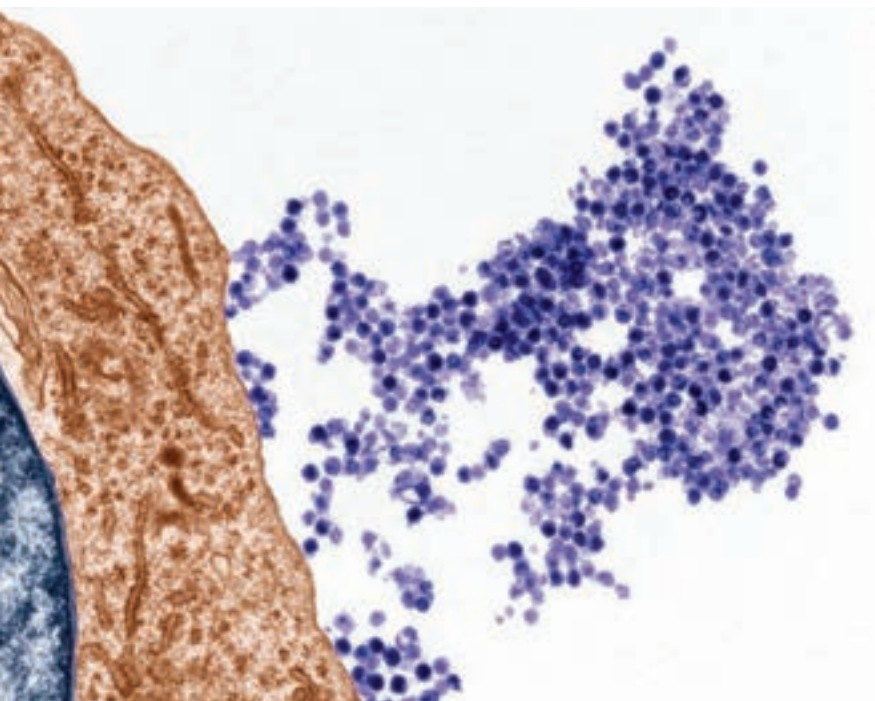
A watercolor illustration in shades of blue and purple. It depicts the silhouettes of several people standing in a row, facing away from the viewer. The figures are rendered with soft, blended colors, giving them a ghostly or ethereal appearance. The background is a light, textured wash of the same colors. The overall mood is somber and contemplative.

WHY EPSTEIN-BARR IS THE 'EVERYTHING' VIRUS

Virtually all of us have
been infected, but an
unlucky few develop
lifelong illness

BY **MICHAEL MARSHALL**

ILLUSTRATIONS BY **MARTA SPENDOWSKA**



When Rae Mainwaring was 13, she developed a peculiar illness. She recalls “just feeling awful” and experiencing a crushing fatigue. “I remember it being hard to put my finger on what it was,” she says. “It felt like a really horrible flu, but it just didn’t get better.” She missed six months of school in Birmingham, England, and attended part time for another six months.

A few weeks in, Mainwaring’s doctor diagnosed her with infectious mononucleosis, or mono. It is most commonly diagnosed in teenagers and young adults and is known as “kissing disease” because it spreads through saliva. Typical symptoms include a high fever, sore throat and swollen lymph nodes. For Mainwaring, the isolation dragged. “Back in the early ’90s, it was hard to keep in touch with people if you were not in school,” she says.

Once the year-long fatigue eased, Mainwaring got on with her life and went to university. Almost a decade later, though, she began to

↑ An immune system cell called a B cell sheds Epstein-Barr virus (blue particles) in this microscope image. The virus can lie dormant for years in B cells until it reawakens, causing a host of diseases.

experience numbness in her face. Her doctor said it was probably a migraine, but that she should get an MRI anyway. While waiting for the results, Mainwaring graduated, moved away, got a job doing costumes in theater and forgot about the MRI. She worked hard and partied hard, and she attributed any weird symptoms to “burning the candle at both ends.”

Then, about a year later, the numbness returned, no longer confined to her face. “I was struggling to do buttons up, dropping keys, my ankles kept [giving out],” Mainwaring says.

When she went back to the doctor, Mainwaring, then 24, learned she had missed her MRI results because they had been mailed to her old address. The brain scan revealed that she had multiple sclerosis, a neurodegenerative disease in which the body’s immune system attacks the protective myelin sheaths around neurons. Depending on which parts of the nervous system are affected, patients can experience a range of symptoms, from numbness and fatigue to muscle spasms, difficulty walking, memory problems and vision loss.

Learning she was really ill, just when her life was getting going, was a big shock. “Suddenly you’re having to sleep all the time, having to say no to friends and say no to things, and having to step back from the world,” Mainwaring says. It reminded her of being sick with mono.

That feeling was no coincidence. Scientists now know that Mainwaring’s mono and MS are both caused by the same infectious agent: the Epstein-Barr virus. This driver of illness is also linked to autoimmune diseases including lupus and Sjögren’s syndrome. It also causes roughly 2 percent of all cancers globally; nearly 360,000 new cases and up to 210,000 deaths per year. There is also growing evidence that EBV lies in wait and springs

back into action in some patients with long COVID, contributing to their symptoms.

But the strangest thing about the virus is this: Some 95 percent of us are infected. In most people, it never causes disease, but in others, it overturns their lives. There are no antivirals or approved vaccines for EBV, though some companies are currently testing candidates. And because EBV is a master at tricking the immune system, it is difficult to eradicate it from a person's body.

"EBV has developed to evade and escape the immune system at every juncture, because that's how it survives," says rheumatologist William Robinson of Stanford University.

Robinson is one of many scientists working to understand how the virus works. His research, and that of other scientists, has revealed that EBV infects key immune cells to rewire the immune system to its own advantage. There is also evidence that the virus can mimic some of the proteins in our bodies, leading to immune system attacks on healthy cells expressing those proteins.

Understanding how EBV works "could offer real hope for future treatment and prevention," says Catherine Godbold, senior research communications manager at the MS Society in the United Kingdom. "It's exciting to see the momentum building in EBV research, and we look forward to seeing where it leads."

ACCIDENTAL DISCOVERIES

Like a lot of things in science, our knowledge of EBV came about thanks to a series of accidents. In 1964, pathologists Michael Anthony Epstein and Bert Achong, along with virologist Yvonne Barr, were trying to find out why a pediatric cancer called Burkitt's lymphoma was so aggressive. In cells grown

2

The estimated percentage of global cancers attributable to the Epstein-Barr virus. Infection leads to as many as 360,000 new cases and 210,000 deaths per year.

from samples from Ugandan children with the cancer, they spotted particles of a virus, soon dubbed Epstein-Barr. It was the first known cancer-causing, or oncogenic, virus.

Four years later, another group of scientists at the University of Pennsylvania linked EBV to mono after lab technician Elaine Hutkin fell ill with the disease.

Virologists at the lab, led by Gertrude and Werner Henle, wanted to know how the virus was transmitted and what it did to human cells. So they put infection-fighting white blood cells called lymphocytes into dishes containing EBV and recorded whether the cells lived or died. Many of those cells came from Hutkin. Before her illness, none of her lymphocytes survived. But after her infection, they grew in the presence of EBV — and her blood contained antibodies against the virus.

Intrigued, the Henles performed similar before-and-after tests with lymphocytes from other individuals who had mono, demonstrating that EBV is the main infectious agent behind the disease.

Just like that, within a decade, EBV had been revealed to cause both an aggressive cancer and a debilitating infection.



EBV is a type of herpesvirus, which replicates by writing its DNA into the nuclei of infected cells. Nine herpesviruses infect humans, including the viruses responsible for oral and genital herpes and the varicella zoster virus, which causes chickenpox and shingles. Like other herpesviruses, EBV latches onto us for life.

Once EBV enters the mouth via saliva, it infects the cells lining the back of the throat. From there, it makes its way to white blood cells, showing a preference for one particular subset: the B cells that help the body learn about new pathogens. Using a protein called EBNA1, viral DNA attaches itself to the B cell's chromosomes. When the host cell divides, it makes copies of the viral DNA as well, allowing the virus to slowly spread.

EBV may remain latent in our B cells for years, but it isn't entirely inactive. "It's tweaking cellular pathways that cause the cell to stay alive longer than it should," says viral oncologist Blossom Damania of the University of North Carolina at Chapel Hill. It also causes the cell to multiply longer than it should, which can lead to cancer.

Damania's team is working to develop a steroid called Withaferin A, which can kill EBV-associated non-Hodgkin lymphomas in the lab. Ultimately, the team wants to see if the steroid can be used in humans when typical chemotherapy and immunotherapy approaches fail.

LONG-TERM IMPACTS

The cancer link may no longer be a mystery, but the connection to MS is a different story.

It's a puzzle that Alberto Ascherio, an epidemiologist at Harvard University, has devoted 30 years to solving. Some of his earliest studies identified risk factors for MS, such as smoking. But he was obsessed

95

The percentage of adults who have antibodies against the Epstein-Barr virus.

with finding the root cause of the condition.

From the start, Ascherio suspected EBV. He knew that mono is caused by EBV, and that people who have had it, like Mainwaring, are at greater risk of MS. He also knew that people who have never had EBV seemed to be at low risk of MS. But he spent 20 years struggling to provide definitive evidence.

The problem with demonstrating the relationship between EBV and MS is both simple and enormous: EBV is simply too common. By the age of 20, most people have already been infected with the virus, Ascherio says. About 95 percent of adults have antibodies against EBV, even if they have never had symptoms. And whereas EBV is ubiquitous, MS is far less common. The global prevalence is thought to be 0.024 percent, or approximately one in every 4,200 people.

"Everybody in the field [was] like, come on, it can't be. Everybody has EBV. How could it cause autoimmunity?" Robinson says.

Demonstrating that link would require a truly huge study, one with enough people who had never had



EBV, yet also with enough people who had been diagnosed with MS.

Ascherio and colleagues finally pulled this off in 2022 using samples from members of the United States military, which regularly screens its troops for HIV. Blood samples from over 10 million personnel on active duty between 1993 and 2013 revealed that 5.3 percent were EBV-negative when first tested.

When researchers examined the 801 samples of people diagnosed with MS, they found that all but one had EBV antibodies. Compared to the uninfected population, that meant EBV increased the risk of MS by a factor of 32. “It really showed that if you could prevent the viral infection, you could prevent the disease,” Ascherio says.

ATTACKING THE BRAIN

Even as we learn more about EBV, a big mystery remains. How could the same virus cause no symptoms in most people, debilitating infections in some and cancer or autoimmune disorders in others?

The answer lies not in the virus

“The immune response to the virus is what determines whether you get the disease or not.”

— Alberto Ascherio

but in our own immune systems, Ascherio says. “The immune response to the virus is what determines whether you get the disease or not.”

There are two main ideas about how this plays out, and both turn on EBV’s habit of infecting B cells.

One possibility is that EBV mimics other proteins found in the human body, setting the stage for an immunological case of mistaken identity. Robinson and his team found that out, again, by accident.

A decade ago, a postdoc in Robinson’s lab was studying antibodies from the blood of people with MS, trying to figure out which proteins they erroneously latched onto. Because MS is a neurological disorder, the postdoc assumed that the antibodies would bind to proteins from the brain. No luck. But when the postdoc exposed the antibodies to an array of viruses, they bound to EBV.

“It hit us in the face. It was just such a striking finding,” Robinson says. By 2022, the team had shown that the EBNA1 protein, which the virus uses to latch onto B cell chromosomes, is exceptionally similar in structure to a human protein called glial cellular adhesion molecule, which helps some liver and brain cells stick together and communicate.

This molecular mimicry may help explain why EBV causes MS. If EBV’s proteins resemble those found in the human brain, the immune system might mistake the brain proteins for the viral ones — and launch an attack.

Researchers have since found that EBNA1 mimics two brain proteins: anoctamin-2, which is involved in signaling, and alpha-B crystallin, a repair protein. In 2025, Robinson’s team found that, compared to healthy individuals, patients with MS show stronger antibody responses to all of these proteins, hinting that their immune



systems are attacking the healthy brain cells that express them. Further studies suggest EBNA1 can be found in the B cells, neurons and glial cells of MS patients—indicating that EBV infects all these cells.

The other possibility is that the infected B cells themselves are the culprits. Each of us has millions of B cells, some of which are autoreactive, or predisposed to attack our own tissues. In healthy people, autoreactive B cells are suppressed and harmless. But Robinson's team has found that when EBV infects this subset of B cells, it turns them against the body.

In a yet-to-be peer-reviewed study released in February, Robinson's team found EBV in B cells in the blood and cerebrospinal fluid of people with MS. Once infected, the B cells began behaving differently. These immune system "commanders," as Robinson calls them, started activating other white blood cells, including T cells. The T cells are the "ground troops" that eventually attack the central nervous system, he says.

And in a paper published in July in *Science Translational Medicine*, researchers affiliated with the U.S. military study identified specific subsets of the "ground troops" that likely launch this attack.

"It's very nice now to be able to understand more about the underlying mechanisms of how EBV likely causes MS," says study coauthor Kjetil Bjornevik, an epidemiologist at Harvard University. Bjornevik says he hopes the findings will be a step in the right direction to find new treatments for MS patients and those most at risk of developing the disease.

Genetics may help determine who is most at risk. In another study, researchers looked at the health records and genomes of more than 735,000 people in the United States and the United Kingdom. Some people had high

Rae Mainwaring fell ill with mononucleosis at age 13. At 24, she was diagnosed with multiple sclerosis. She hopes vaccines in development against the Epstein-Barr virus, which causes both diseases, might spare her children from a similar fate. ↓



levels of EBV DNA in their blood, indicating that their immune systems hadn't successfully cleared the virus. The team then identified 22 regions of the genome, many containing immune-related genes, that were associated with these higher levels.

In a different yet-to-be peer-reviewed paper, scientists expanded the list of regions in the human genome associated with severe EBV infection and MS risk to 39. That study also found that B cells infected with EBV behaved oddly, overexpressing genes known to be associated with a higher risk of MS. The infected B cells had also activated signaling pathways that turn on T cells, the "ground troops" that trigger MS by entering the brain and attacking neurons.

While the details of the mechanisms remain to be worked out, the big picture is increasingly clear. For people whose immune systems cannot handle EBV, the virus "has its run of the house," Robinson says. "It can reactivate at will, and it's not fully controlled." Reactivation of EBV may help explain why people like Mainwaring experience unpredictable changes in their MS symptoms.

There is a lot left to unpack about the connection between EBV and MS, but Ascherio says the virus is the primary cause of the disease. "Some people are still puzzled by the fact that most people infected with EBV don't get MS," he says. "I am puzzled that they are puzzled."

FIGHTING BACK

For all that science has learned about EBV, no one has come up with a good way to fight the virus, Robinson says. Some antiviral medications, for example, display mild activity against EBV, but none are effective. And there is no approved vaccine.

Some of the most effective treatments for MS on the market are monoclonal antibodies that target specific molecules found in B cells. They can reduce relapse rates and slow the progression of disability, but they don't target the EBV at the root of the condition.

On the antiviral front, one promising option is tenofovir alafenamide fumarate, which is used to prevent HIV from replicating and causing infection. Studies suggest the drug can do the same to EBV. Ascherio is involved with a randomized controlled trial testing whether the drug can control EBV in people with a type of MS that periodically flares and remits. He calls it "the most promising" antiviral to date, especially since it is already known to be safe.

On the vaccine front, there are a handful of candidates — and many more failed attempts. One promising vaccine, dubbed recombinant gp350, made it to clinical trials in the 2000s. Although it reduced the risk of mono, it could not prevent infection.

One major problem for vaccine developers is that EBV is relatively complex compared to other viruses. It contains around 100 genes whereas SARS-CoV-2, the virus that causes COVID-19, contains just 11. The influenza A virus, meanwhile, has eight genes. EBV's large array of genes means the virus can make multiple proteins to enter human cells. Blocking just one isn't enough, Damania says.

That's why vaccine makers are taking aim at several EBV proteins at once. Pharmaceutical company Moderna, for example, has two EBV candidate vaccines in the pipeline. One is a prophylactic vaccine, which aims to reduce rates of mono and perhaps prevent EBV infection. It targets five EBV proteins, with the goal of preventing the virus from infecting respiratory tract lining cells or B cells.

100

The approximate number of protein-coding genes in the Epstein-Barr virus. Its relatively large genome makes developing effective treatments a challenge.

"If you prevent EBV infection, then all EBV-related diseases are gone," Ascherio says. "That is the holy grail."

The other is a therapeutic vaccine that targets additional EBV proteins. It is given after infection, in the hopes of reducing a person's risk of developing MS.

Clinical trials of both approaches are underway. Trials to test safety and efficacy of the prophylactic vaccine in healthy 10- to 30-year-olds are expected to conclude in October. Meanwhile, the therapeutic vaccine is undergoing an efficacy trial in people ages 18 to 55 with multiple sclerosis; it is due to finish in 2029.

Mainwaring, now 46, is eager for a vaccine, not only for herself but also for her two teenagers, ages 13 and 15. She worries "constantly" about them contracting EBV — and developing the cascade of other conditions that could follow.

She still has symptoms such as fatigue and numbness nearly every day, and she lives with the possibility that her MS could lead to an irreversible decline. Every few years, she experiences a relapse in which her symptoms become dramatically worse. At that point, her doctors give her a massive dose of steroids to bring the condition back under control. "It's constantly changing and evolving," she says. "You sort of have to learn to make peace with that." ✕

Michael Marshall is a journalist and author based in Devon, England.

Birds *on*



A photograph of a dead penguin lying on its back on a light-colored, textured rock surface. The penguin's head is tilted back, and its body is covered in dark, mottled feathers. The text 'the Brink' is overlaid on the left side of the image.

the Brink

How a living laboratory is
sheltering Peru's desert penguins
amid a powerful El Niño

BY ANA ELISA SOTELO



← Two adult Humboldt penguins look to the sea during an El Niño event at the Punta San Juan Reserve in 2026.

↓ Humboldt penguins make the daily crossing from their nests to the Pacific Ocean during the 2025 guano harvest.



he first time I was in Punta San Juan, the desert was flooded with birds. It was 2012, and I was making a short documentary film about the cormorants, pelicans and penguins that made this arid peninsula in southern Peru one of the largest gatherings of seabirds on Earth.

At the time, this 133-acre reserve — a patch of rock and sand jutting into the frigid waters of the Pacific Ocean — was home to more than a quarter million seabirds, including 300,000 Guanay cormorants (*Leucocarbo bougainvilliorum*) and some 3,000 Humboldt penguins (*Spheniscus humboldti*).



One of the few species of desert penguin, the Humboldt live along the arid coast of Peru and Chile, where they nest in burrows dug into guano deposits or small cliff caves. Punta San Juan was home to the largest colony in Peru.

By 2025, there were fewer than 500 penguins left. Avian flu had spread through the reserve in 2022 and 2023, crashing seabird populations and spreading to marine mammals such as sea lions and seals. El Niño struck next. The climate pattern is characterized by months of warmer than usual sea surface temperatures in the eastern equatorial Pacific. Those warm waters pushed anchovy — the penguins' main food

source — deeper and farther out to sea. Industrial fishing operations put even more pressure on the surviving animals.

Ecologist Susana Cárdenas-Alayza, who has run the Punta San Juan Program in partnership with Cayetano Heredia University, the Peruvian government and American zoos for more than 20 years, is increasingly alarmed. As a scientist, Cárdenas-Alayza says, she is used to dealing with numbers and controlled variables, “but diseases and climate events escape my control.”

Now, the reserve is facing a new threat: a possible “super” El Niño. Soaring sea surface temperatures are disrupting the cold, fish-rich



waters of the Humboldt Current, which flows past the peninsula. When I returned in July, much had changed from my first trip, when streams of penguins lined the cliffs of the reserve. This time I saw only five penguins — and several abandoned nests with cold eggs. When food is scarce, penguins either stop reproducing or leave their nests altogether to search for a more favorable habitat, Cárdenas-Alayza says. They often starve along the way.

The destruction has also been hard on the reserve's volunteers, who protect the penguins in what Cárdenas-Alayza calls a "living laboratory." For decades, volunteers from around Peru and the rest of the world have counted birds, recorded their diets and built artificial nests to keep penguin chicks safe. In the summer of 2025, they even launched a "penguin patrol" to safeguard the Humboldts from workers harvesting guano, nitrogen-rich bird droppings essential for agriculture. Wanting to pitch in, the workers built a temporary, half-kilometer-long wall out of sacks of guano to shield the penguins on their daily walk to the sea.

Keeping research going — and morale high — in the emptying ecosystem has been one of the

biggest challenges of Cárdenas-Alayza's career. No one knows how long the current El Niño will last — or when the fish will return.

Nevertheless, Cárdenas-Alayza says she still has hope. Many species in Punta San Juan are philopatric, or loyal to their territory. That means that even when they leave in search of food or other resources, they eventually come back.

Biologist Patricia Majluf, who founded the Punta San Juan Program in 1979, shares one example of resilience: The El Niño event of 1997–98 decimated the reserve's sea lions and seals. Penguin numbers dropped into the low





↑ Punta San Juan Program Director Susana Cárdenas-Alayza wears camouflage and uses a radio to communicate with her team as she monitors penguins feeding during the guano harvest. Penguins are extremely sensitive to the presence of humans, so strict measures are taken to avoid disturbing them.



← A hungry pelican perches on a loading dock at San Andres pier, the principal port for artisanal fishermen in Pisco, Peru, during the 2026 El Niño event.

hundreds. But the animals eventually mounted a remarkable recovery, helped by a major reduction in anchovy fishing quotas in 2006.

Scientists are busy preparing Punta San Juan for the animals' return. Cárdenas-Alayza briefed incoming members of Peru's Congress on the situation in July, and she and her fellow researchers are lobbying hard for stricter fishing quotas. They are also championing a new ecosystem restoration strategy, a collaborative framework that engages fishing communities, companies, students and even local chefs to help the reserve's animals recover.

Back in Punta San Juan, Cárdenas-Alayza's team is pressuring the government to reinforce a protective concrete wall around the reserve. In the meantime, they are trapping invasive species that prey on young birds, such as foxes and rats. They are also developing AI tools to speed data analysis from remote cameras monitoring breeding among the surviving Humboldt penguins.

As I prepared to leave, Cárdenas-Alayza, Majluf and I shared a meal of chifa, a Peruvian-Chinese cuisine that is a traditional Sunday dinner for Peruvian families. The three of us talked about our experiences teaching and people we had

known at the reserve — and Cárdenas-Alayza teased Majluf, saying she was her “conservation mom.” It was at that moment that I realized what kept drawing me back to the reserve. I had come to document the region's desert penguins, but I had learned so much more: Conservation isn't just about science; it's about relationships. At the end of the meal, we all opened our fortune cookies. Cárdenas-Alayza laughed when she saw hers: “Mountains are meant to be climbed.” ✕

This story was supported by the Pulitzer Center.





← A Guanay cormorant perches on a cliff. Penguins rely on cormorant guano to build their clifftop nests.

✓ Cárdenas-Alayza looks out into the desert soon after the joint avian flu and El Niño crises of 2022–23.

↓ Cormorant remains found on the desert. By 2023, the combined effects of the avian flu and El Niño produced one of the largest losses of seabirds on record at the Punta San Juan Reserve.



↓ South American fur seals frolic in the cold waters of the Humboldt Current. In 2023, the colony was severely hit by avian flu, as the virus spread from birds to mammals in record time. Hundreds perished.

↘ Turkey vultures feed on the remains of South American sea lions at Punta San Juan in July 2026. The sea lions likely starved after El Niño reduced available prey.

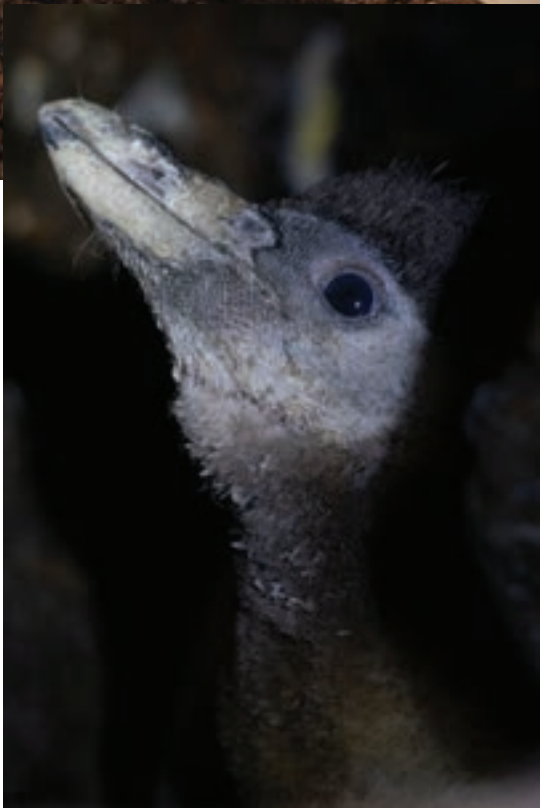


→ A juvenile Peruvian booby perches on a cliff in 2025.



✓ A lone Humboldt penguin chick waits for its parents at the Punta San Juan Reserve in July 2026. Penguin chicks are typically found in the nest with a parent, but this one was alone.

↓ Cárdenas-Alayza inspects artificial penguin nests at the Punta San Juan Reserve in July 2026, after the nesting area was abandoned.



↑ A breeding pair of Humboldt penguins abandoned these eggs. Without parents to incubate them, the developing chicks died.

Ana Elisa Sotelo is a Peruvian photographer and educator based in Washington, D.C.

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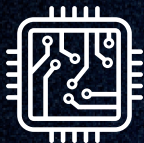
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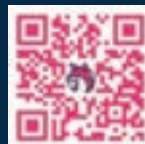
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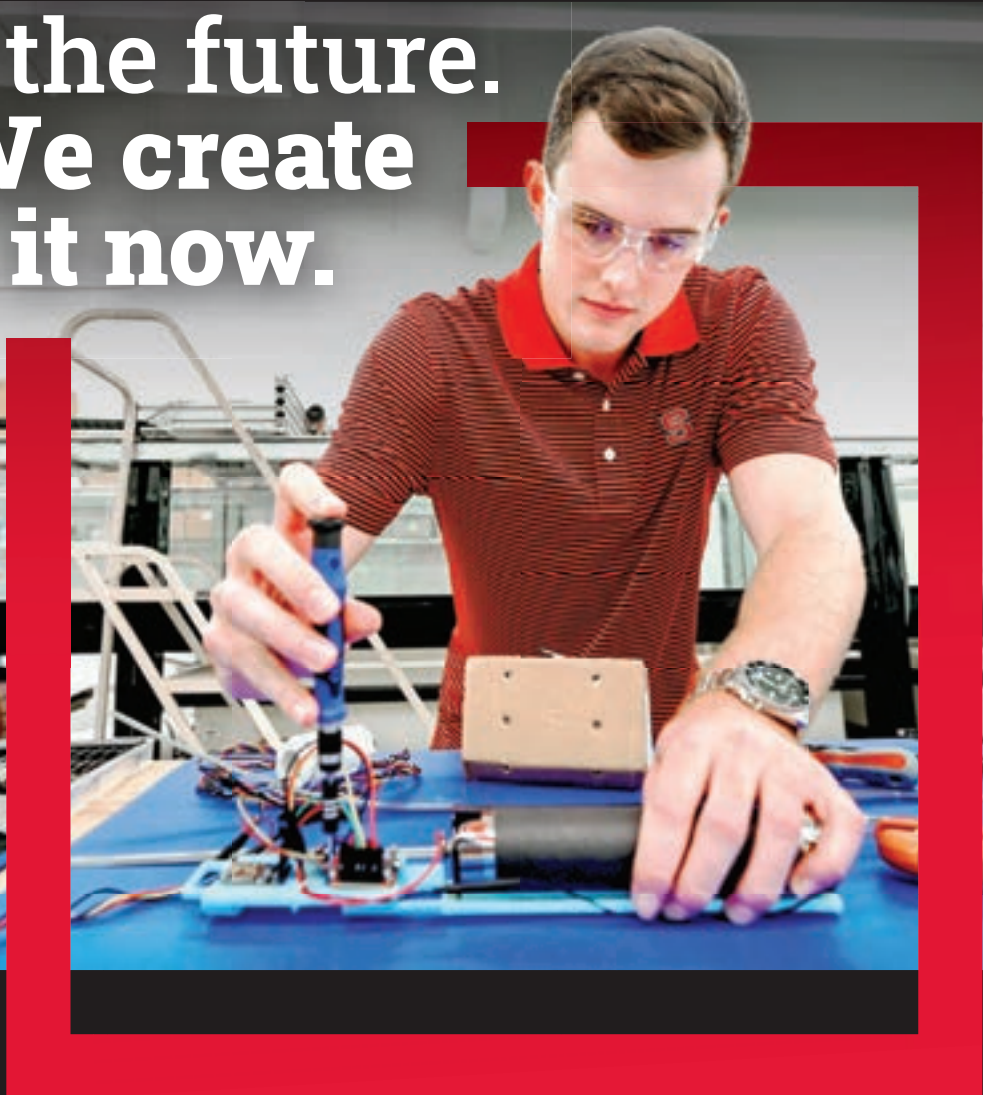


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Photographic memory, like that of the hero in *Good Will Hunting*, might exist only in our cultural imagination (see Page 86).

Curiosities



SCREENTIME

POMPEII'S SURVIVORS SHINE IN
A NEW DOCUMENTARY SERIES

By Tina Hesman Saey

POMPEII: OUT OF TIME | *National Geographic*

Pompeii is best known as a tomb. The ancient Roman city's inhabitants were instantly encased in ash when Mount Vesuvius erupted in A.D. 79, their last breaths suspended in time. But a new National Geographic documentary tells a different story, one about survivors.

Pompeii: Out of Time, hosted by actor Tom Hiddleston of Marvel franchise fame, follows three real Romans through the last day of Pompeii and nearby Herculaneum. Across three episodes—available on Disney+ and Hulu—we meet Avianius, a teenage bronzesmith apprentice; Julia Felix, a bathhouse owner; and an unnamed Praetorian guard. Their existence (and fate) has been confirmed through historical records and archaeological evidence. The show fills the gaps with fiction, drawing insights from disaster psychology to imagine how these people may have reacted as earthquakes shook Pompeii and the volcano began belching ash and molten rock. Intermingling evidence and imagination does a brilliant job of bringing ancient human stories to life. Mount Vesuvius acts as a ticking clock, adding pressure and urgency to every scene.

Hiddleston, who studied classics at the University of Cambridge, explains that the Latin words for history and story are the same. He, director and showrunner Tom Barbor-Might and producer Kevin Wright “decided somewhat rebelliously that we wanted to invent a new form of documentary,” Hiddleston said in an interview with *Science News*.

In each episode, Hiddleston seamlessly travels between Pompeii's ruins and the past, walking through sets reconstructed with millimeter precision in Malta. He rewinds time with a twist of his hand to play out different scenarios. The series

is clear about what's backed by evidence and what's dramatization.

We first meet Avianius. The series' creators found the teen in a historian's database of inscriptions placing people in Pompeii shortly before the eruption and locating them elsewhere after the disaster. The poignant scenarios created for Avianius ultimately show that he is a scared boy just trying to survive.

Next, we meet Julia Felix. Her estate was one of the first houses excavated in Pompeii, says archaeologist Caitie Barrett of Cornell University. Barrett helps Hiddleston tell Felix's story: She was unusual in Roman culture as an independent woman who owned a business. Archaeologists found no sign of horses, carts or treasures at her wealthy estate, suggesting it was evacuated. The documentary explores decisions that Felix may have made about whether to flee.

The series imagines the final character, the Praetorian guard, as a jaded veteran who helped people escape the nearby city of Herculaneum. His story illustrates the cooler heads that could have allowed most residents to get out before ash buried the city.

Pompeii: Out of Time bills itself as telling the stories of survivors, so (slight spoiler) I was crushed to learn that not all the protagonists survived the disaster.

No one knows the actual circumstances these people lived through, but the documentary explores plausible scenarios. That's something historians and archaeologists often do when physical evidence is lacking. Barrett appreciates that the series “uses informed reconstruction of people's biographies as a way to emotionally engage with the past,” she says. “These were real people. They did have real lives.” ✖

In *Pompeii: Out of Time*, a Praetorian guard watches Mount Vesuvius erupt. The documentary aims to tell the stories of people who escaped the volcano's wrath. ✓



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An ETF - Symbol KNOW

2/21/24 IPO Market Open:	\$10.00
7/14/26 Market Close:	\$13.07
Dividends Paid:	\$0.41

Why Not Us?

Abstract

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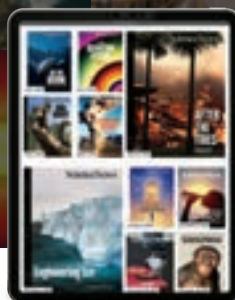
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Expanding STEM Access Through Action



Grassroots organizations play a vital role in expanding STEM opportunities for young people in their communities. Just look at Detroit Educational Takeover, a nonprofit that provides sustained STEM education, academic support and career mentoring for students from underserved communities, helping them build the skills, confidence and connections needed to pursue futures in science and related fields.

Society for Science, publisher of *Science News*, helps make this important work possible through its STEM Action Grants program. The program supports mission-driven nonprofit organizations that are increasing STEM access and scientific understanding across the country. This year, the Society is awarding \$295,000 to 61 organizations across 31 states, Washington, D.C. and Puerto Rico.

Detroit Educational Takeover serves hundreds of students across Detroit and neighboring communities, working to expand STEM programming in schools, launch free STEM camps and build partnerships that allow students to engage with STEM through hands-on learning and long-term mentorship.

Detroit Educational Takeover received one of five \$10,000 capacity-building grants, which are designed to strengthen successful organizations and expand their impact.

The funding supports after-school programming, instructor training and new STEM kits, while also helping the organization create digital learning resources and deepen connections with local STEM professionals.

“The STEM Action Grant has enabled us to continue prioritizing depth of engagement over rapid expansion,” says Jhawan Davis, Founder and President of Detroit Educational Takeover. “The grant has been a stabilizing force for our organization, enabling us to prioritize quality, consistency and equity while thoughtfully refining and expanding our work.”

“We are thankful for the Society’s support thus far,” Davis says. “By prioritizing sustained connection over one-time exposure, the project is supporting outcomes that will endure well beyond the grant period.”

Since its launch in 2016, the STEM Action Grants program has awarded over \$1.7 million to 193 impactful organizations across the country.



WWW.SOCIETYFORSCIENCE.ORG/STEMACTIONGRANTS

Society for Science is a nonprofit organization best known for our award-winning journalism, world-class STEM competitions and STEM outreach programming. For more than a century, our mission has been to promote the understanding and appreciation of science and the vital role it plays in human advancement: to inform, educate, and inspire.



SCIENCE SUPPORTS CALLS TO LIMIT SCREENS IN SCHOOLS

BY SUJATA GUPTA

Last school year, every kindergartner entering the Los Angeles Unified School District was almost certain to spend some school time staring at a screen. This year, not so much. The school board for the nation's second largest district has banned educational technologies, or EdTech, for kindergartners and first graders and is imposing strict use limits for others: a daily maximum of one hour for grades two to five and two hours for grades six to 12.

My own son struggled to manage his computer use in middle school in Vermont, so I have watched with keen interest as the pendulum has swung from the pandemic rallying cry of a device for every student to today's calls for restricting school screen time from concerned parents, educators and policy makers.

Even before lockdowns, companies marketing EdTech promised that the devices and programs could improve academic outcomes by making learning fun and delivering personalized instruction. Mounting research suggests that promise has largely not been realized.

"The global evidence ... exposes the ways unprecedented educational dependence on technology often resulted in unchecked exclusion, staggering inequality, inadvertent harm and the elevation of learning models that put machines and profit before people." So says a damning 2025 book from the United Nations Educational, Scientific and Cultural Organization.

But definitively proving social and academic harms from screen use in school is challenging, and many parents and educators say waiting to act is not an option.

Almost all U.S. students now have school-issued devices, according to the National Center for Education Statistics. And data on EdTech use, though limited, suggests that screen time can take up a big chunk of the school day: up to four hours, per a 2021 nationally representative survey of 850 teachers. What's more, school screen time increases with age, the *New York Times* reported in November. In the *Times*' survey of 350 educators, 32 percent of elementary teachers said their students use screens for an hour or more per day compared with 86 percent of upper-school teachers.

“Your kid can get addicted to digital media at school even if they don’t have access at home.”

— Anna Lembke

EdTech’s proliferation in schools reminds Ben Woo of the arrival of cafeteria vending machines when he was growing up. “The new default lunch for the student body was a soda and a honey bun,” says Woo, a parent and volunteer with Schools Beyond Screens, an LA-based advocacy group that pushed for the new measures. With computers, he says, “schools are putting the honey buns and [sodas] in each kid’s hands.”

Independent research into any given EdTech program tends to be limited. So when school districts choose which program to purchase, they frequently consult company-funded research. Those findings can be misleading, scientists reported in 2020 in the *Journal of Research on Educational Effectiveness*. When EdTech companies study their own programs, they find them to be nearly twice as effective, on average, than independent evaluators do. And companies appear incentivized to bury poor results, the team says.

EdTech can still help students learn, but it has limitations. Plenty of literacy programs for elementary students can help children decipher letter sounds, but few exist for more complicated skills like reading comprehension and written expression, studies have found.

EdTech use has also been linked with declines in test scores in the United States and abroad. The findings fall in line with multiple studies that show students who use a laptop to read and take notes tend to have lower comprehension levels, test scores and course grades than students who use paper. Even the best-designed EdTech programs can’t overcome this screen inferiority effect, says language and technology expert Naomi Baron of American University in Washington, D.C.

Baron’s own work looking at reading comprehension in some 300,000 U.S. fourth and eighth graders has found that reading on screens for just 30 minutes per day was associated with a decrease in scores on a national standardized test. The drop was particularly sharp in younger students, her team reported in 2023 in *Reading and Writing*. Those findings echo a link, reported by other researchers in 2022, between EdTech use and lower test scores on an assessment of reading, math and science literacy among 15-year-olds around the world.

The assumption, Baron says, is that encountering words on a screen or on a page shouldn’t make a difference in comprehension. The data consistently suggest otherwise.

In 2023, every sixth grader at my son’s school received a laptop and a warning from administrators that they’d penalize device misuse. Except they never caught my son.

He’s given me permission to tell his story. His semi-responsible computer use deteriorated after a broken wrist. Sidelined during classes like orchestra and physical education, he was allowed to spend that time on his laptop. Soon, he was hooked on YouTube videos, watching on the sly during other classes and even exams. By the time his cast came off one month later, he was spending half his school day streaming videos.

“Your kid can get addicted to digital media at school even if they don’t have access at home,” says Anna Lembke, a psychiatrist and addiction medicine expert at Stanford University.

With enough time, even the most conscientious students can succumb to digital temptations, says educational psychologist Abraham Flanigan of the University of Georgia in Athens. “If you have devices in the classroom, unless you have really strong controls, you’re going to have distraction.”

But what constitutes strong control? My son’s device use flew under the radar because he didn’t try to access content that would have triggered the school’s monitoring software.

Changes are afoot. At least 14 states are considering or have passed laws limiting in-school screen time. But policy change can be slow and childhood is short. Given that reality, my husband and I moved our son to a low-tech private school where he’s thriving. We are fortunate that we can afford the tuition and that our son’s tendency toward tech addiction was caught early enough for him to regain his footing. Still, I worry about all the other kids hiding behind screens. What does their future hold? ✕

A PHOTOGRAPHIC MEMORY IS WISHFUL THINKING

BY ERIN GARCIA DE JESÚS

In *The Sheep Detectives*, Mopple can't forget anything. He joins a long line of fictional characters with some version of photographic memory — a strikingly useful skill, or at least a key plot device. Sherlock Holmes uses perfect recall to solve crimes (as long as, in the case of the BBC television series, it's in his mind palace). And medical student Joy Kwon's ability comes to the rescue in *The Pitt*, remembering patient room numbers, symptoms and treatments after the ER loses access to electronic medical records.

But our brains don't really work that way.

"A lot of people [believe] that our memory acts like a video recorder, that it exactly captures reality, it holds on to it perfectly," says Gabrielle Principe, a developmental psychologist at College of Charleston in South Carolina. To debunk that idea, she has a simple task for her students: Draw a penny from memory. None can.

Some rare people, mostly children, claim to have what's called eidetic imagery, or an ability to conjure up mental images of objects even after they've been removed from sight. But those images are not perfect and are still temporary. Though exceptional memories do exist, everyone forgets. And that is not a flaw.

In fact, human brains *can't* retain everything. "If we did, we would live in a very cluttered place," says

Simona Ghetti, a developmental psychologist at the University of California, Davis. Our brains wouldn't know which memories to prioritize, affecting our ability to recall the events or details that matter over unimportant particulars.

The ability to retrieve memories of experiences usually starts around age 3, although most early memories are ultimately lost. "There's always the occasional person who thinks that they remember going through the birth canal," Ghetti says. But these claims often fall apart upon careful questioning.

The memories we do hold on to are closely tied to mood. Good ones boost mood, while regularly recalling bad memories can worsen conditions like depression or anxiety. "We forget negative things quicker than we forget positive things," Principe says. And that "is good for us emotionally."

STUDIO DESK





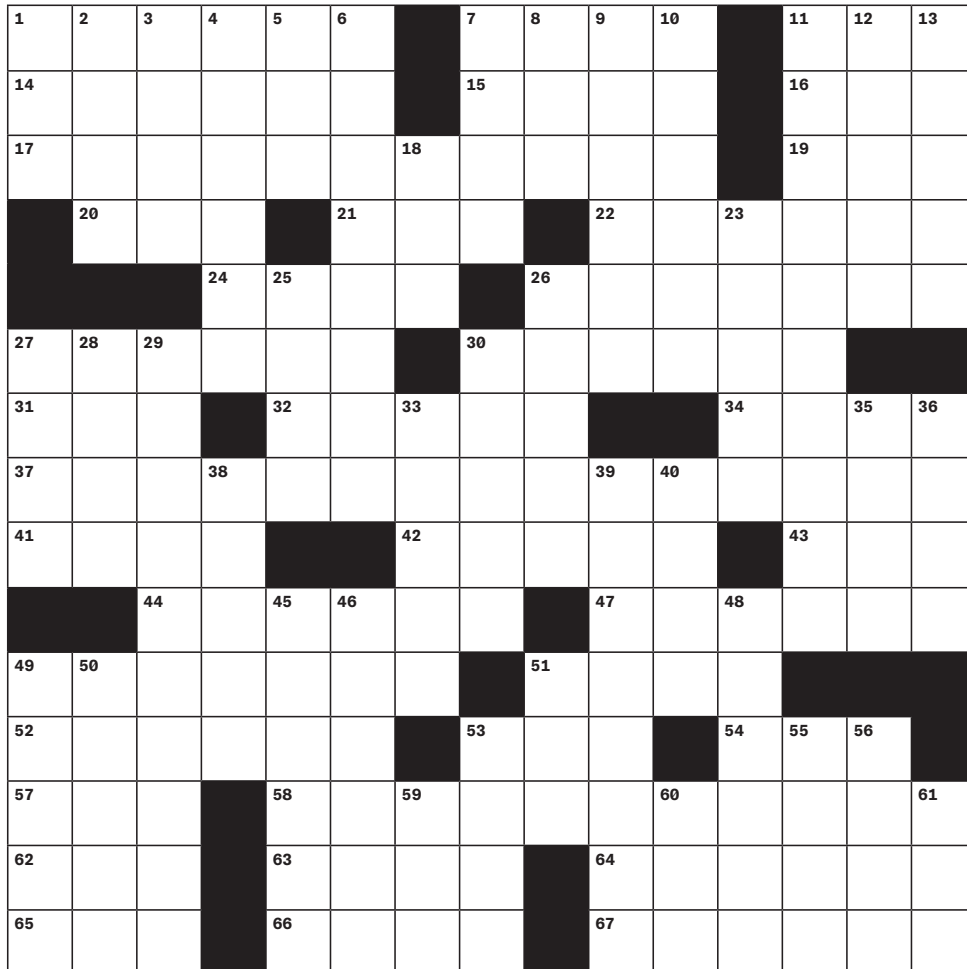
We're also inclined to forget experiences that don't line up with our sense of self, Principe adds. "If we think that we're someone who's kind and optimistic, if there's times where we haven't been, we tend to forget those."

Even retained memories aren't perfectly preserved photographs. They can be faulty, or flat-out false.

Retrieving memories involves activating collections of nerve cells in various parts of the brain, such as the hippocampi, each nestled near an ear; the pre-frontal cortex, toward the front of the brain; and the cerebellum at the back. "Sometimes we grab the wrong thing," Principe says. "We grab what someone told us, we grab a dream, we grab something we've been imagining. And sometimes, those other pieces begin to feel real." Even people who have the rare ability to remember their own experiences in extreme detail — called highly superior autobiographical memory — can make mistakes.

"Most of the time these false memories are pretty innocuous," Ghetti says. Perhaps someone remembers telling their partner a funny story, when in reality, they told their mother or imagined the event altogether. When it's a memory of a crime, though, mistakes can mean the difference between sending someone to prison or not.

As much as we might wish to have a photographic memory in those cases, it's the forgetting that makes room for the memories we do have. And even if the edges are blurred by time, "nostalgia is wonderful," Principe says. "I love the fact that I can still think back on my kids, and they can still be babies when I want to conjure that up in my head." ✕



- 3 Glowing review
 4 Sign up for the military
 5 It may be inflated
 6 Scarfed down
 7 Like tidy beds
 8 Words said at an altar
 9 French brandy
 10 State as fact
 11 Molecule whose blood levels rise during anaerobic exercise
 12 Out of this world
 13 50 percent of fair coin flip outcomes
 18 Camera with a mirror, for short
 23 Exchanges
 25 Currency of Mexico
 26 Sounds indicating a correct answer on a game show
 27 Sliding door on a fume hood
 28 First word of many a fairy tale
 29 Physicist known for his degrees?
 30 Kind of sax
 33 Counterparts to virtues
 35 Zippo
 36 LAX flight board figs.
 38 Oxidize, perhaps
 39 Augustus and Montezuma, for two
 40 Meander
 45 "Ye olde" establishment
 46 Foundational principles
 48 Honors named for the inventor of dynamite
 49 Mythical goat-human hybrids
 50 Monthly *Science News* output
 51 Where Valeri Polyakov spent a record 437 days in space
 53 Church recess
 55 Sch. that sent the first ARPANET message
 56 Self-soothe with repetitive actions, informally
 59 Bit of ink
 60 Caffeinated cup contents, casually
 61 "You follow?"

LAB ANIMALS

BY BEN FELDMAN

ACROSS

- 1 Like much baby food
 7 Shiny, layered mineral
 11 ___-di-dah
 14 Safety ___ (road sign color chosen to contrast sharply with the sky)
 15 Synonym and rhyme of "hullabaloo"
 16 Drink that may come in a yard
 17 *Those for whom the bell tolled in psychology?
 19 Spy org. in the "Bourne" films
 20 Floral adornment
 21 Fútbol cheer
 22 Like programming loops that are inside other programming loops
 24 Goad

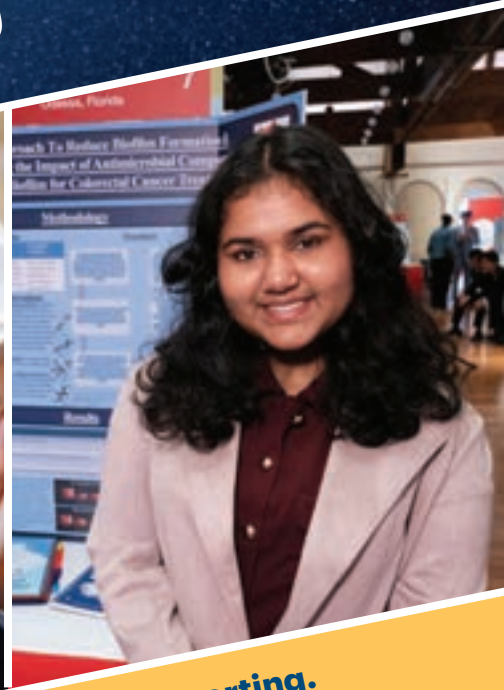
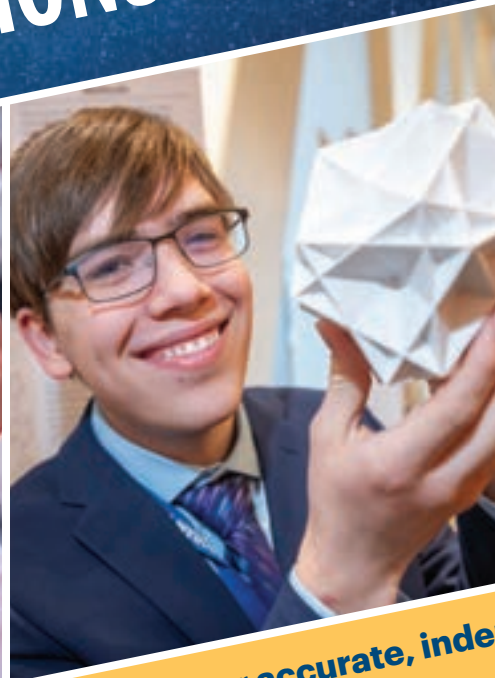
- 26 *With 49-Across, group of species known for how well they fit the bill?
 27 Rated lower on the Mohs scale
 30 Alternative to an Altoid
 31 SNL alum Gasteyer
 32 pH of a chemically neutral solution
 34 Window shopper's purchase, maybe?
 37 *Quantum matter of life and death?
 41 Roll call call
 42 Pink cocktail, for short
 43 Activist ___ B. Wells
 44 Word with egg or Bunny
 47 Bao Li and Qing Bao at the National Zoo, e.g.
 49 *See 26-Across
 51 Office note
 52 Decathlete Eaton
 53 Atmospheric makeup
 54 Clear dishes from
 57 Function
 58 Pursuits driven by personal interest... or what the answers to the starred clues might be called?
 62 Rapa ___ (island with moai)
 63 School support grps.
 64 Luxury wristwatch brand, informally
 65 Collector's goal, perhaps
 66 Direction in which el sol rises
 67 ___ Street (where Bert and Ernie live)

DOWN

- 1 Bubble wrap sound
 2 Border mountain between Europe and Asia

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