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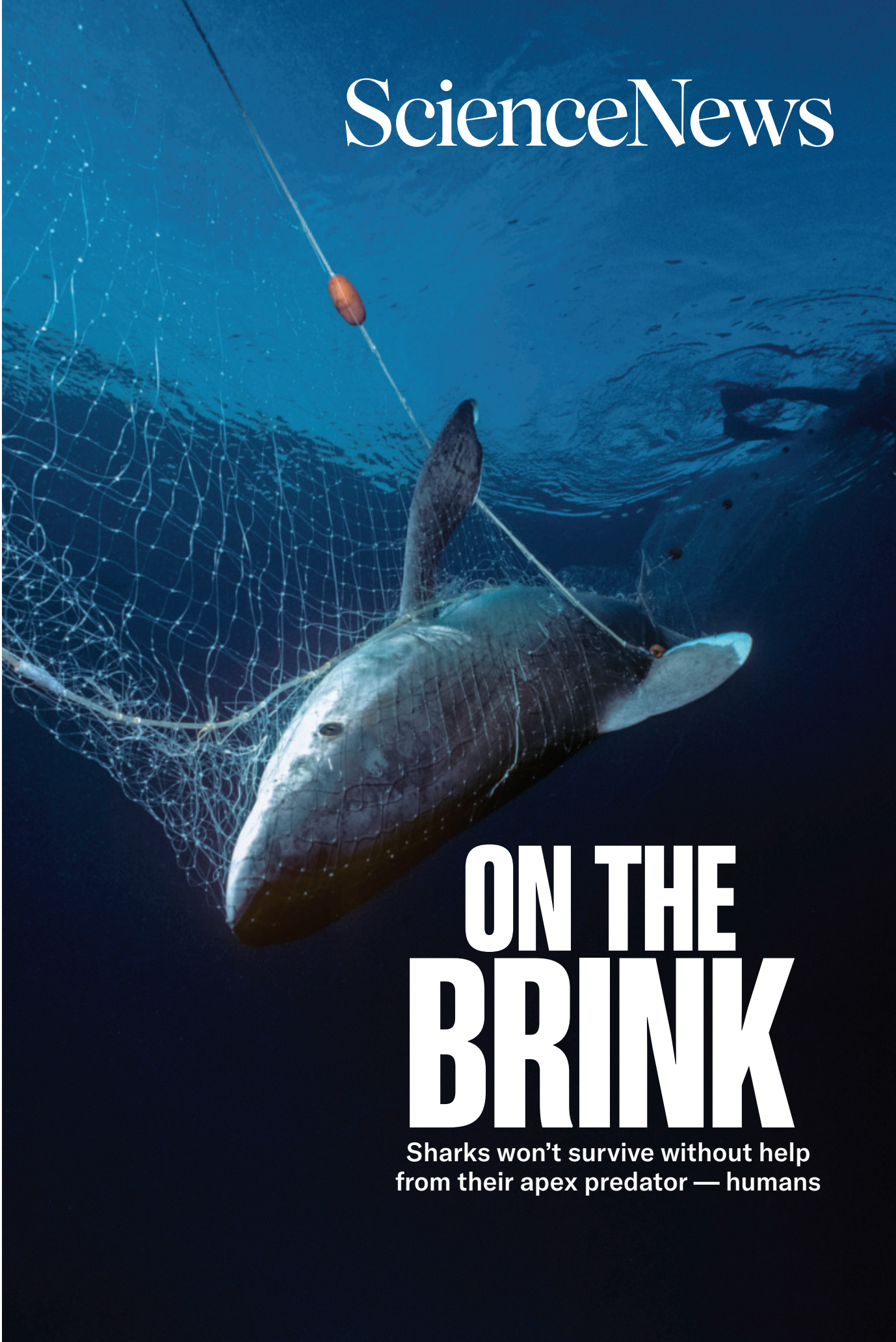

ON THE BRINK

Sharks won't survive without help from their apex predator — humans

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VOL. 207 NO. 7

JULY 2025

THE GREATEST CHALLENGES OF OUR TIME

THROUGH THE EYES OF THE GLOBAL HERO WHO CHANGED THE COURSE OF HISTORY

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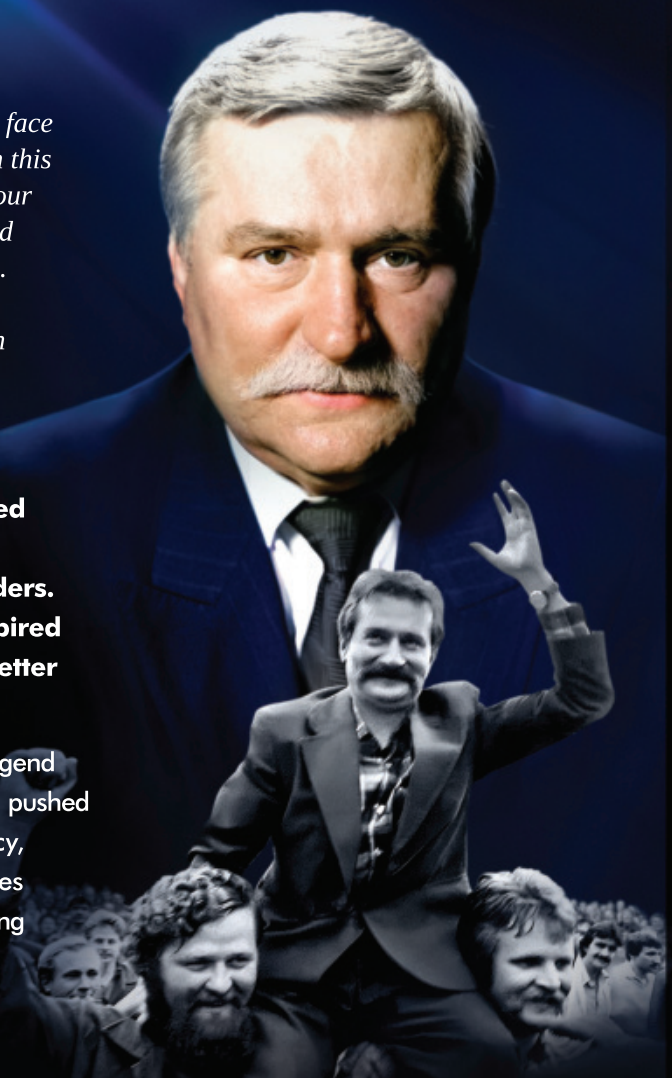

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On the Cover

Jeff Rotman/Alamy Stock Photo

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Save the Sharks 32

Sharks are essential to the health of the ocean, but many species are on the brink of extinction. Can humans get over their misplaced fear of these predators and help them survive? *By Brianna Randall*

The Legacy of the Scopes Trial 40

This year marks the centennial of the case against John Scopes, who was found guilty of breaking a Tennessee law that banned the teaching of human evolution. *Science News* looks back at the controversy and its lingering effects. *By Darren Incorvaia*

Bad Bites 48

Tickborne illnesses are a growing concern in the United States. And perhaps the strangest threat of all is alpha-gal syndrome, an allergy to red meat that develops after the bite of certain tick species. *By Meghan Rosen*

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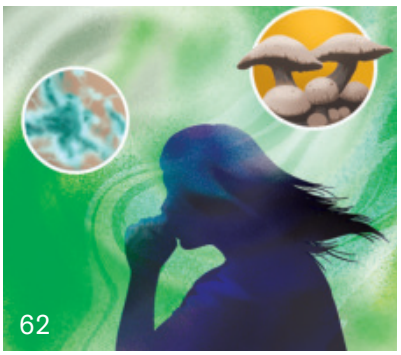

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FROM TOP: SHANE GROSS; ARIK ROPER

Which animal should scare you more?

People have strong feelings about animals. When asked which creatures they fear the most, respondents will often point to spiders, snakes, crocodiles and large furry carnivores like lions, tigers and bears. And all too often, sharks sit at the top of the fear list. But sharks are getting a bad rap. They rarely attack humans, averaging around 64 bites a year worldwide, with fatalities in the single digits.

Lions, elephants and hippos pose greater threats, with hippos killing more than 500 people a year. And like these other keystone species, sharks do good deeds, helping keep prey populations in check and thus supporting the ocean's health (Page 32).

Our fear of sharks is not benign, freelance journalist Brianna Randall writes. Researchers say it contributes to a lack of concern about the rapid declines in shark populations worldwide — declines that are largely driven by human actions such as overfishing. Conservationists are working to change sharks' image in the hopes that humans will learn to love these essential predators before it's too late.

While we're talking about animals we revile, consider ticks. They also end up near the top of humans' most-hated critters list, though they spark disgust more than fear. The teeny arachnids spread a number of diseases, some of which, including Rocky Mountain spotted fever and Powassan virus disease, can be fatal. And as senior writer Meghan Rosen reports, they're increasingly sparking a severe allergic reaction that kicks in after a person eats red meat (Page 48).

Tickborne diseases in humans have more than doubled in the United States in the last two decades, driven in part by rising heat and humidity, which help ticks thrive. There are various treatments but so far no way to prevent infection other than wearing protective clothing, applying repellents and staying out of areas where ticks abound, including brush and grassy areas.

And let's not forget fungi. In the hit series *The Last of Us*, fungi turn people into zombies. We needn't fear zombification, senior molecular biology writer Tina Hesman Saey reports, but climate change is making dangerous infections like valley fever more common (Page 62).

Given the choice, I'd rather spend a day with a shark than a tick. Maybe I'm picking up on director Steven Spielberg's professed regret at making the shark the villain in his blockbuster *Jaws*, which turns 50 this year. How about next time, the shark plays the hero?

Nancy Shute
Editor in Chief
nshute@sciencenews.org

Urgent: Special Summer Driving Notice

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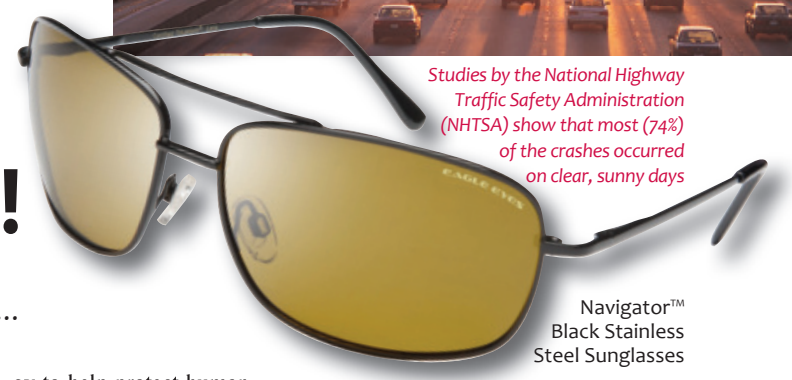

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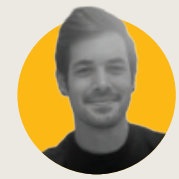
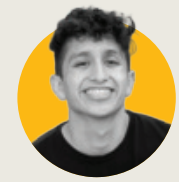
BRIANNA RANDALL

FREELANCE JOURNALIST

● BRIANNA RANDALL used to be scared of sharks. "But the more I learn about these ancient predators, the more I'm in awe." Humans' fear of sharks has hampered efforts to protect them. In this issue, Randall dives deep into the many perils faced by sharks and rays worldwide. Overfishing is a big threat to their survival, and Randall investigates how they are caught, where they're sold and how humans are devising ways to protect them (Page 32). This year, Randall saw firsthand how conservation efforts are working. She swam beside dozens of sharks and rays in French Polynesia, where shark fishing is banned. But on a trip to Baja, Mexico, where shark fishing is still mostly legal, she spotted only a few small rays. While it was disheartening, "it also gave me hope that if people want to protect these animals, like they do in French Polynesia, sharks will return in abundance."



Darren Incorvaia
In July 1925, high school biology teacher John Scopes went on trial in Tennessee for teaching human evolution. The case sparked national debate and became one of the defining moments in the clash between fundamentalism and modernism in the United States (Page 40). Writing about the landmark case was of personal interest to freelance journalist Darren Incorvaia, who studied the evolution of bees' foraging behaviors for his evolutionary biology Ph.D.



Alex Viveros
Science News' former intern Alex Viveros investigated what happens when municipalities halt the fluoridation of drinking water by taking a close look at two cities: Calgary, Canada, and Juneau, Alaska (Page 12). Viveros recently became *Jackson Hole News&Guide*'s town and health reporter. Working on this fluoride story provided a good training ground. "It gave me an example of how science and local government stories can often go hand in hand," he says.

Maria Temming
Maria Temming, assistant managing editor at *Science News Explores*, a publication for younger readers, loves seeing sci-fi tech that's reaching the real world. So she was thrilled that a technology featured in *Iron Man*—a floating 3-D display that a viewer can grab and rotate—is now possible (Page 19). Temming also brought the news to TikTok to "showcase more visual examples of how the display works," she says. Check out the video at bit.ly/SN_floatingdisplay.

Evan Howell
For his geology master's degree, Evan Howell traced the origins of river deposits in Petrified Forest National Park in Arizona. Ever since, the freelance journalist has been enamored with geochronology—the dating of rocks and minerals. In this issue, Howell let his fascination loose by reporting on a new contender for the oldest rock in the United States (Page 21). The story is the fourth most popular article published on *Science News*' website this year—evidence that lots of people care about the history of Earth.

CLOCKWISE FROM TOP LEFT: B. RANDALL; D. INCORVAIA; A. VIVEROS; SOCIETY FOR SCIENCE; E. HOWELL

24 meters

MEGALODON
Otodus megalodon
Extinct for 3.6 million years, these enormous sharks ate pretty much everything in the food chain, an analysis of their teeth suggests.

WHALE SHARK
Rhincodon typus

19 meters

BASKING SHARK
Cetorhinus maximus
Although their gaping mouths stretch a meter wide, these harmless giants gorge themselves on tiny plankton in the water.

12 meters

7 meters

6 meters

GREAT WHITE SHARK
Carcharodon carcharias

6 meters

COMMON THRESHER SHARK
Alopias vulpinus
These predators stun their prey by whipping their long tail, which can be half the length of their body.

ORDERS

- Lamniformes (mackerel sharks)
- Orectolobiformes (carpet sharks)
- Carcharhiniformes (ground sharks)
- Squaliformes (dogfish sharks)
- Hexanchiformes (cow and frilled sharks)

BACKGROUND: KIATTISAKCH/GETTY IMAGES

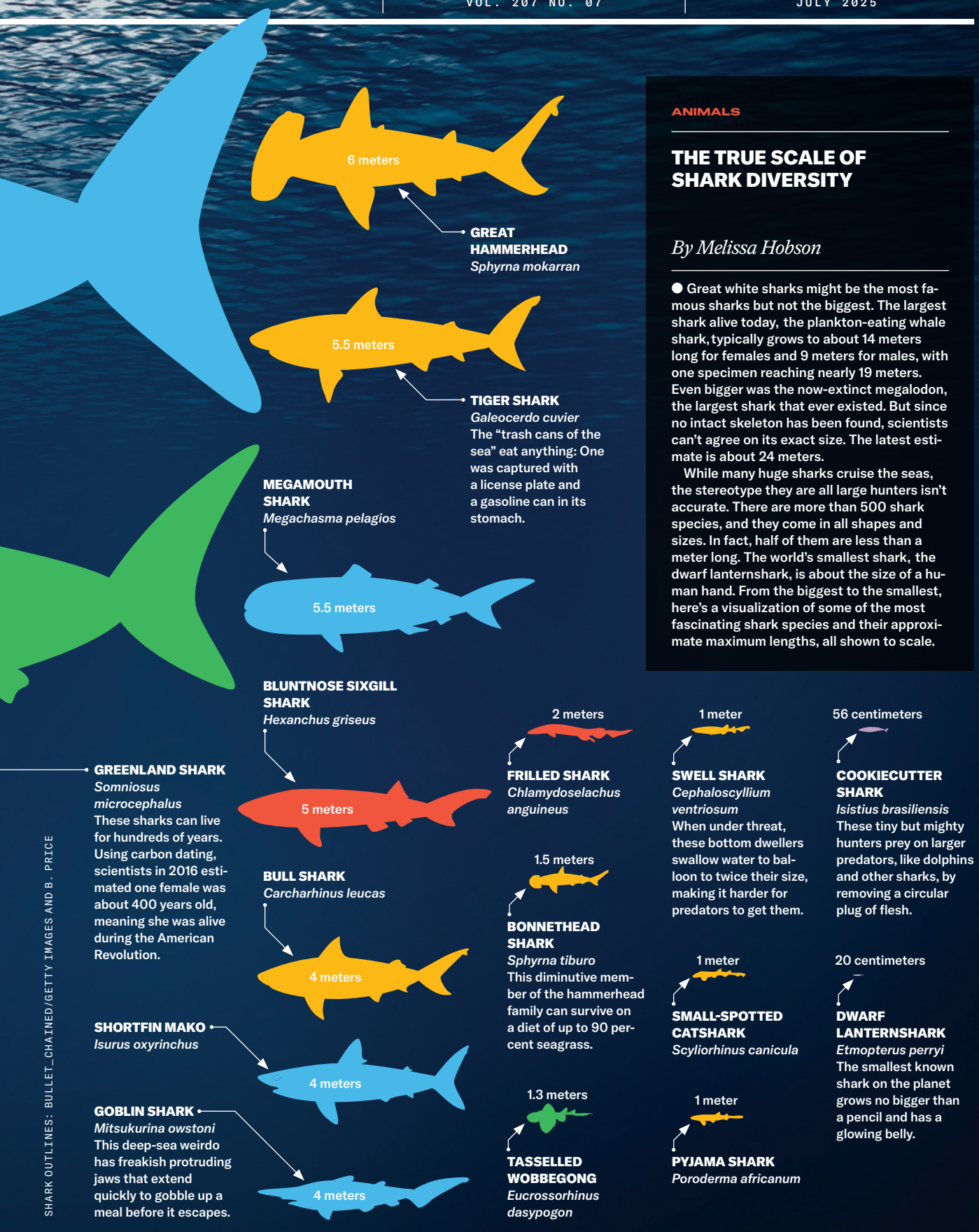
ANIMALS

THE TRUE SCALE OF SHARK DIVERSITY

By Melissa Hobson

● Great white sharks might be the most famous sharks but not the biggest. The largest shark alive today, the plankton-eating whale shark, typically grows to about 14 meters long for females and 9 meters for males, with one specimen reaching nearly 19 meters. Even bigger was the now-extinct megalodon, the largest shark that ever existed. But since no intact skeleton has been found, scientists can't agree on its exact size. The latest estimate is about 24 meters.

While many huge sharks cruise the seas, the stereotype they are all large hunters isn't accurate. There are more than 500 shark species, and they come in all shapes and sizes. In fact, half of them are less than a meter long. The world's smallest shark, the dwarf lanternshark, is about the size of a human hand. From the biggest to the smallest, here's a visualization of some of the most fascinating shark species and their approximate maximum lengths, all shown to scale.



SHARK OUTLINES: BULLET_CHAINED/GETTY IMAGES AND B. PRICE

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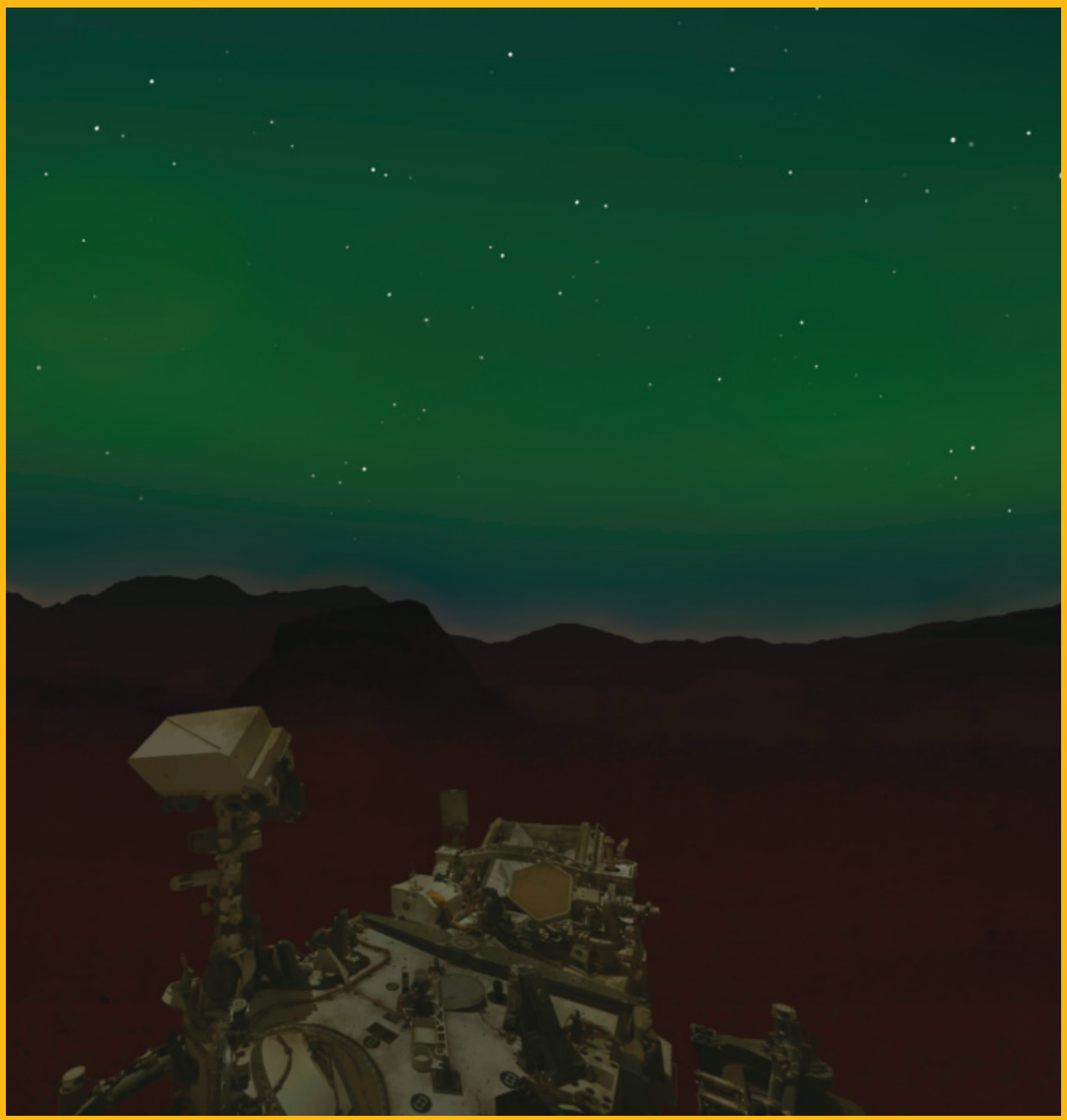
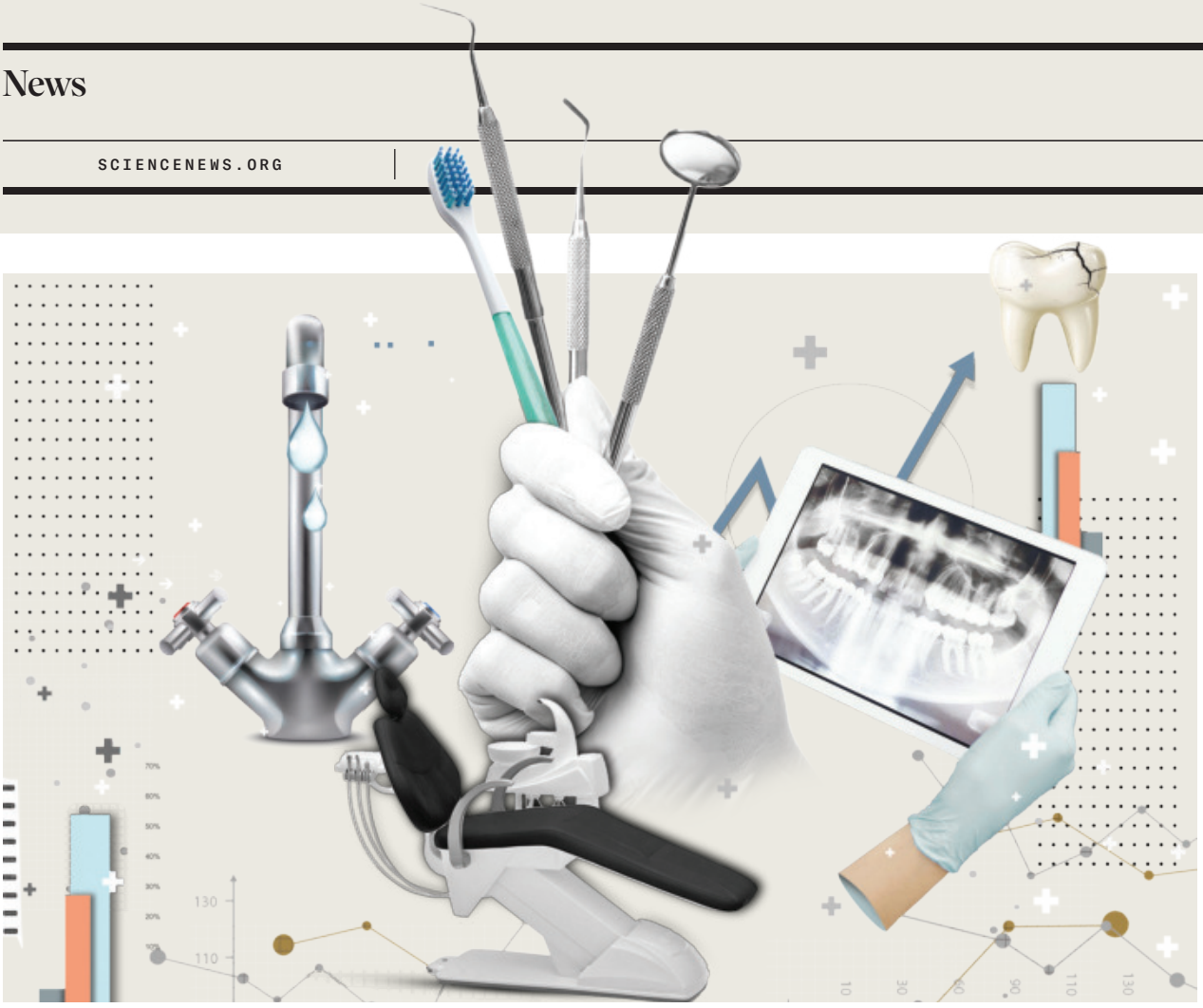


ALEX MCDOUGALL-PAGE

ASTRONOMY

DIM AURORAS LIGHT UP MARTIAN SKIES

● The Perseverance rover has observed an aurora on Mars. It's the first record of a visible aurora from the surface of a planet that isn't Earth, researchers report in *Science Advances*. Unlike on our planet, Mars' auroras are not concentrated near the poles. They appear at all latitudes, but they're relatively dim. Since Perseverance's photos are fuzzy, scientists made this illustration to show what future astronauts might see on Mars, based on the rover's photos. —*Nikk Ogasa*



HEALTH & MEDICINE

When cities stop adding fluoride to water, teeth suffer

By Alex Viveros

● **Warren Loeppky has** been a pediatric dentist in the Canadian city of Calgary for 20 years. Over the last decade, he says, tooth decay in children he's seen has become more common, more aggressive and more severe. Many of his young patients have so much damage that he has to work with them under general anesthesia.

"It's always sad seeing a young child in pain," Loeppky says. "Dental decay is very preventable. It breaks your heart to see these young kids that aren't able to eat."

Loeppky notes that many factors can contribute to tooth decay in children, including their diet and genetics. Still, he believes part of the problem is linked to a decision made in the halls of local government: In 2011, Calgary stopped adding fluoride to its drinking water.

"This decision of city councilors was ... shocking and alarming to dentists, to pediatricians, to anesthesiologists and others in the health care field, who knew what it would mean," says Juliet Guichon, a legal and ethics scholar at the University of Calgary who formed a group that advocated for adding fluoride back to the city's water.

Time and again, studies have shown that fluoride is a safe and effective way to prevent tooth decay. It recruits other minerals, such as calcium and phosphate, to strengthen tooth enamel and fend off acid made by bacteria. Oral health can also affect a person's overall health.

The U.S. Centers for Disease Control and Prevention recommends that communities add 0.7 milligrams of fluoride for every

↑ **Adding fluoride to public drinking water can help prevent tooth decay. But the practice has recently been banned in two states.**

NADIA RADIC

"Ending fluoridation ... based on weak or misrepresented evidence is not a precaution, it's negligence."

— Jennifer Meyer

liter of water. It's up to state and local governments to decide if they want to follow that recommendation. In 2022, the CDC reported that 63 percent of Americans received fluoridated water.

But that practice now is coming under new scrutiny. This year, Utah and Florida became the first states to ban fluoridation; many local governments are also debating the issue. And Department of Health and Human Services Secretary Robert F. Kennedy Jr. directed the CDC to review its recommendation.

Adding fluoride to water has been contested in the United States since the practice became widespread in the mid-20th century. Opponents have historically voiced health concerns, including about tooth discoloration and disproved worries that fluoridated water could cause bone cancer, as well as arguments that fluoridation amounts to mass medication and violates individual freedoms.

More recently, opponents to fluoride in water have cited a controversial systematic review released in 2024 by the National Toxicology Program, which is nested in HHS and evaluates the health effects of substances. That review concluded with "moderate confidence" that water with more than 1.5 milligrams of fluoride per liter was associated with lowered IQ in children.

But that dose is more than double the CDC's recommended amount. The review authors couldn't determine if low fluoride concentrations had a negative effect on children's IQ. And merely finding an association does not prove that higher levels of fluoride caused lowered IQ, the NTP notes on its website.

What happened in Calgary may be a cautionary tale for other municipalities. Lindsay McLaren, a quantitative social scientist at the University of Calgary, recruited dental hygienists to go to schools and inspect the mouths of second-grade students. Some went to schools in Calgary and others went to schools in Edmonton, a similar city in the same province that still fluoridated its water.

In Calgary, the team surveyed 2,649 second-graders around seven years after fluoridation ended, meaning they had likely never had fluoride in their drinking water. Of those, 65 percent had tooth decay. In Edmonton, 55 percent of surveyed children had tooth decay. Those percentages may seem close, but they mark a statistically significant difference at the population level.

"Compared to Edmonton kids, Calgary kids were now considerably worse as far as dental health goes," McLaren says. Other variables, including diet and socioeconomic factors, did not explain the differences, she says.

In 2024, another study found a higher rate of tooth decay-related treatments for which a child was placed under general anesthesia in Calgary than in Edmonton. From 2018 to 2019, 32 out of every 10,000 children in Calgary were put under general anesthesia to treat tooth decay, compared with 17 for every 10,000 children in Edmonton.

The findings didn't surprise local dentists, says Bruce Yaholnitsky, a periodontist in Calgary. "This is just obvious to us. But you need to have proper science to prove, in some cases, the obvious."

In a similar decision, Juneau, Alaska, stopped adding fluoride to its drinking water in 2007, after a six-member commission reviewed the evidence around fluoridation.

A copy of the commission's report obtained from Jennifer Meyer, a public health researcher at the University of Alaska Anchorage, shows that two commission members opposed to fluoridation made claims about the health effects that Meyer says are "false" and "not grounded in quality investigations."

The commission's chair criticized anti-fluoride positions, at one point writing that part of the literature was based on "junk science." But he ultimately recommended that the city stop fluoridation, claiming that the evidence about its safety at low concentrations was inconclusive. With the commission's members split at 3–3, the Juneau Assembly voted to end fluoridation.

Meyer and colleagues analyzed Medicaid dental claims records made before and after the city stopped fluoridation. The average number of procedures to treat tooth decay rose in children under age 6, from 1.5 treatments per child in 2003 to 2.5 treatments per child in 2012.

CONT. ON PAGE 14

CONT. FROM PAGE 13 The cost of these treatments, when adjusted for inflation, jumped by an average of $303 per child from 2003 to 2012. Those costs end up being paid by taxpayers, Meyer says.

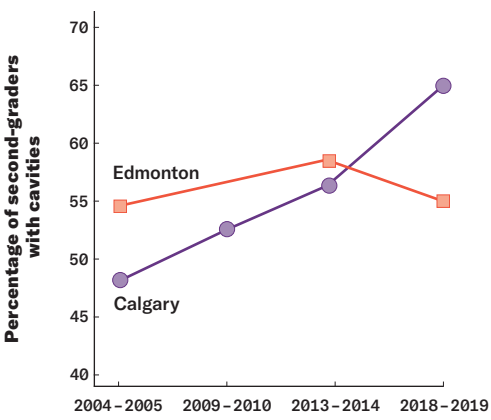
"When politicians decide to withhold a safe and effective public health intervention like fluoridation, they are imposing a hidden health care tax on everyone in their state or community," she says.

More broadly, Meyer says, "ending fluoridation ... based on weak or misrepresented evidence is not a precaution, it's negligence."

Juneau remains without fluoridated water. Calgary, though, voted in 2021 to bring it back.

"More people voted to reinstate fluoride than voted for the mayor. So that's a success," Meyer says. "But in America, we are entering a dark time." ✖

PREVALENCE OF CHILDHOOD CAVITIES IN TWO CANADIAN CITIES



Two Canadian cities with different policies about fluoride in water ended up with diverging dental health in children. Calgary stopped adding fluoride to its water in 2011, while Edmonton did not. Seven years later, the rate of cavities among Calgary's second-graders had increased. In Edmonton, the rate dropped.

FROM LEFT: L. MCLAREN *ET AL/COMMUNITY DENT. ORAL EPIDEMIOL.* 2022; CENTIVAX

HEALTH & MEDICINE

A man let snakes bite him 202 times. For science

By Meghan Rosen

● **Tim Friede recalls** his worst snakebites in screaming detail. The first was from an Egyptian cobra. The second, an hour later, from a monocled cobra. Both bites occurred at his home in Wisconsin. Both were from highly venomous snakes. Neither bite was an accident.

Friede has now logged 202 deliberate snakebites. "It always burns and it's always, always painful," he says. After the back-to-back cobra bites, Friede had to be airlifted to the hospital and spent four days in a coma. "Was it a mistake? Yes. Was it stupid? Yes," he says. But he's in it for the science.

For nearly 20 years, Friede, a snake collector and self-taught herpetologist, has "self-immunized" against venom from some of the world's deadliest snakes. The process involved milking venom from snakes and then injecting tiny — followed by increasingly larger — doses into his body.

Think *The Princess Bride*, says Jacob Glanville, president and CEO of the biotech company Centivax. In the movie, Westley built up immunity to the poisonous (and fictional)

↑ To build immunity to snakes like this water cobra, Tim Friede injected himself with venom over time.

iocane powder by gradually exposing himself to it over time. That's essentially what Friede did, Glanville says. He built up immunity to more than a dozen venomous snakes, including coral snakes, black mambas and rattlesnakes. Then, he'd let snakes bite him. Without that slow buildup, "most of those snakes would have killed him," Glanville says.

But Friede survived. That's because he's got what may be a one-of-a-kind assortment of antibodies in his bloodstream. These molecules can neutralize the toxins in different venoms — and they may help accidental snakebite victims, too.

Glanville, who is working to develop a universal flu vaccine, was interested in other examples where broad immunity might be useful in medicine. Snakebites immediately came to mind. Venomous snakebites kill up to 140,000 people each year, according to the World Health Organization. And more than 600 species of venomous snakes exist. Glanville wanted to create a single antivenom that could target toxins from multiple snakes. He thought Friede could help.

Glanville contacted Friede after reading about him in the news. "I said, 'This might be an awkward question, but I would really like to get some of your blood.'" Friede responded: "I have been waiting so long for this call."

Using a small sample of Friede's blood, Glanville and his colleagues developed an antivenom cocktail that can quell the effects of certain venoms. A combination of just two of Friede's antibodies plus a toxin-blocking drug called varespladib completely protected mice from an otherwise lethal dose of venom from 13 different kinds of snakes, and partially protected mice from the venom of an additional six species, the researchers report in *Cell*.

The new drug is a big step forward, says Andreas H. Laustsen-Kiel, a biotechnologist at the Technical University of Denmark in Kongens Lyngby who was not involved with the work. But that doesn't mean Glanville's cocktail is ready for prime time. "It's an experimental antivenom," Laustsen-Kiel says. "It's a proof of principle."

There are about 10 toxin families that are key targets for antivenoms, says study coauthor Peter Kwong, a structural virologist at Columbia University. The new antivenom cocktail targets three. That's enough to move on to the next phase of testing. The researchers are looking to collaborate with veterinary groups in Australia to treat snakebit dogs.

Friede retired from snakebites and self-administered injections in 2018. Today, he's a healthy 57-year-old who's had regular liver and kidney checkups to ensure that his history of venom exposures hasn't damaged his organs.

"Tim did something remarkable, and we think it could change medicine," Glanville says. But he emphasizes that no one should be injecting themselves with snake venom. "We are actively discouraging anybody from trying it." ✖

PHYSICS

HOW TO GENERATE ELECTRICITY FROM RAIN

By Jude Coleman

● A new way of generating clean power could run your lights with rain.

Hydropower typically relies on moving water to create electricity through mechanical energy, such as spinning turbines in a dam. But a new method, described in *ACS Central Science*, harnesses tiny bursts of energy sparked when rain plunks into a narrow tube.

"There is a lot of energy in rain," says Siowling Soh, an engineer at the National University of Singapore. "If we can tap into this vast amount of energy, we can move toward a more sustainable society."

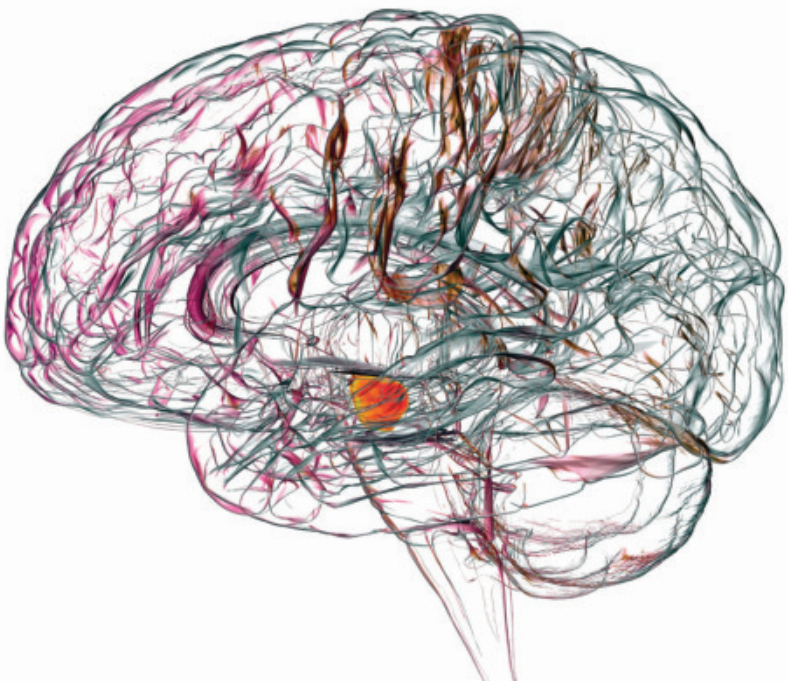
The technique relies on charge separation, in which oppositely charged particles become spatially divided, creating a voltage between them. It's like shuffling across a rug and getting zapped when touching a light switch.

Water running through a conductive tube also creates charge separation. But the amount of charge separation is negligible, and in past experiments the energy produced was outweighed by the power needed to pump water through the system. Soh wanted a way around that.

Instead of using a continuous flow of water, he and his team dripped rainlike drops into a tube 2 millimeters wide. Inside the tube, water driblets flowed with air pockets between them, creating a movement pattern called a plug flow. Plug flows trigger more charge separation than continuous flows, resulting in roughly 100,000 times as much energy.

After traveling the length of the tube, each charged droplet fell into a stainless steel cup. Separate wires connected to the tube and the cup allowed the built-up charge in each to power circuits, creating an electric current. The plug flow from four 32-centimeter-long tubes for 20 seconds produced enough electricity to continuously power 12 LED lightbulbs during that time.

The method could be scaled up by installing rain-catching tubes on roofs or next to water sources that create spurts of water ideal for plug flow, such as waterfalls. ✖



NEUROSCIENCE

Stem cell treatments show promise for Parkinson's

By Laura Sanders

● **Two small clinical** trials revive hope for an old idea: Cells injected into the brain might replace the nerve cells that die in Parkinson's disease. The studies, published in *Nature*, represent early steps for stem cell therapies that aim to replace these dead cells in the brain — and stop Parkinson's and the movement problems, tremors and rigidity that it brings.

In both trials, scientists injected cells derived from stem cells that would go on to become specialized neurons that pump out the chemical messenger dopamine. These are the crucial cells in the brain that die in Parkinson's disease, a relentless neurological disease that is estimated to affect more than 8 million people worldwide.

Together, the results "mark an encouraging first step in stem cell–based therapy for Parkinson's disease," says neurologist Ole Isacson of Harvard Medical School and McLean Hospital in Belmont, Mass.

This isn't a new idea. Decades ago, scientists attempted to replace these missing cells with transplants of fetal brain tissue. The attempts were beset with problems and ethical objections, and ultimately didn't work. But some patients did improve. "There have been times of hype versus hope," says Viviane Tabar, a neurosurgeon and stem cell biologist at Memorial Sloan Kettering Cancer Center in New York City and coauthor of one of the new studies. The current findings point toward hope, she says.

Both of the new studies were small: 12 patients in Tabar's study and seven in the other. These trials were designed to test whether injections of cells derived from stem cells — from fetal tissue in Tabar's study and adult blood cells in the other — are safe. Those earlier studies on fetal brain tissue left some of the volunteers with movement problems that were distinct from those caused by Parkinson's, Tabar says. Other worries included bleeding from where the tube full of cells enters the brain and uncontrolled growth of these added cells, a scenario that could lead to tumors.

None of these scenarios happened. "We confirmed the safety," says neurosurgeon and researcher Jun Takahashi of Kyoto University in Japan, who is a coauthor of the other study.

In both studies, some participants experienced negative events that may have been related to the immune-suppressing drugs they

↖ In Parkinson's disease, nerve cells in the brain's substantia nigra (orange region in this illustration) become impaired or die. New trials suggest stem cells could replace those cells.

KATERYNA KON/SCIENCE PHOTO LIBRARY/GETTY IMAGES

needed to take with foreign cells. Other scientists, including Isacson, get around the need for these drugs by using stem cells made from a person's own cells. Using familiar cells for the starting material may be more time consuming and more variable, Tabar says. But, Isacson notes, cells derived from the person they're meant to treat "may offer additional advantages." Isacson holds patents and licenses for possible therapies that use a patient's own cells.

The new studies weren't designed to test whether added dopamine-producing cells improved symptoms. But there were hints that the cells did help, at least for some people. "It's early days, but it gives us optimism that the treatment may really enhance quality of life for these patients," Tabar says.

Similarly, Takahashi and colleagues saw signs of dopamine being produced in the brains of study participants and symptoms improving for some of the volunteers, suggesting that this approach could be effective. But scientists won't know without larger studies.

Those studies are coming. Later this year, scientists will begin a larger trial with about 100 people using the same cells Tabar used. Tabar has financial interests in BlueRock Therapeutics, the cell therapy company that sponsored the current Phase I clinical trial that she worked on and will also sponsor the larger trial. That study will be double-blind, meaning neither the patients nor the clinicians examining them will know who received cells and who received a sham surgical incision.

Takahashi and colleagues are also collaborating with a pharmaceutical company on a possible clinical trial, he says. ✖

CHEMISTRY

SCIENTISTS HUNT FOR 'FOREVER CHEMICAL' REPLACEMENTS

BY SKYLER WARE

Harmful and persistent "forever chemicals" build up in the environment and in the bodies of animals, including humans. But a new review article lays out a blueprint for replacing those chemicals in certain situations.

A research team has compiled more than a decade of work from multiple labs to detail chemical principles of per- and polyfluoroalkyl substances, otherwise known as PFAS. PFAS show up in products as varied as firefighting foams, nonstick cookware and stain-resistant fabrics. While none of the proposed substitutes outperform existing PFAS yet, the best alternatives approach the same performance in certain water-repelling applications, scientists report in the *Journal of Colloid and Interface Science*.

PFAS usually contain long chains of carbon atoms. Depending on the chemical, most or all of the carbon atoms have strong bonds to one or more fluorine atoms. Mixed with water, some PFAS act as surfactants, which cause water droplets to spread out rather than bead up, even in the presence of oily chemicals where water normally wouldn't mix. This behavior relies on properties known as surface energy and surface tension. Molecules in a material with low surface energy or surface tension don't mind being at the surface of a solid or a droplet of liquid. PFAS surfactants lower the surface tension of water, so they excel in applications like foams that fight gasoline or grease fires.

When used as solid coatings, PFAS force liquids on a surface to bead up into droplets rather than spread out, which gives PFAS-coated materials like nonstick pans their water- and oil-repelling properties.

The strong carbon-fluorine bonds in PFAS don't break down easily, says Julian Eastoe, an interface scientist at the University of Bristol in England. Therefore, the chemicals accumulate in the environment and in our bodies, a buildup that "can be considered as one of the great ticking time bombs in our civilization," Eastoe says. PFAS have been linked to a range of health issues, from high cholesterol to cancer. Some researchers are investigating how to break CONT. ON PAGE 18

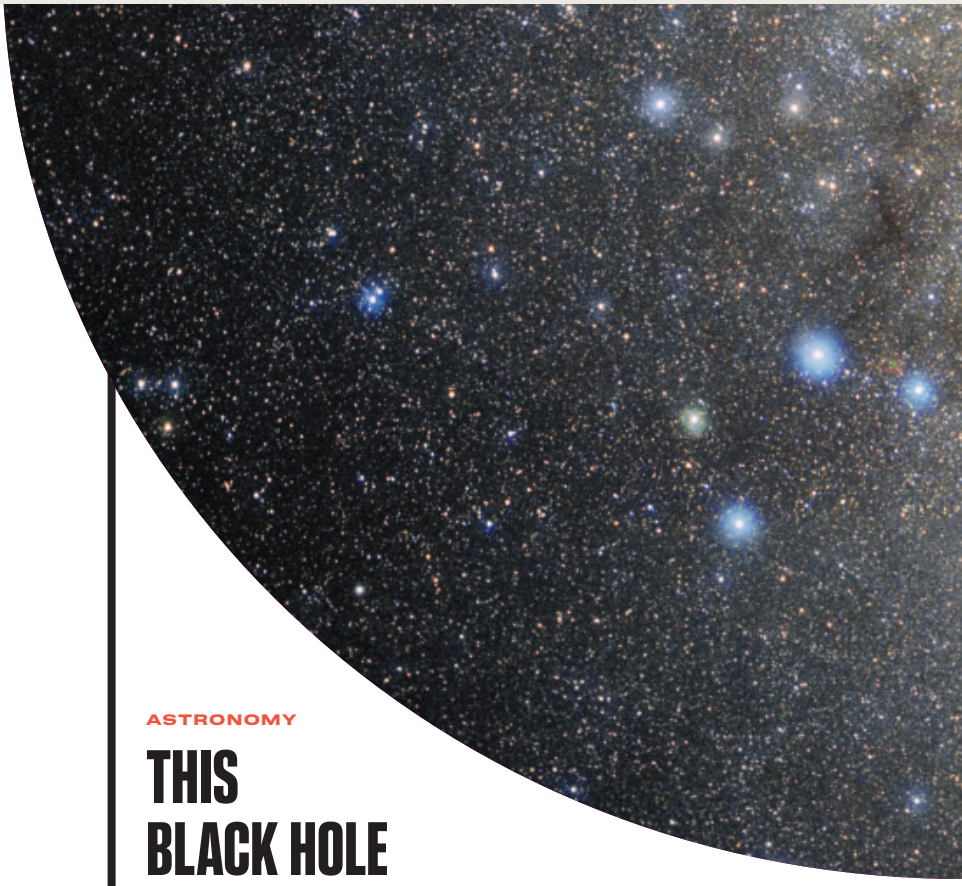
CONT. FROM PAGE 17 down PFAS in the environment, while others — like Eastoe — are making fluorine-free alternatives.

To replace PFAS, scientists need to keep a material's surface energy low without fluorine. Eastoe and colleagues report that for PFAS acting as surfactants, chains of mostly carbon and silicon atoms with a bulky, tree branch–like structure can replace fluorine-rich fragments.

The researchers determined the surface tension of solutions containing water and fluorine-free surfactants at different concentrations, usually by measuring the force required to pull a metal plate out of each solution. These tests suggest that the surfactants' "branches" pack tightly at the surface of a water droplet to reduce the surface tension. Some of the best-performing alternatives reduced the water's surface tension about as well as PFAS surfactants in use today.

It's much harder to compete with PFAS in oil-repelling applications. Oils typically spread out easily, so designing a surface coating that rebuffs oils would require a material with a very low surface energy — a difficult feat without invoking fluorine, says Kevin Golovin, a mechanical engineer at the University of Toronto who was not involved in the work. To effectively repel oils with fluorine-free surfaces, "we really do need a breakthrough."

Still, the research could help counter perceptions that PFAS cannot be replaced, says Martin Scheringer, a chemist at ETH Zurich who was not involved in the work. "We need scientists, chemists and materials scientists who break out of that PFAS track." ✖



E. SLAWIK/NOIRLAB/NSF AND AURA, M. ZAMANI

ASTRONOMY

THIS BLACK HOLE FLIES SOLO

BY KEN CROSWELL

For the first time, astronomers have confirmed the existence of a lone black hole — one with no star orbiting it.

It's "the only one so far," says Kailash Sahu, an astronomer at the Space Telescope Science Institute in Baltimore.

In 2022, Sahu and his colleagues discovered the dark object coursing through the constellation Sagittarius. A second team disputed the claim, saying the body might instead be a neutron star. Observations from the Hubble Space Telescope now confirm that the object's mass is so large that it must be a black hole, Sahu's team reports in the *Astrophysical Journal*.

The discovery made headlines three years ago because all previously known stellar-mass black holes have companion stars that betray their presence: The visible star races around an invisible object with more than three times the sun's mass,

indicating a black hole rather than a neutron star.

While solitary black holes should be common, they are hard to find. The one in Sagittarius revealed itself when it passed in front of a dim background star, magnifying the star's light and slowly shifting its apparent position due to the black hole's gravity.

This passage occurred in July 2011, but the star's position is still changing. "It takes a long time to do the observations," Sahu says. "Everything is improved if you have a longer baseline and more observations."

The original discovery relied on precise Hubble measurements of star positions from 2011 to 2017. The new work incorporates Hubble observations from 2021 and 2022 as well as data from the Gaia spacecraft.

The upshot: The black hole is about seven times as massive as the sun. The second research team revised its assessment in 2023 and agreed that the object is a black hole.

Located 5,000 light-years from Earth, this black hole is much closer than the supermassive one at the Milky Way's center, which also lies in Sagittarius about 27,000 light-years from us. The star-rich region around the galactic center provides an ideal hunting ground for solitary black holes passing in front of stars.

Sahu hopes to find more lone black holes with the Nancy Grace Roman Space Telescope, slated for launch in 2027. ✖

↑ A lone black hole lurks in the far right region of this image, beyond the bright stars of Sagittarius.

UPNAL AB

TECHNOLOGY

TOUCHABLE 3-D DISPLAY LETS YOU PLAY IRON MAN

By Maria Temming

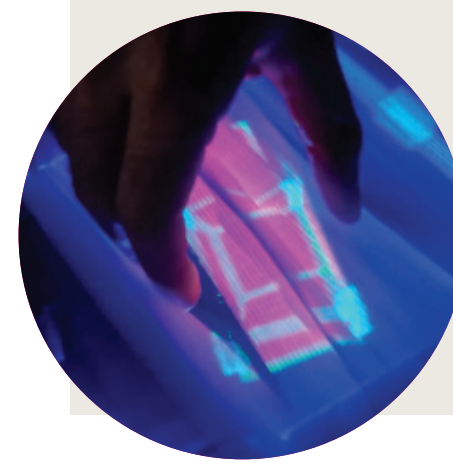
● Floating displays like the ones Tony Stark uses in the *Iron Man* movies are one step closer to reality. A new device renders 3-D graphics that users can grab, drag and rotate. Such interactive visuals—which can be seen without a virtual reality headset—could help create hands-on educational tools, museum exhibits, artwork or video games.

In the past, machines have rendered 3-D objects by moving a flat screen up and down and projecting different 2-D slices of the object onto the screen at different heights. When the screen moves quickly, those slices blur together and look like one continuous shape.

Human-computer interaction expert Elodie Bouzbib and colleagues replaced the flat screen with a row of elastic strips like those in the waistbands of stretchy pants. Users could reach down into the display to touch virtual objects. Cameras tracking users' hand let them manipulate the graphics. Bouzbib's group at the Public University of Navarre in Pamplona, Spain, showcased the device at the CHI Conference on Human Factors in Computing Systems in Japan.

Volunteers who tried the display found it was easier and more accurate than a 3-D mouse. Several expressed surprise that the device felt nice to the touch.

"It feels really soft, actually," says Bouzbib. "It tickles a bit." ✖



GENETICS

WHAT MAKES ORANGE CATS ORANGE?

By McKenzie Prillaman

● Orange cats act so goofy that people joke that the chaotic kitties share one communal brain cell.

But most of these domestic felines—along with multicolored calicos and tortoiseshells—actually do share something: a single genetic mutation that makes their fur ginger, researchers report in two studies in *Current Biology*. Independent teams identified a DNA deletion that causes pigment cells to produce a yellow-red color rather than the default brown-black, solving a mystery that has stumped scientists for decades.

Researchers knew the genetic instructions for ginger fur reside in the X sex chromosome. Most orange cats are male because they usually have just one X chromosome, which is active in each cell. Because female cats normally have two X chromosomes, both X chromosomes would need to carry the orange trait for a girl to be fully ginger. If just one X contains the trait, her coat would likely become a patchwork of orange and black because only one X chromosome is turned on in each cell.

Most other mammals don't get orange hair based on sex, which hinted that domestic cats carry an unusual mutation.

Both research teams identified a deletion near a gene called *Arhgap36*. The deletion boosts production of the protein encoded by *Arhgap36*, but only in pigment cells. There, the protein prevents genes needed to create the brown-black pigment from turning on, leaving the more easily made yellow-red pigment to be produced instead. ✖

PHYSICS

IMITATION DARK MATTER PARTICLES HAVE ARRIVED

BY EMILY CONOVER

If imitation is a form of flattery, then scientists are enamored with the axion. The hypothetical subatomic particle has long eluded scientists. But it's now been conjured up in imitation form, scientists report in *Nature*.

If axions exist, they could explain dark matter, an invisible form of matter inferred from observations of the cosmos. But efforts to spot the particles have been unsuccessful. The axion imitators are the next best thing. "This is the first observation of something like axion particles," says experimental condensed matter physicist Seongshik Oh of Rutgers University in Piscataway, N.J., who was not involved with the research.

The axion imitators arise from the collective behavior of numerous particles within a material, forming what's known as a quasiparticle. The idea to make these axion quasiparticles, proposed in 2010, went unfulfilled for 15 years. To create them, chemist Suyang Xu of Harvard University and colleagues needed just the right substance — thin sheets of a material called manganese bismuth telluride, first created only in 2019.

In this material, electric and magnetic fields are connected: Applying an electric field to a sheet of manganese bismuth telluride induces magnetization. An axion quasiparticle results when the coupling between the electric field and magnetization changes over time, oscillating in a particular way. True axion particles likewise would forge a connection between electricity and magnetism: An axion entering a strong magnetic field would be converted into an oscillating electric field, which forms a particle of light, or photon.

The researchers used a laser to create a magnon, a magnetic wave that travels through the material. Then they used another laser to probe the magnetization of the material, revealing an oscillation in the coupling between the electric field and magnetization over time — the hallmark of an axion.

Manganese bismuth telluride could be used to create a detector capable of spotting true axions in the wild — if they exist. If an axion entered a magnetic field around the material, it would convert into a photon, which would interact with an axion quasiparticle. This interaction would amplify the photon signal, which would otherwise be too weak to detect. ✖

CATHY SCOLA/GETTY IMAGES

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PAUL BRANDES

EARTH

A Michigan rock takes title of oldest in the U.S.

By Evan Howell

● **A weathered sign** in the Minnesota River Valley proudly proclaims "World's Oldest Rock." Erected in 1975, it marks a 3.8-billion-year-old gneiss — or so scientists thought.

Turns out, it's not the world's oldest rock. Since 1999, that title has been held by the estimated 4-billion-year-old Canadian Acasta Gneiss. Now, an analysis indicates that it's probably not even the oldest in the United States, geologist Carol Frost of the University of Wyoming in Laramie and colleagues report in *GSA Today*. The age proclaimed on the sign may be overstated by at least 300 million years, the team argues. Instead, the sign should be uprooted, revised to "America's Oldest Rock" and hammered into Michigan's Watersmeet Gneiss, estimated to be at least 3.6 billion years old.

Like many geology debates, this one started as "a beer question," says coauthor Bob Stern of the University of Texas at Dallas. Extracurricular curiosity led him and Ph.D. student Clinton Crowley to geologists, including Frost, who specialize in dating ancient rocks.

When geologists date rocks, they're dating minerals. "A rock can be composed of minerals that formed at different ages," Frost says. It's like trying to date a building by analyzing its bricks. For Frost, it's almost metaphysical: "So, what is the age of the rock? I mean, what does the question really mean?"

The mineral zircon is a helpful but imperfect record keeper. Its durability — able to withstand weathering, heat and pressure — means it often outlasts its host rock. After crystallizing in magma, zircons can be swept into sediments or crushed by tectonic forces, processes that form new rocks but may (or may not) distort the crystal's age.

↖ Geologists estimate that the Watersmeet Gneiss in Michigan formed at least 3.6 billion years ago.

The team sampled gneisses, a type of metamorphic rock, from the primordial heartland of the North American continent in Minnesota, Wyoming and Michigan. The rocks' banded striations and deformed grains hint at a tumultuous history.

To calculate the rocks' ages, the researchers zapped embedded zircons with lasers and ion beams to measure the steady radioactive decay of uranium to lead.

The disputed champion, Minnesota's Morton Gneiss, contains zircons dating to 2.6 billion, 3.3 billion and 3.5 billion years ago. "There may have been two rocks of different ages that became mixed at a third youngest time," Frost says. The sign boasting an age of 3.8 billion years? Probably incorrect.

Most zircons in Wyoming's Sacawee Gneiss date to 3.4 billion years ago, the team found.

Then there's Michigan's Watersmeet Gneiss. Its zircon ages span a wild 3.8 billion to 1.3 billion years old, with evidence of a violent past: volcanic intrusion (which is as rude as it sounds), metamorphism and tectonic upheaval. The team settled on a minimum age of 3.6 billion years, handing Watersmeet the title of "America's Oldest Rock" — at least for now.

Geologist Mark Harrison of UCLA applauds the efforts but emphasizes that the results only reflect rocks available at Earth's surface.

Frost agrees. The zircons in the Michigan and Wyoming gneisses hint at older rocks that were either recycled in Earth's mantle or remain buried in the crust. "I would love to find them," she says. ✖

HEALTH & MEDICINE

Ozempic and Wegovy take on liver disease

By Meghan Rosen

● **The diabetes and weight-loss drug** semaglutide may also reverse signs of liver disease.

That's the headline result of a new clinical trial that tested the popular medication in patients with MASH, or metabolic dysfunction-associated steatohepatitis.

The disease is marked by fat droplets piling up in liver cells, chronic inflammation and scar tissue in the liver. But a 72-week regimen of semaglutide seemed to turn the disease around. Patients on the drug saw liver scarring improve and fat and inflammation wane, scientists report in the *New England Journal of Medicine*.

Scientists hope "the improvement in scar tissue will translate into less cirrhosis, and less of all of the bad things that can happen if scar tissue continues to progress," says study coauthor Arun Sanyal, director of the Stravitz-Sanyal Institute for Liver Disease and Metabolic Health at Virginia Commonwealth University in Richmond.

MASH is a more severe form of the liver disease MASLD, or metabolic dysfunction-associated steatotic liver disease. The conditions were previously called nonalcoholic fatty liver disease, or NAFLD, and nonalcoholic steatohepatitis, or NASH.

Whatever the name, one thing is clear: Too much fat in the liver can be dangerous. Some 25 percent of people with MASH may develop liver cirrhosis — permanent scarring that damages the organ — and liver cancer, both of which can cause organ failure. Today, an estimated 22 million adults in the United States may be living with the disease. And experts predict that the number will keep rising.

MASH is considered a silent condition. "One of the scary things about liver disease is that for a very long time you have almost no symptoms," Sanyal says. "And then suddenly, all hell breaks loose."

Semaglutide, sold under the brand names Ozempic and Wegovy, has become famous for treating type 2 diabetes and obesity, which are both risk factors for MASH. The drug may treat multiple conditions at once, says Grace Su, president of the American Association for the Study of Liver Diseases.

In the new trial, Sanyal and colleagues examined the effects of taking the drug or a placebo in 800 patients. After 72 weeks, 37 percent of people on the drug saw liver scarring improve, compared with about 23 percent on the placebo. And 63 percent saw liver fat and inflammation go down, compared with 34 percent on the placebo. Follow-up will run through 240 weeks.

How the drug helps the liver remains a mystery. Patients losing weight could explain the organ's loss of fat. But it's not clear how semaglutide might affect liver scarring. "We don't have all the answers," says Stephen Gough, senior vice president at Novo Nordisk, the maker of Ozempic and Wegovy.

Novo Nordisk plans to seek accelerated approval from regulatory agencies in the United States and the European Union to use the drug to treat MASH. According to the company, the U.S. Food and Drug Administration will review its application within six months.

Scientists plan to report results from the second part of the trial in 2029, Gough says. It will evaluate whether semaglutide lowers the risk of serious outcomes, like the development of cirrhosis, liver failure, liver transplantation and death.

If approved to treat MASH, semaglutide would be just the second drug cleared by the FDA for the disease. The first, a medication called resmetirom (brand name Rezdiffra), was approved last year. Doctors expect many more drug approvals in the next two to three years. "It's going to be a flood," Su says. ✖

22 million

Estimated number of Americans living with MASH, a liver disease that can lead to cancer, organ failure and death

E. GORA

PLANTS

LIGHTNING LETS THESE TREES ZAP COMPETITION

BY JAVIER BARBUZANO

Getting hit by lightning is not usually a good thing. But one tropical tree species seems to harness heaven's wrath. Not only does the tree survive strikes, but its height and voluminous crown act as a natural lightning rod, attracting strikes that damage foes and boost its competitive advantage in the dense jungle.

The finding, reported in *New Phytologist*, comes from a years-long effort in Panama, where scientists studied lightning's overall impact on the forest. Using a camera array, drones and ground teams, researchers tracked lightning strikes and their effects. The team expected to find only detrimental effects. But it soon became clear that *Dipteryx oleifera*, also called almendro, benefited from the shock therapy, which harmed rival trees and killed parasitic vines called lianas.

↑ A *Dipteryx oleifera* tree stands out in a forest in Panama. The trees not only survive lightning strikes, but deflect them to damage competing vegetation.

The effects on one liana-covered *D. oleifera* in 2019 cemented the idea of lightning being beneficial, says forest ecologist Evan Gora of the Cary Institute of Ecosystem Studies in Millbrook, N.Y. "It looked like a bomb went off." The strike damaged 115 surrounding trees, half of which died within two years. All the liana vines covering the *D. oleifera* perished. The impacted tree, however, was practically unscathed.

Gora and colleagues documented the fate of 93 trees hit by lightning, including nine *D. oleifera* trees. After two years, all the *D. oleifera* trees were thriving, Gora says. In contrast, there was a 64 percent mortality rate among the other species.

The electric shock also eliminated most of the lianas. Connections between the vines and branches on neighboring trees spread electrical current from the *D. oleifera* trees, damaging those trees as well. This freed up space, light and nutrients for the *D. oleifera* trees. About nine nearby trees were killed per strike.

The findings suggest that *D. oleifera* trees attract lightning. Because they tend to grow taller and wider than their neighbors, *D. oleifera* are 68 percent more susceptible to strikes. One tree was struck twice in five years, and the typical *D. oleifera* is struck an estimated five times on average over its 300-year life span.

Thanks to the competitive advantage gained from these strikes, *D. oleifera* trees are up to 14 times as likely to produce offspring.

How *D. oleifera* survives lightning strikes remains unclear. Perhaps the tree's wood has low electrical resistance, allowing it to safely conduct current to the ground without excessive heat buildup. Another hypothesis is that the tree's crown structure redirects electricity away from the trunk, channeling it toward nearby trees.

"It's really difficult to understand the dynamics of the interaction between trees and lightning," says ecologist Bianca Zoletto of Wageningen University & Research in the Netherlands. She stresses the importance of collaborating with physicists to understand what happens when a tree is struck and to find the coping mechanisms. "It would be fascinating to be able to say something more on that, but that goes a bit more in the physics side rather than the ecological side of the study." ✖

ANIMALS

Frog ribbits erupt via a variety of vocal sacs

By Susan Milius

● **Here's a case of real life** being stranger than fiction. From baby's first storybook to sly adult graphic novels, we're told that male frogs croak with the bottom of their mouths ballooning out in one fat, rounded bubble. Yet "that's actually only half the species of frogs," says herpetologist Agustín Elías-Costa of the Bernardino Rivadavia Natural Science Museum in Buenos Aires. The diversity of structures for ribbitting is astounding.

Some males serenade with a pair of separate puff-out disks like padded headphones that slipped down the frog's neck, throbbing in brilliant blue. Some have sacs that look like balloon Mickey Mouse ears in khaki. Others ribbit with a single upright bubble like a fat horn stub on some inflatable swimming pool toy rhino.

All together, 20 basic forms for vocal sacs have evolved among frogs and toads, Elías-Costa and herpetologist Julián Faivovich report in the *Bulletin of the American Museum of Natural History*. About 18 percent of the 4,358 species examined didn't have vocal sacs at all.

The team studied 777 specimens while visiting museums around the world over 10 years. The survey showed that vocal sacs disappeared between 146 and 196 times across the very twiggy evolutionary branchings of the frog and toad family tree.

That's "an astounding number considering their biological importance," Elías-Costa says. Even without sacs, the animals still emit sounds because, like human speech, frog and toad ribbits originate from the larynx. Vocal sacs amplify the sound and could convey nuances of male quality and sexiness, but can also tip off eavesdropping predators. Females in a few species vocalize too, but it's mostly a male endeavor.

Now that the researchers have worked out the patterns of which species have kept or lost vocal sacs, "we can ask the ecological questions," Elías-Costa says. Frogs and toads shop for mates in a wide range of environments, from lake edges to cozy tree holes, or even the itsy pools that form in the center of bromeliad leaves. Each has different risks — and acoustic issues — necessitating different types of vocal sacs. ✖

Vocal sacs puff out in many different ways among ribbitting frogs and toads. In the male Indian bullfrog (top), a pair of blue bulges puffs outward. In the Surinam golden-eyed tree frog (bottom), the sacs balloon upward toward the head. ↙

FROM TOP: R. RAJU KASAMBE/WIKIMEDIA COMMONS (CC BY-SA 4.0); ARNAUD AURY/WIKIMEDIA COMMONS (CC BY 4.0)

MARK SUMMERFIELD/ALAMY STOCK PHOTO

ANTHROPOLOGY

A DNA study supports a tribe's oral histories

By Bruce Bower

● **Members of New Mexico's Picuris Pueblo Tribal Nation** have long told stories about having descended from ancient ancestors residing in Chaco Canyon.

Genetic evidence now backs up what Picuris people — but not archaeologists — knew all along and fleshes out lost pieces of the tribe's past. The findings, published in *Nature*, came out of a collaborative study between Picuris Pueblo representatives and scientists.

Traditional knowledge keepers at Picuris Pueblo describe ancestral and cultural connections to Chaco Canyon society, a regional network of more than 200 communities that flourished from about 850 to 1150. Chaco Canyon lies 275 kilometers west of Picuris Pueblo.

"Our elders knew we had always been here, but it was very moving and powerful to see it validated on paper," said Craig Quanchello, Picuris Pueblo lieutenant governor and study coauthor, at a news briefing.

Frustrated that their objections to oil and gas drilling in Chaco Canyon were being ignored, Picuris officials asked evolutionary geneticist Eske Willerslev of the University of Copenhagen to fill in gaps in their tribal history using genetic data. Willerslev had organized previous studies of Native American history using DNA.

With tribal permission, Willerslev and his colleagues analyzed DNA from 16 individuals buried 700 to 500 years ago at Picuris Pueblo. For comparison, 13 current tribal members provided blood samples. Additional DNA came from individuals buried in Chaco Canyon.

Ancient and modern Picuris show close genetic ties, including descent from a maternal Chaco Canyon line, the researchers say. Patterns of inherited gene variants among ancient Picuris indicate that their population remained stable, at roughly 3,000 individuals, after the abandonment of Chaco Great House settlements.

Genetic analyses suggest Picuris numbers dropped about 85 percent after Spanish colonial rule began in the mid-1500s, Willerslev's group says. Picuris Pueblo people currently number 306.

In a research area marred by controversy over how archaeologists have treated Indigenous people in genetic research, the Picuris investigation "is a landmark project," says archaeologist David Hurst Thomas of the American Museum of Natural History in New York City.

Unlike many past studies, Picuris people recruited the scientists, keeping full control over participation and publication. ✖

↑ A Round House at Picuris Pueblo is used for rituals and meetings. A DNA study supports oral histories connecting Picuris to ancient Chaco Canyon society.

ANIMALS

WILD CHIMPANZEES GIVE FIRST AID TO EACH OTHER

By Martin J. Kernan

● For wounded chimpanzees, help sometimes comes from other chimps.

Thirty years of observations in Uganda's Budongo Forest reveal that chimp-administered health care—both ape-to-ape care and self-care—happens regularly there, say naturalist Elodie Freymann of the University of Oxford and colleagues.

From the 1990s through the early 2020s, 34 incidents of self-care were recorded at Budongo, Freymann and colleagues report in *Frontiers in Ecology and Evolution*. Some were hygienic acts, like wiping with leaves after bowel movements or mating. Others resembled first aid applied after attacks by other chimps, or being caught in human-laid snares. Licking wounds and dabbing them with leaves were the most observed acts of self-care. Some saliva and plants contain antimicrobial compounds that might prevent infection.

In seven other instances, a chimp helped another chimp. In one extraordinary display, a male freed an unrelated female from a snare set for game, probably saving her life.

Freymann also saw one young male licking the wounds of an unrelated male. "I thought, wow, that's potentially dangerous for them," Freymann says. "But he's doing it anyway."

The fact that chimpanzees help others "suggests a level of social awareness that is too often underestimated," says Christine Webb, a primatologist at Harvard University who was not involved in the research. "It hints at an empathic sensitivity that we typically reserve for our own species."

For most injured chimps in Budongo, however, a helping hand doesn't come, Freymann says—and she doesn't yet understand why. "If chimps sometimes know how to help others get out of snares, for example, why aren't they helping all chimps get out?" she asks. "Why are they being selective about this care, and why do some chimps seem to warrant it, while others don't?" ✖

DELANEY DRUMMOND, ©FIELD MUSEUM

PALEONTOLOGY

This exquisite fossil reveals the evolution of bird flight

By Carolyn Gramling

● **An exceptionally preserved** specimen of the oldest known bird, *Archaeopteryx,* offers the most detailed window yet into the evolution of flight, researchers report in *Nature*.

The remarkable preservation of the specimen lets scientists study aspects of the ancient bird that were previously difficult to discern, from the anatomy of its skull to the arrangement of its feathers to the soft tissues on its hands and feet.

"This is the best *Archaeopteryx* fossil ever found, of what's

arguably the most important fossil taxon of all time," says Jingmai O'Connor, a vertebrate paleontologist at the Field Museum in Chicago.

This new specimen, along with the 13 previously found, highlights "the vast amount of evolutionary change that took place between animals like *Archaeopteryx*... and the origin of modern birds tens of millions of years later," says Daniel Field, a vertebrate paleontologist at the University of Cambridge who was not involved in the new study.

At some point in the 150 million years since *Archaeopteryx* lived, the lineage of feathered landbound dinosaurs began to evolve features that allowed them to fly. When exactly this transition occurred is a great mystery. But *Archaeopteryx* is widely considered the oldest known actual bird, based on aspects of its feathers and skeleton that suggest it was able to take to the skies, O'Connor says. By contrast, its close relative, the feathered dinosaur *Anchiornis*, just misses that cutoff.

↖ When viewed under ultraviolet light, the soft tissues and fine skeletal details of a new *Archaeopteryx* specimen become visible.

Chicago's Field Museum acquired the new fossil in 2022 from a private collector, who had acquired it from another private collector, who in turn had purchased it from yet another private collector back in the 1990s; the history of the fossil before that date is lost to the mists of time.

The purchase was a huge gamble, O'Connor says. At the time, the fossil was still largely encased in rock. But after 1,300 hours of meticulous fossil preparation, the team was astonished to see that they had acquired an almost perfect specimen: nearly 100 percent complete, uncrushed by postmortem geologic pressures, with imprints of soft tissues like feathers and skin.

Perhaps most compelling of all are its feathers. The body was preserved with its wings outstretched, revealing a type of specialized inner, secondary feathers on its upper arm bones known as tertials. Modern flying birds all have tertials, while nonavian feathered dinosaurs, including *Anchiornis*, did not have them.

This suggests that tertials might have been a key advance in the evolution of feathered flight. The presence of tertials may also shed light on another long-standing debate—whether powered feathered flight evolved once or multiple times.

If there's one common ancestor of all flying feathered dinosaurs that had tertials and could fly, then all of its descendants should also retain those tertials, O'Connor says. Later feathered dinosaurs, like *Velociraptor*, that might have lost the ability to fly would still have vestigial feathers. But that isn't the case, she says. "The absence of tertials in all nonflying dinosaurs... supports the idea that flight evolved multiple times."

Archaeopteryx had other ways of getting around, the team says. Scaled feet reveal that it walked on the ground most of the time, O'Connor says. It may even have been able to climb trees. "It was the first dinosaur to use feathers to fly, but by modern standards it was a very poor flyer." ✖

THE HEALTH CHECKUP

CHERISH THE SOUNDS OF SUMMER

BY LAURA SANDERS

The symphony of summer is under way: Lawn mowers droning, cicadas buzzing, kids shrieking, outdoor concerts and cracking fireworks. Summer's delights often reach us through our ears. But protecting our hearing is often an afterthought, if we think of it at all. Here, I'm urging you to take a moment to appreciate the sounds in your life — not as the daughter of an audiologist (which I am) or as a neuroscience writer (also me), but as an everyday enthusiast of sounds.

People are quick to name a favorite color, but favorite sounds aren't always as obvious, says audiologist Deanna Meinke of the University of Northern Colorado in Greeley. To prompt people to think more about their hearing, Meinke has been collecting a treasure trove of people's favorite sounds: kids' laughter, rain on a roof, wind in the trees, a loved one's heartbeat. Animal sounds. Music.

"We protect things we treasure," Meinke says. "So we have to get people to value their hearing."

As we get older, hearing loss is somewhat inevitable, says Frank Lin, an otolaryngologist and epidemiologist at Johns Hopkins University. Cells that detect sounds and send signals to the brain can't regenerate, Lin says. "So it doesn't matter who you are, no matter what you do, everybody's hearing will monotonically get a little bit worse over your entire lifetime."

And that matters, not just for your ears but for your brain. Lin and others have found a link between hearing and cognition. Hearing interventions, including hearing aids when warranted, slow the loss of memory and thinking skills among older people at risk of cognitive trouble.

Although many factors that affect hearing can't be helped, there's one big one that can be: noise exposure. Lin compares loud sounds to sun exposure. One sunburn won't kill you, he says. But like repeated sunburns, "if you keep on getting exposed to a lot of loud noise, you're going to be paying the cost many years down the road."

Part of protecting your hearing is knowing how good it is to begin with. Lin and colleagues have developed a free app called Hearing Number to test hearing at home using headphones or earbuds. As I took it, I flashed back to being a kid in my dad's sound booth, listening intently for the beeps. I didn't get an official hearing test back then, but now I have a baseline: 15 decibels in the left ear and 14 decibels in the right ear. My numbers suggest I don't have trouble hearing people talk in noisy environments, which is a great place to be at middle age.

"People have to think about hearing as this number that they follow over their lives, much like they follow their blood pressure or their weight," Lin says.

Beyond this tracking, there are obvious ways to protect your hearing. Turn the volume down when possible, move away from loud noises and limit the time spent near them. When those adjustments aren't possible, get some hearing protection.

Usually, the type of protection isn't all that important, Lin and Meinke both emphasize. Earmuffs or cheap foam plugs effectively block sounds from lawn mowers or chainsaws, for instance. For concerts, specialized earplugs reduce sounds evenly across the frequency spectrum, leaving music truer to its original sound. And electronic earplugs quickly lessen big sounds, like firearms or nearby explosions. The key is comfort.

When I ask her own favorite sound, Meinke doesn't hesitate: "the sound of the sandhill crane early in the morning in a mountain valley in southern Colorado."

So this summer, give some thought to your hearing, and all of the melodious, tinkling, sharp, beautiful sounds it lets you hear. ✖

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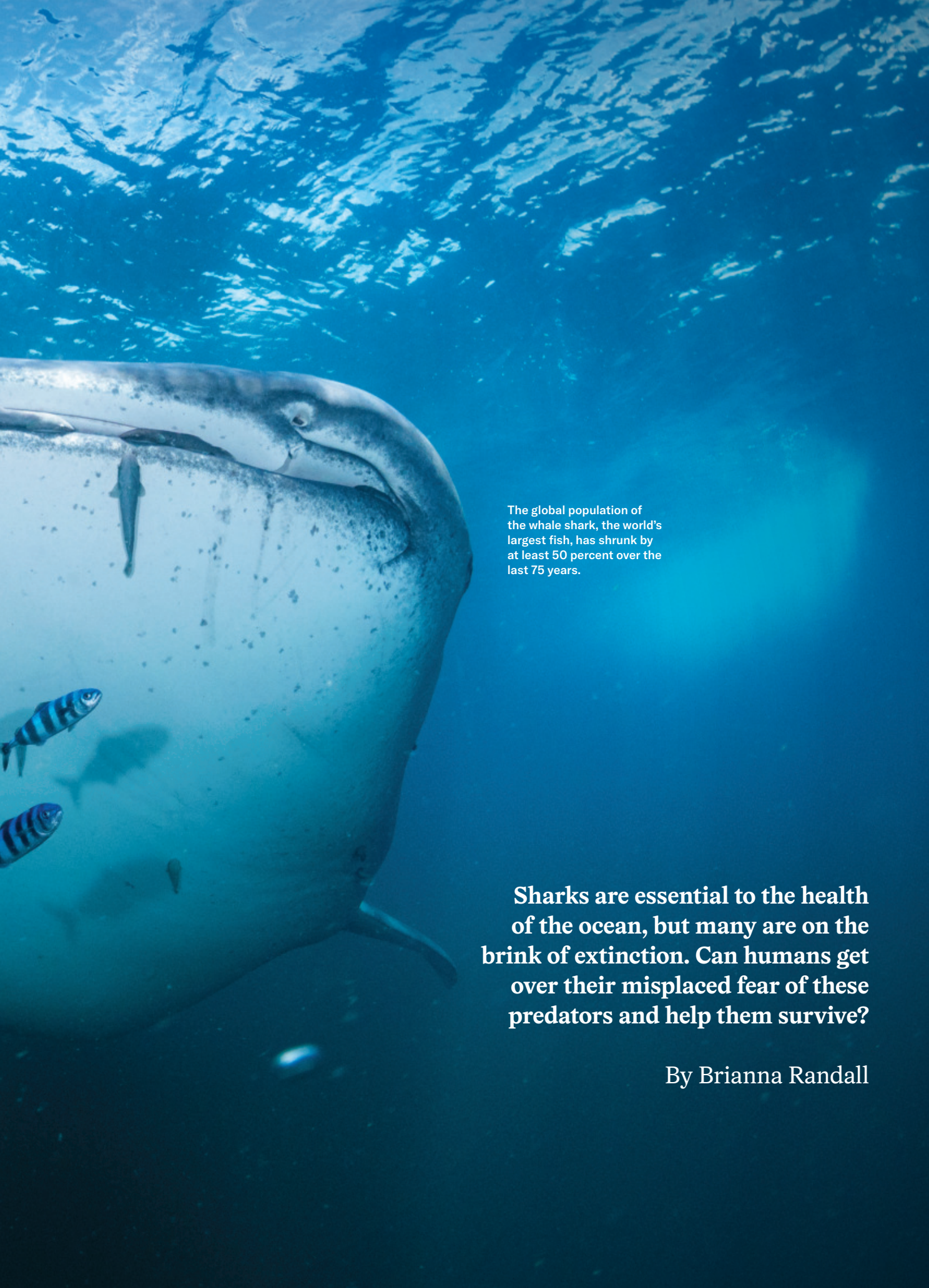
The barbed mouthpart of the lone star tick (false-color micrograph, shown) allows the arachnid to pierce and anchor into skin. Its bites can cause a rare allergy to red meat in humans (Page 48).

Features

DENNIS KUNKEL MICROSCOPY/SCIENCE SOURCE

SAVE
THE
SHARKS



The global population of the whale shark, the world's largest fish, has shrunk by at least 50 percent over the last 75 years.

Sharks are essential to the health of the ocean, but many are on the brink of extinction. Can humans get over their misplaced fear of these predators and help them survive?

By Brianna Randall

FIFTY YEARS AGO this summer, a fictional great white shark stalked beachgoers on Amity Island — and struck terror into moviegoers around the world. *Jaws*, based on Peter Benchley's best-selling novel, was a blockbuster. Its portrayal of sharks as bloodthirsty man-eaters bred widespread mistrust, fear and outright ill-will toward these animals.

In truth, you're more likely to be struck by lightning than bitten by a shark. Millions of people swim in the seas each year, but an average of just 64 bites are recorded annually worldwide. And only 9 percent of those bites are fatal, equaling about six shark-inflicted deaths globally, according to the International Shark Attack File.

Rather than worrying about sharks while we frolic in the ocean this summer, we should instead fear *for* them. Sharks are keystone species that are vital to maintaining the health and resilience of the oceans. But since the 1970s, populations of the world's sharks and their close cousins, rays, have declined by more than 70 percent, scientists reported in 2021. One-third of shark and ray species are threatened with extinction, according to a report released at the end of last year by the International Union for Conservation of Nature.

Although climate change, pollution and habitat destruction take a toll on sharks, the biggest peril they face is the humans who catch them. Overfishing has driven the decline of more than 90 percent of the 1,266 species assessed by the IUCN.

"Generally, people think that sharks are monsters — cold, unfeeling — and we don't really have much compassion for them," says Grant Smith, managing director of Sharklife, a research and education nonprofit in South Africa. "That just leaves them wide open to exploitation and harm."

Steven Spielberg, the acclaimed director of *Jaws*, still feels responsible for turning humans against sharks. "That's one of the things I still fear. Not to get eaten by a shark, but that sharks are somehow mad at me," he said in an interview a few years ago. "I truly and to this day regret the decimation of the shark population because of the book and the film. I really, truly regret that."

To save sharks, Smith and other advocates believe we need to flip the script, to think of sharks as awe-inspiring wildlife instead of food or foes. This requires concerted outreach about why sharks are more valuable alive than dead.

The shift in public perception of whales over the last half-century is one example of how this is possible. Once hunted nearly to extinction, these marine mammals are now protected in most parts of the

Steven Spielberg (sitting atop a dummy shark) directed 1975's *Jaws*, a film that instilled in the public a fear of sharks.

PREVIOUS SPREAD: SHANE GROSS; THIS PAGE: ZANUCK/BROWN PRODUCTIONS/ UNIVERSAL PICTURES/ALBUM/ALAMY STOCK PHOTO

"That's one of the things I still fear. Not to get eaten by a shark, but that sharks are somehow mad at me."

—STEVEN SPIELBERG

world, and whale watching contributes more than $2 billion annually to the tourism economy.

Scientists and shark conservationists say they're seeing signs of progress, though the fishes continue to face substantial threats worldwide.

Animals at risk

Sharks, rays and skates are grouped together as the Chondrichthyes, the class of fish with skeletons made from cartilage rather than bone. They come in all shapes and sizes, from the whale shark, the world's largest fish, which can grow as long as a bowling lane, to the dwarf lanternshark, which can fit in the palm of your hand. They live all across the world, from tropical reefs to polar straits. As predators, many sharks influence the entire food web by keeping in check the populations of fish, marine mammals and crustaceans that they eat. In turn, this impacts the growth of coral, algae and marine plants.

Although sharks have survived on Earth for at least 400 million years, their biology makes them especially vulnerable to threats like overfishing. They grow slowly and don't reproduce until later in life. The Greenland shark, the world's longest-lived vertebrate, has an average life span of 272 years, but females don't breed until they are 150. Great whites can live to be 70 but aren't ready to have babies until middle age. And while some sharks lay eggs, most give birth to only a few pups at a time after a long pregnancy.

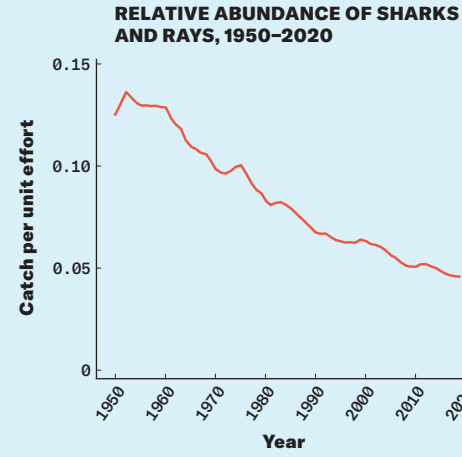
This slow life cycle means sharks "can't keep pace with how fast we're removing them from the environment or how fast their habitat is changing," says Jodie Rummer, a fish physiologist at James Cook University in Townsville, Australia.

Overall, we know very little about most shark species, especially ones that dwell in the deep. This lack of knowledge has made it challenging to protect them. Luckily, that's starting to change. Research has proliferated in the 20 years since the IUCN's first global status report on sharks, published in 2005.

Researchers are using an array of methods to learn more about sharks, from spear guns that collect tissue samples to underwater ultrasound machines that can detect pregnancies to aerial drones that document hunting behavior. Scientists are now discovering about one new shark or ray species each month, says Rachel Graham, executive director of the conservation nonprofit MarAlliance. One-quarter of the more than 1,200 known species of sharks, skates and rays have been identified since 2001.

GLOBAL DECLINE

The relative abundance of sharks and rays worldwide, as measured by fish catches, has dropped since the 1950s. This graph shows the decline in the catch per unit effort, an index calculated by dividing the total weight of a catch by fishing effort.



Fishing sharks to extinction

In a rural village on the coast of Oman, Rima Jabado drives up to a port where men are unloading hundreds of dead sharks from their boats. The shark scientist smiles to disarm the skeptical fishermen. She's there to catalog the hauled-in species and hopes to rely on the men's expertise. Then she wades into the mass of bloody bodies.

This is often how Jabado, who chairs the IUCN's Shark Specialist Group, begins her fieldwork. Across Africa and Asia, Jabado and colleagues survey fish landing sites and markets, where they identify, measure and collect genetic samples from dead sharks and rays to estimate diversity. They also interview fishers to learn how and why they catch these animals. "People thought I was kind of crazy," Jabado laughs as she recalls driving the coast of the United Arab Emirates and Oman for her Ph.D. research 15 years ago. "Not a lot of people are interested in spending days with dead sharks at a fish market."

But it's an effective, if grisly, way to figure out what is (or was) in different parts of the ocean. For instance, from 2010 to 2012, Jabado and colleagues collected data at a bustling

N. K. DULVY *ET AL.*/*SCIENCE* 2024, ADAPTED BY B. PRICE

fish market in Dubai, where sharks are auctioned daily for international trade. More than 12,000 sharks were identified from 37 different species, many of them destined for Asia, Jabado's team reported in 2015 in *Biological Conservation*.

Talking with fishers and fish sellers also reveals how people use sharks and rays, Jabado says. In Mauritania, where people catch several tons of sharks each day, few people eat them. Instead, the animals are dried, packed and shipped to elsewhere in West Africa for food. In Monaco, the skins of critically endangered rays wallpaper elevators in luxury hotels and the interiors of mega-yachts. Around the world, women outline their eyes with makeup that consists of shark liver oil. In China, the bodies of small sharks become pet chew toys.

The 2024 IUCN report, led by Jabado, compiled information from 353 scientists in 158 countries to show where sharks are caught and where they are shipped — and it's not all developing countries. Indonesia, India and Spain account for 35 percent of all sharks killed worldwide. The United States and Mexico round out the top five shark-fishing countries. Meanwhile, the European Union imports nearly 25 percent of all shark and ray meat globally.

Only about one-quarter of sharks are intentionally caught. The rest are bycatch, falling prey to the many nets, hooks and traps that target tuna, cod, shrimp and other seafood. Trawlers towing football field–sized nets that scoop up everything in their path are particularly deadly.

Still, demand for shark and ray meat has doubled since 2005. The global value of this food source rose from $157 million in the early 2000s to $283 million in 2016, according to the IUCN report. More people are turning to these fish as a protein source because supplies of other seafood have also declined from overfishing. And many rural communities depend on sharks for food and income, creating pressure to overfish.

Shark fishing can be sustainable, if the animals are responsibly harvested and quotas are set and enforced by authorities. For instance, 85 percent of the volume of sharks caught in the United States are spiny dogfish, which are certified as a sustainable seafood source by the Marine Stewardship Council because commercial harvests are carefully monitored and regulated. This abundant, roughly meter-long shark is mainly exported to the European Union for fish and chips.

One bright spot is that the demand for shark fins — used to make a popular soup in many Asian countries — has declined in the last 20 years. Typically, fins are collected by catching a shark, hacking off its dorsal fin and then chucking the bleeding animal back into the ocean to die. Targeted media efforts have illuminated this gruesome practice and led to many countries

Workers drag a shark across a fish market in Dubai, where more than three dozen species of shark are sold off.

FROM TOP: TOBY MATTHEWS/OCEAN IMAGE BANK; ARON SUEVEG/ANZENBERGERARON SU/REDUX

A hammerhead shark gets tangled in nets meant to collect other seafood. This type of bycatch is a major threat to sharks.

FROM TOP: GERVAIS ET BOULART/WIKIMEDIA COMMONS; SAMUEL GARMAN/WIKIMEDIA COMMONS; FRANCIS DAY/WIKIMEDIA COMMONS; DUANE RAVER/USFWS/WIKIMEDIA COMMONS; J. MÜLLER AND F.G.J. HENLE/WIKIMEDIA COMMONS

banning shark finning, similar to the outreach campaigns that helped reduce commercial whale harvests.

In 2006, the NBA superstar Yao Ming partnered with WildAid, an international wildlife conservation nonprofit, to expose how the soup is made. When the campaign began, three-quarters of the Chinese people surveyed didn't know that the soup was made from shark fins. (The Mandarin translation is "fish wing soup.") Nineteen percent believed that sharks grow their fins back. (They don't.) Two years after Ming appeared in ads with the slogan "When the buying stops, the killing can too," 82 percent of Chinese people surveyed said they would reduce or stop eating the soup. And 89 percent said shark finning should be banned, which China did in 2019. But illegal finning remains a problem.

Another kind of fishing

Off the palm tree–lined coast of Key West, Fla., on a balmy April weekend, dozens of excited anglers head out in boats. Each team's goal: Hook as many bull sharks as possible in two days to win the Spanish Fly Shark Tournament.

Catch-and-release tournaments like this one are popular in the United States, Australia, South Africa and other countries where recreational sport fishers hope to land a shark for the thrill of it. Between 2005 and 2015, more than 66 million sharks were hauled in by recreational anglers along the U.S. Atlantic coast.

Although most sport fishing rules require releasing the animal after it's been landed, photographed and measured, many sharks are injured or die in the process. When they are pulled up from the water, their internal organs can be crushed and their vertebrae damaged. A global review of catch-and-release research found that an average of 14 percent of sharks die post-release, though mortalities are species specific: Hammerheads, for instance, nearly always perish after being released. Pregnant females of any species are especially susceptible to the stress of capture, which often leads to premature birth or loss of the pregnancy, according to research published in *Conservation Physiology* in 2023.

"Catch and release is still harm," says Smith, of Sharklife. He argues this type of sport would not be condoned for

RARE AND VANISHING

More than 90 species of sharks, rays and skates are critically endangered. Here are just a few species whose populations have plummeted by 80 percent or more over the last 50 to 100 years.

Common angelshark
Home: Northern Europe and the Mediterranean
Threats: Accidental catches (bycatch), recreational fishing, habitat degradation

Dwarf gulper shark
Home: Parts of the Indo-West-Pacific oceans
Threats: Bycatch, fishing for meat, fins and liver oil

Green sawfish
Home: Tropical and subtropical Indian and Pacific oceans
Threats: Bycatch, habitat loss, climate change

Sand tiger shark
Home: Temperate and subtropical waters globally
Threats: Bycatch, recreational and commercial fishing, climate change

Brazilian guitarfish
Home: Argentina, Brazil and Uruguay
Threats: Bycatch, fishing for meat

charismatic land animals like lions. “Would you be allowed to exhaust an animal and then suffocate it for a while, starve it of oxygen, take a few pictures, everybody says, ‘Good’, and then let it free?”

If people were snapping gleeful photos with a dead or injured dolphin, Smith says, “there would be an absolute public outcry.” He hopes we can “close the public empathy gap” and treat sharks with respect and compassion, too.

Smith is advocating to revamp recreational shark fishing rules in South Africa to minimize harm, including mandating the use of professional guides who will enforce humane standards. Another change would be requiring recreational fishers to use low-impact gear like circle hooks, as opposed to the more common — and more deadly — j-shaped hooks. This would reduce the chance of hooking a shark in the gut or gills, which is much more likely to cause harm or death than hooking the fish by the jaw.

Turning fear into fascination

As I kayaked up to a century-old family fishing camp on Isla Partida off Mexico’s Baja California, a dozen children were playing on a sandy spit beside the blue sea. Their fathers and uncles sat in the shade mending fishing nets, the fourth generation of Leóns to make a living by chasing fish — including sharks — from dawn to dusk. Most of them hope the children do not follow in their footsteps.

Paloma Aniló Calderón León, 15, wears a t-shirt with a hammerhead shark logo, framed by the name of a local conservation organization, Pelagios Kakunjá. She told me that she wants to be a marine biologist when she grows up. Her mother, Ana León, and father, Malaeel Salgado Calderón, are all for it. “Fishing is not a business, with the changes we’ve seen,” Calderón says. “There are very few fish left today.” Because it takes increasingly more time and more fuel to find sharks, he says, the profit from fishing is marginal at best.

Now, Calderón hopes to get paid to study sharks instead of kill them. He and his family are part of a project led by Pelagios Kakunjá to train 30 fishers in Baja California as field technicians. Each will drive a boat to find the sharks, then collect blood and tissue samples, drop cameras to collect videos and place sensors underwater to track temperature and water chemistry. One of the species they are searching for is the scalloped hammerhead.

“Coming to Baja in the ’80s and ’90s, it was like going to the Galápagos. There were hammerheads everywhere,” says James Ketchum, a shark ecologist who cofounded Pelagios Kakunjá in 2010. The collapse of shark populations in Baja was sudden, he says. By 2012, “there was nothing, it was an empty lot,” Ketchum remembers. “I was basically crying underwater.” The number of scalloped hammerheads near Isla Partida declined 97 percent in the last 50 years, Ketchum and colleagues reported in *Marine Policy* in 2024. They cited overfishing as the primary cause.

In 2012, Mexico banned shark fishing from May through July each year to protect vulnerable species during the breeding season. And sharks have started to come back. Last year, researchers captured and tagged a juvenile hammerhead for the first time in Cabo Pulmo National Park, a marine protected area near the southern tip of Baja.

Other fishers in Baja are joining the growing ecotourism industry. The region is a world-class destination for swimming with or watching mako, blue, thresher and white sharks. Cristobal Perez, cofounder of the tour company Nomad Diving, says he “hires 100 percent Mexicans” as captains and guides, often choosing local fishers for their knowledge of the ocean and wildlife.

More people on and in the water watching sharks also means more eyes — and cameras — observing them, a boon for science. Kathryn Ayres, a shark ecologist with the conservation nonprofit Beneath The Waves and a tour guide with Latitude Encounters, leads shark-watching trips out of Cabo San Lucas. Ayres and colleagues used tourists’ videos from Baja to help document how orcas feed on whale sharks.

Ayres is also collecting data for an economic valuation of sharks by surveying tourists who come to Baja. Shark-related tourism generates more than $300 million per year globally, a number expected to double in the next 20 years, according to the IUCN report.

A success story

While snorkeling in the teal water off the island of Rangiroa in French Polynesia, I watched two scientists scuba diving below me in search of great hammerhead sharks. When they spot one, they film the animal for identification and use a laser plate to measure its 4-meter-long

LAURENT BALLESTA

There's at least one clear reason why sharks thrive in French Polynesia: A law banned shark fishing in 2006.

body. Next, they deploy a spear gun that places a tracking tag on the shark and also collects tissue for analysis. It's a little like giving a human a shot with a needle, and the hammerhead swims away unharmed.

As part of the three-year Tamataroa Project supported by the groups L'Œil d'Andromède and Gombessa Expeditions, this data will help reveal why endangered great hammerheads aggregate off this island from December through April, where they migrate from and what they eat.

Rangiroa is home to one of the largest remaining groups of these sharks, whose population has declined by an estimated 80 percent globally over the last 70 years. The area also boasts abundant tiger sharks, lemon sharks, gray sharks, blacktip reef sharks, manta rays, stingrays and spotted eagle rays.

There's at least one clear reason why sharks thrive here: A law banned shark fishing in 2006. An analysis of nearly 14,000 observations collected by divers from 2011 through 2018 found an increase in the overall abundance of sharks and rays in French Polynesia, including in Rangiroa. Divers sighted a total of 20 species of sharks and seven species of rays and demonstrated the fishing ban is helping endangered species recover, researchers reported in 2023 in *PLOS ONE*.

Polynesians' willingness to protect sharks stems in part from the "grand cultural link" between people and sharks, says Tatiana Boube, a shark ecologist at the University of French Polynesia in Tahiti. "In Polynesian culture, mankind is at the same level as any other life." For some Polynesian families, sharks are a totem animal.

French Polynesia's success shows that the people who live closest to these animals need to be on board with keeping them alive, Boube says. It also gives hope that sharks will return in force to Baja and other coastal regions where local fishers are changing practices.

Once people are invested in conserving sharks, they are more willing to create and uphold rules that help keep sharks alive, says Graham, of MarAlliance. Conservation regulations in play globally include limits on how many sharks can be killed, no-take marine protected areas and restrictions on fishing gear like nets that kill sharks as bycatch.

The most positive sign that the currents might be shifting in sharks' favor, Graham says, is a change in attitude and behavior. She points to reactions from tourists in Belize as an example. "Instead of 'Oh my god, I'm so scared ... They need to kill the shark.' It's 'Oh my goodness, we got to see a great hammerhead! It was huge. Everybody was so excited,'" Graham says.

Her grand vision is that everyone sees a shark every time they swim in the ocean. For that dream to come true, Graham says, "we need a shark hero in every community." ✖

A scientist measures a great hammerhead shark with a laser plate in French Polynesia, where shark fishing is illegal.

Brianna Randall is a freelance writer based in Missoula, Mont.

In July 1925, celebrity lawyers William Jennings Bryan (seated, left) and Clarence Darrow (standing, right) sparred over whether Tennessee could bar the teaching of human evolution. Here, proceedings were moved to the courthouse lawn due to the sweltering heat.

The legacy of the Scopes trial

A century later, evolution and science are still under attack

By Darren Incorvaia

One hundred years ago, a small town in eastern Tennessee captured the attention of the entire country.

A biology teacher in Dayton was accused of teaching human evolution to his students — which was illegal in Tennessee at the time. The teacher went on trial for his crime, and it quickly became 1925's biggest media event and one of the most sensationalized trials in U.S. history.

From July 10 to July 21, two nationally known, powerhouse lawyers — prosecutor William Jennings Bryan and defense attorney Clarence Darrow — traded barbs in acrimonious court proceedings that were about far more than one small-town teacher violating a state law. The trial was about religion versus science, old versus new and a personal beef between Bryan and Darrow that completely overshadowed John Scopes, the man ostensibly at the center of the case that still bears his name.

The State of Tennessee v. John Thomas Scopes, better remembered today as the Scopes trial, ended with Scopes being found guilty and fined $100, though the verdict was later overturned on a technicality. But the trial was not simply about Scopes' innocence or guilt. It impacted science education for decades and teed up future court battles that far exceeded the Scopes trial in legal importance, though not in spectacle.

While the majority of Americans now accept the theory of evolution as valid, there remain those who reject the idea, even as it has become increasingly essential to understanding the natural world and humankind's origins. Evolution also has broad practical implications for grasping the rise of new pathogens like the virus that caused the COVID-19 pandemic, the emergence of pesticide and antibiotic resistance, and how plants and animals adapt to changing environments.

Looking back on the famous trial, it's impossible to ignore the parallels between the anti-evolution Christian fundamentalists of the Scopes era and today's anti-science movements, including those that reject the reality of human-caused climate change or the safety of vaccines.

To commemorate the centennial of this part-trial, part–media circus, and to understand its legacy, freelance journalist Darren Incorvaia spoke with Randy Moore, a biologist at the University of Minnesota who has researched the Scopes trial for decades and penned the 2023 book *John Thomas Scopes: A Biography*. The conversation has been edited for length and clarity.

Substitute biology teacher John Scopes (shown a month before his trial) was charged with breaking the Butler Act, which prohibited the teaching of human evolution in Tennessee schools.

PREVIOUS SPREAD AND THIS PAGE: WATSON DAVIS/SMITHSONIAN INSTITUTION

Incorvaia: The country was very different 100 years ago. What was life like back then and how did it set the stage for the Scopes trial?
Moore: The first cars were coming off assembly lines. Women claimed the right to vote in 1920. There was new music called the devil's music: jazz. People were leaving rural areas and moving to cities. There was this great war — World War I — that shattered many people's views of all this societal progress. Many people became afraid of change, and there was this collective nostalgia for the good old days.

Combined with that was a movement that came to be known as modernism. This new modern "religion" harmonized with Darwin's theory of evolution by natural selection. Reason and logic became the arbiters of truth, not literal readings of scripture. Many people abandoned the old ways for this modernism, because they felt the old ways were narrow-minded, ill-suited for this new life. The modernists viewed traditional religion as a reversion to ignorance. Meanwhile, the traditionalists said, "This is how you destroy a country."

Incorvaia: So there was a big reaction against this social change going on.
Moore: There was the advent and popularity of religious celebrities, preachers who tapped into this discontent and made opposing evolution their cause. Dwight Moody sort of started it in the 1800s in Chicago. Later, there was Billy Sunday, who would go into towns and attract 5,000 or 10,000 people per service.

Here in Minneapolis, about a mile from my office, was the guy who started to change everything. A preacher here at First Baptist Church named William Bell Riley realized that to change society, he had to get laws passed. He organized the World Christian Fundamentals Association in the late 1910s, and it caught on immediately. Riley was a Baptist, but the group was nondenominational and had membership of up to 6 million people at its height.

In 1925, Tennessee [state representative] John Butler introduced a law banning the teaching of human evolution, and it passed.

Incorvaia: Not all evolution, just human evolution?
Moore: Human evolution. That was the sacred cow. It's fine for skunks to evolve.

Many politicians realized, how can we vote against the law? Billy Sunday had just been in Memphis. He had preached to almost 10 percent of Tennessee's population. If they wanted to be re-elected, they couldn't oppose it.

Incorvaia: So fundamentalists opposed human evolution because the idea that we share a common ancestor with other apes and evolved from earlier forms contradicts the Bible's story of creation, a concern that anti-evolution groups still hold. But that wasn't the only factor that led to the trial. The American Civil Liberties Union wanted to challenge the constitutionality of the law, and locals hoped a court challenge would bring publicity to Dayton. How did those forces combine?
Moore: A secretary at the ACLU saw a little news clipping about Tennessee criminalizing the teaching of human evolution and showed it to the executive director. They placed an advertisement in some Tennessee papers [seeking a defendant to challenge the Butler Act]. They got one response. An engineer named George Rappleyea was in Dayton to close a big coal plant. The coal industry had collapsed several years earlier. The population plummeted. The standard of living was down. They needed something to revive the economy. Rappleyea showed the ad to a group of local businessmen and said, "Why don't we have a test case here?"

They weren't activists in terms of evolution. But they realized, look at all this publicity. We can make some money. This could revive Dayton.

Incorvaia: How did they find their defendant?
Moore: They approached the high school's full-time biology teacher, William Ferguson, who was also the school principal, and they asked him, "Would you consent to be arrested?" He said no. They came across John Scopes, who had been the substitute teacher in Ferguson's biology class for two weeks in April of 1925. He was a first-year teacher and a football coach, and he immediately agreed to it. The trial could not have happened without his consent.

Incorvaia: How did the arrest of a small-town teacher charged with a misdemeanor evolve into a national event?
Moore: The next big step involved William Bell Riley, the guy in Minneapolis who organized the

The trial was not simply about Scopes' innocence or guilt.

fundamentalists in opposition to evolution. Riley heard about this and said, "This is where we take our stand. Who can we get to represent us? William Jennings Bryan."

Bryan was a national figure. He had run for president three times as the Democratic nominee [and was a former U.S. congressman and secretary of state]. He had been condemning evolution. And he said, "Yes, I will help prosecute John Scopes."

His joining the prosecution was a big deal. And then the biggest publicity event occurred. Arguably the most famous criminal defense attorney in the country's history, Clarence Darrow, volunteered to defend Scopes. Darrow had campaigned for Bryan. But Darrow hated Bryan's turn to fundamentalism, especially his opposition to evolution. Darrow was an agnostic, and he wanted to expose Bryan's fundamentalism.

When Darrow entered the contest, people immediately forgot about John Scopes. He was almost irrelevant in his own trial. It became Christianity versus atheism, the old versus the new, Bryan versus Darrow, a showdown. One day, they started the afternoon proceedings before Scopes even got to the courthouse. It wasn't about him.

Incorvaia: What was this showdown like? How did the day-to-day of the trial go?

Moore: The prosecution claimed that just John Scopes is on trial. Did he teach human evolution? That's the only issue. According to his own students, he did. Two of them got up and testified. Meanwhile, the defense explicitly said John Scopes isn't on trial. The law is on trial. This is about his rights. Darrow brought in experts to testify about the validity of evolution, that evolution was a well-accepted idea. The prosecution objected. And on the second Friday of the trial, the 17th, the judge announced that expert testimony would be excluded, and most didn't testify.

Incorvaia: What was the media coverage like? Was it as big as those businessmen hoped?

Moore: More than 100 reporters came to Dayton. Anything Scopes trial was selling papers. What Scopes wore. He was popular with the ladies. He was described as a great football coach. He was a media darling. They could not care less about evolution. They wanted the name-calling, and there was a lot of that. Reporters said, "My editor can't get enough."

The biggest event of the trial happened when the judge ruled that the scientific testimony was irrelevant. The weather had gotten so hot that the proceedings moved outside to this dais, and there was a crowd of several thousand people standing outside the Rhea County Courthouse watching the trial. The defense asked, "You would not let us put on experts about science, can we put on an expert about the Bible?" The judge said yes. And then the defense, in a spectacular move, called William Jennings Bryan as a witness. Bryan knew he couldn't refuse. Darrow grilled him with questions about literal interpretations of the Bible. Was Jonah really swallowed by a big fish? Did the sun stand still? How old is the Earth?

Bryan defended himself relatively well, but the press portrayed him as the loser. *Science News-Letter*, the precursor of *Science News*, reported on "Bryan's pitiful exhibition of ignorance."

Incorvaia: That was a savvy move from Darrow. So in the eyes of the media, Darrow won the showdown with Bryan, even though Scopes lost the trial. What happened after the verdict?

Moore: One of the biggest impacts

The word *evolution* disappeared from textbooks.

THIS PAGE: HULTON ARCHIVE/GETTY IMAGES;
OPPOSITE: TOPICAL PRESS AGENCY/GETTY IMAGES

Local businessmen in Dayton welcomed the Scopes trial, hoping it would bring attention to the economically depressed town. And it did. A thousand people, including reporters, packed the courtroom daily (above). People on both sides of the issue took advantage of the publicity (left).

The Scopes trial damaged the notion of expertise.

of the trial was that the word, literally the word, *evolution* disappeared from biology textbooks. Pictures of Charles Darwin were gone. It was a horrible loss for teaching evolution. This unifying idea in all of biology was not mentioned. Fundamentalism didn't go away. It got stronger.

Incorvaia: And because Scopes' conviction was overturned, the defense couldn't appeal the case, right?
Moore: The ACLU looked for another defendant and couldn't find one. And so the Butler Act was on the books for 40-something years, until the late 1960s.

Two other states had passed similar laws, Arkansas and Mississippi. A teacher challenged Arkansas' law, and the case went to the U.S. Supreme Court. The court ruled unanimously that banning the teaching of human evolution in public schools is unconstitutional [because it violated the First Amendment's guarantee of free speech].

Incorvaia: That's Epperson v. Arkansas in 1968.
Moore: The plaintiff, Susan Epperson, was a new biology teacher in Little Rock. She felt she was in an untenable position. If I teach legitimate biology, I'm knowingly breaking the law. If I follow the law, I'm doing a disservice to my students. She was asked if she would test the anti-evolution law. After getting the enthusiastic support of her husband, she took on the case and won.

Incorvaia: But people don't remember that trial, which seems like a big win for science and evolution.
Moore: There weren't witnesses. There wasn't an explosive Bryan versus Darrow confrontation. The lawyers stuck with the facts. You're right; it was a dramatically important case for science education. The freedom for teachers to teach truth, to teach well-accepted ideas in public schools. Hard to top that one. Susan Epperson finished what John Scopes started.

Incorvaia: Today, anti-science sentiment can be found all across society, including in the federal government. What's the legacy of the Scopes trial and how did it help get us to our current moment?
Moore: The Scopes trial is looked at as damaging the whole notion of expertise. The judge wouldn't allow the scientific experts to testify, and we see that now with experts being shut down. Everybody has their own microphone now. Everyone's an expert. And experts are important, but you need skepticism all the way through it. ✖

BETTMANN/GETTY IMAGES

Biology teacher Susan Epperson (below) challenged an Arkansas law that banned the teaching of human evolution in public schools. In 1968, the Supreme Court ruled the law and others like it were unconstitutional.

Darren Incorvaia is a freelance journalist based in the western United States.

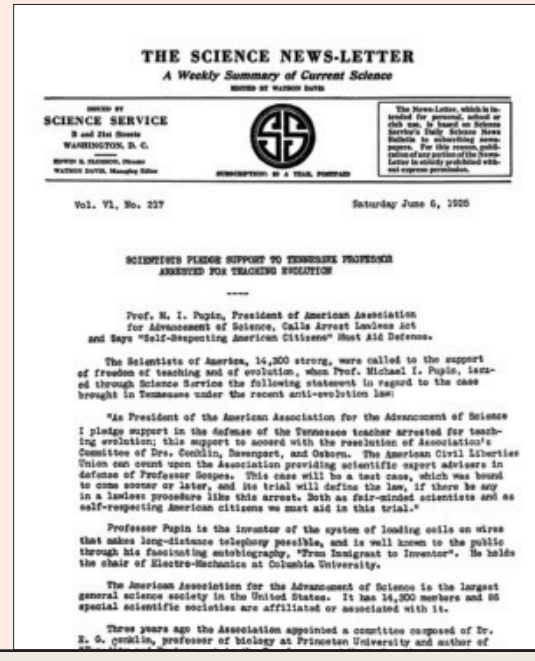
For *Science News*, 100 years of covering attacks on evolution

Watson Davis was among the reporters who descended on Dayton, Tenn., to cover the trial of biology teacher John Scopes in 1925. Davis was there on behalf of *Science News-Letter*, later rebranded as *Science News*.

One hundred years later, the *Science News* archive records the history of legislative attempts to undermine the teaching of evolution — the theory that unites biology — and how that effort evolved over time.

At the heart of the Scopes trial was a state law that banned the teaching of human evolution. But by 1925, there was already fossil evidence that humans had indeed evolved from apelike ancestors. Neandertal fossils had been discovered in Germany in 1856, three years before Charles Darwin published *On the Origin of Species*. The even more ancient species *Homo erectus* had been unearthed in Asia in 1891. And a skull that looked like a mash-up of an ape and a human had been uncovered in Africa in 1924. "There seems to be little doubt," *Science News-Letter* said of the skull, "that there has been discovered ... a most important step in the evolutionary history of man."

When Davis and colleague Frank Thone, *Science News-Letter*'s biology editor, went to Dayton, they didn't just report on the trial. They were also chummy with the defense lawyers, even staying in the defense team's command post, which Thone called "the headquarters for the defenders of science, religion and freedom." Davis also rounded up evolution experts who could testify on behalf of Scopes. Today, such activism is considered unethical in journalism. But standards were different in the 1920s. Even with Thone and Davis' help, Scopes still lost.



THE SCIENCE NEWS-LETTER

A Weekly Summary of Current Science

ISSUED BY SCIENCE SERVICE, WASHINGTON, D. C.

Vol. VI, No. 227 — Saturday June 6, 1925

SCIENTISTS PLEDGE SUPPORT TO TENNESSEE PROFESSOR ARRESTED FOR TEACHING EVOLUTION

Prof. H. I. Pupin, President of American Association for Advancement of Science, Calls Arrest Lawless Act and Says "Self-Respecting American Citizens" Must Aid Defense.

The Scientists of America, 14,000 strong, were called to the support of freedom of teaching and of evolution, when Prof. Michael I. Pupin, issued through Science Service the following statement in regard to the case brought in Tennessee under the recent anti-evolution law:

"As President of the American Association for the Advancement of Science I pledge support in the defense of the Tennessee teacher arrested for teaching evolution; this support to accord with the resolution of Association's Committee of Drs. Conklin, Davenport, and Osborn. The American Civil Liberties Union can count upon the Association providing scientific expert advisers in defense of Professor Scopes. This case will be a test case, which was bound to come sooner or later, and its trial will define the law, if there be any in a lawless procedure like this arrest. Both as fair-minded scientists and as self-respecting American citizens we must aid in this trial."

Professor Pupin is the inventor of the system of loading coils on wires that makes long-distance telephony possible, and is well known to the public through his fascinating autobiography, "From Immigrant to Inventor". He holds the chair of Electro-Mechanics at Columbia University.

The American Association for the Advancement of Science is the largest general science society in the United States. It has 14,000 members and 86 special scientific societies are affiliated or associated with it.

Three years ago the Association appointed a committee composed of Dr. E. G. Conklin, professor of biology at Princeton University and author of

In 1925, *Science News-Letter* published a statement from scientists who pledged support for John Scopes.

Bans on teaching evolution prevailed for another 40 years, until high school teacher Susan Epperson took on Arkansas' version. As *Science News* wryly noted, "Typically, Arkansas teachers skip [evolution] chapters or tell their students it is illegal to read them, thereby assuring that they will be read." In 1968, the U.S. Supreme Court struck down the law as unconstitutional.

But that didn't stop foes of evolution.

In the 1970s and '80s, the aim became adding the "science" of creationism — the biblical belief that the universe and all life were created by God — to school curricula. In 1982, *Science News* covered a challenge to another Arkansas law, the Balanced Treatment for Creation-Science and Evolution-Science Act.

The American Civil Liberties Union had filed suit because creationism is not science, and the law "would bring religion into the schools," *Science News* reported, noting that "the purpose of the law was to advance a religious belief." A judge agreed and declared the law unconstitutional based on freedom of religion protected by the First Amendment.

In the 2000s, creationism returned to the classroom under a new guise, intelligent design. "That viewpoint holds, among other things, that organisms are too structurally and biochemically complex to have arisen only in accordance with natural forces," *Science News* explained in 2006. The creator was left unsaid, but a federal judge still ruled that intelligent design was religion.

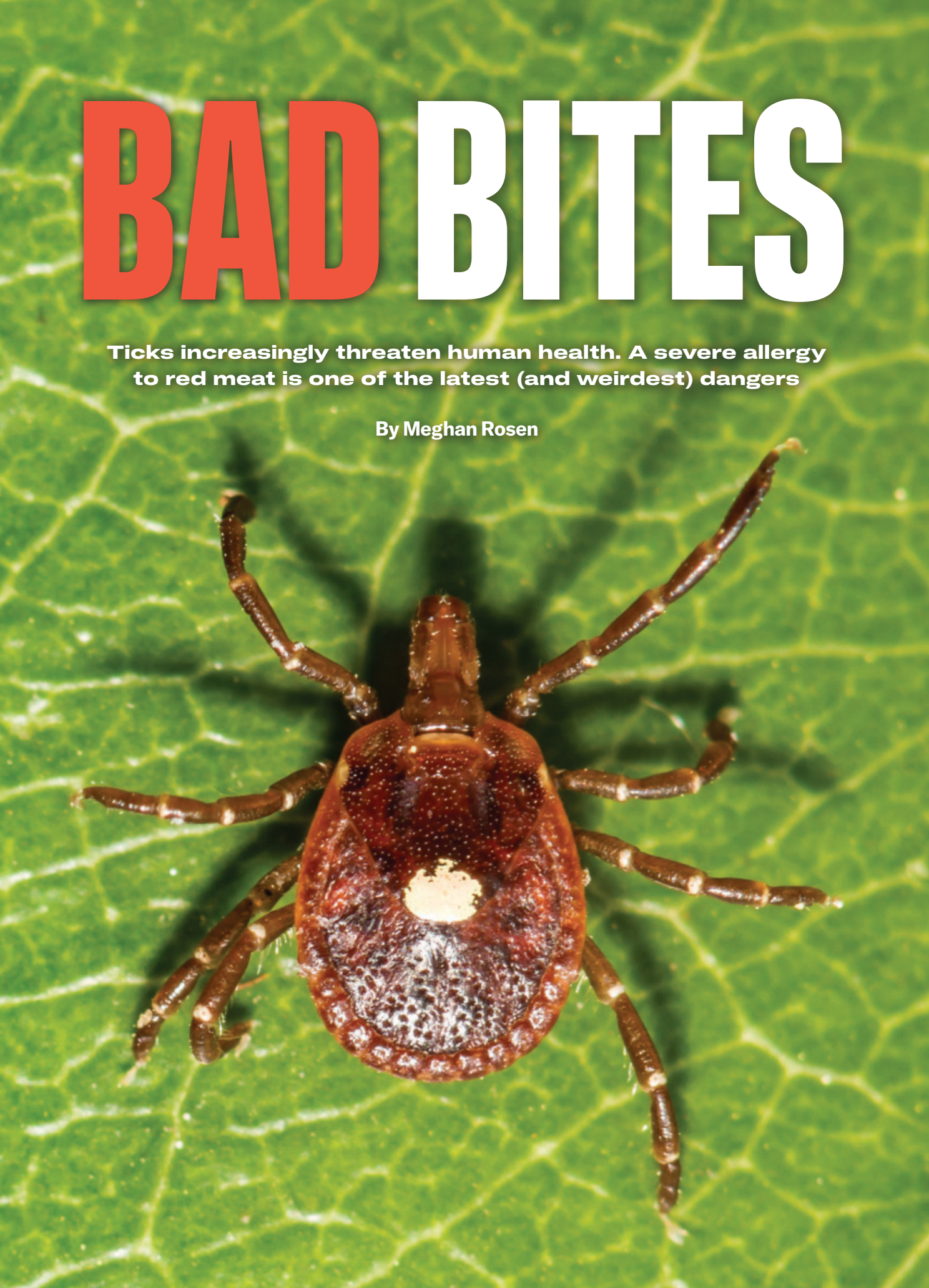
Today, several states have laws that define academic freedom as being able to teach scientific controversies, allowing discussion of intelligent design. As we embark on our second century on the beat, *Science News* will continue to report on efforts to prevent teaching of evolution.

— *Erin Wayman*

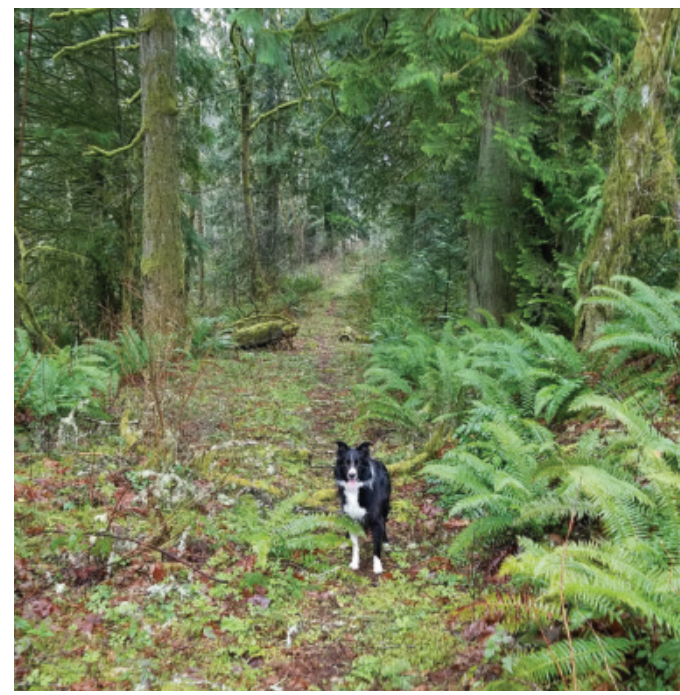
BAD BITES

Ticks increasingly threaten human health. A severe allergy to red meat is one of the latest (and weirdest) dangers

By Meghan Rosen



Cathy Raley has picked up ticks on hikes with her border collie, Jake, in the wooded outskirts of Olympia, Wash. One may have sparked alpha-gal syndrome, a severe allergy to red meat. ↓



Cathy Raley's first bout of hives woke her in the middle of the night with itchy bumps that crept up her arms and spread to her legs and back. Her second bout took her to the hospital.

It was a June afternoon in 2017, and she was getting ready to take her dog, Jake, on a hike. The hives started suddenly, when she was about to load Jake into the car, but this time was different, Raley says. Her tongue was swelling, and her throat was getting tight. "That's when I called 911."

First responders gave Raley a shot of epinephrine in her thigh, but it didn't help much. Her vision tunneled. Paramedics helped her into an ambulance and injected another shot into her arm. On the way to the hospital, Raley stopped being able to swallow.

Immediate treatment with a steroid and an epinephrine nebulizer, which delivered the medicine directly to her throat,

↖

Lone star tick (*Amblyomma americanum*)

Linked to: Alpha-gal syndrome, Bourbon virus, Ehrlichiosis, Heartland virus, Southern tick-associated rash illness and Tularemia

OPPOSITE PAGE: JASON ONDREICKA/ALAMY STOCK PHOTO;
THIS PAGE, FROM TOP: C. RALEY; XZISE/WIKIMEDIA COMMONS, CDC

↗
Black-legged tick (*Ixodes scapularis*)

Linked to: Alpha-gal syndrome (suspected), Anaplasmosis, Babesiosis, Ehrlichiosis, Hard tick relapsing fever, Lyme disease and Powassan virus disease

eventually calmed her symptoms. By the time she arrived at the emergency room, she was able to swallow again. After four hours in the hospital, she was cleared to go home.

Raley had had an anaphylactic reaction — "a fairly major one," doctors told her. Such reactions can be life-threatening. But what triggered it? She was 61 years old and wasn't allergic to anything that she knew of. "I had absolutely no idea," she says.

About a week later, Raley visited Seattle-based allergist William Butler, who combed through her history looking for clues to explain the symptoms. Her hives had erupted in the middle of the night, a sign that she was experiencing a delayed reaction. She hadn't eaten anything out of the ordinary. Though on both occasions the hives had occurred after she'd cooked for visiting company — beef tacos one time, pork sausage the other.

"I have no idea if it's related," Raley finally told Butler, but "two months ago, I got bitten by a tick." Butler looked at her. "That opens up some real possibilities," she recalls him saying.

Raley lives in the wooded outskirts of Olympia, Wash., and liked to hike with Jake, an energetic border collie, on the old logging roads near her property. After one hike earlier that year, she had pulled a tick off her shoulder. The bite became irritated and sore to the touch. That had never before happened to Raley, a now-retired wildlife biologist who had been bitten by ticks in the past.

Butler suspected she had alpha-gal syndrome, a rare red meat allergy that can develop in response to the bite of a lone star tick (*Amblyomma americanum*). The diagnosis was later confirmed by lab testing. There was just one problem: Lone star ticks aren't found in Washington. Their range is entirely east of the Rocky Mountains — thousands of kilometers from Raley's hiking trails.

Her case and a different one reported in Maine suggest that the lone star tick isn't the only species in the United States capable of triggering this allergy, researchers reported in two papers published in the April *Emerging Infectious Diseases*. Two other tick species, the western black-legged tick (*Ixodes pacificus*) and the black-legged tick (*Ixodes scapularis*), also called the deer tick, may be culprits.

"It was a very surprising finding," says Hanna Oltean, an epidemiologist at the Washington State Department of Health.

But in general, tickborne diseases in the United States are on the rise. A changing climate may be driving the critters into new areas. Higher temperatures mean ticks are more likely to survive in places that were once inhospitable. And more ticks means more diseases like alpha-gal syndrome.

Because alpha-gal syndrome isn't well-known, experts such as Oltean are trying to raise awareness among health care providers and the general public alike. "It's important for people to be aware of the risk," she says, "so that they can take appropriate precautions."

Missed diagnosis

The saliva of certain tick species carries a sugar molecule called alpha-gal. These species include the lone star tick and others found in Europe and Australia. Scientists think that when these ticks bite, the sugar molecule and perhaps other factors in tick saliva get into the body and can somehow make the immune system go haywire. The next time a person encounters alpha-gal, which is abundant in red meat like beef, pork and lamb, and also in other mammalian products, like milk and gelatin, the body may mount an allergic reaction — and symptoms can vary wildly.

"Alpha-gal syndrome can present very differently from patient

FROM LEFT: XZISE/WIKIMEDIA COMMONS, CDC; SCOTT BAUER/USDA

to patient," says Johanna Salzer, an epidemiologist at the U.S. Centers for Disease Control and Prevention. It can look like anaphylaxis, like Raley experienced. Or, as in the case from Maine, symptoms can be entirely gastrointestinal. In that case, a woman was bitten by a black-legged tick and then later experienced abdominal pain, diarrhea and vomiting after eating different kinds of red meat.

The delayed onset of symptoms and the often mysterious nature of patients' stomach issues can make alpha-gal syndrome hard to diagnose, says Sarah McGill, a gastroenterologist at the University of North Carolina School of Medicine in Chapel Hill. Traditionally, gastroenterologists haven't been taught to consider food allergies when seeing adult patients with chronic GI problems, she says. Most food allergies appear when people are young.

"But alpha-gal syndrome is very unique," she says. "Adults can get it suddenly."

McGill has seen patients who've had their symptoms discounted by doctors or even had requests to be tested for the condition refused. Those experiences remind her of celiac disease, which was misunderstood for a long time. That disease is caused by the immune system overreacting to gluten, but patients were sometimes told their symptoms were in their head, McGill says. "I see that same pattern happening with alpha-gal syndrome."

There's no cure for the condition. Other than emergency care for serious reactions, treatment is largely preventive, avoiding beef, pork, lamb and the like. Scientists can't predict how long symptoms will last, but some people may eventually be able to eat red meat again without sparking an allergic reaction.

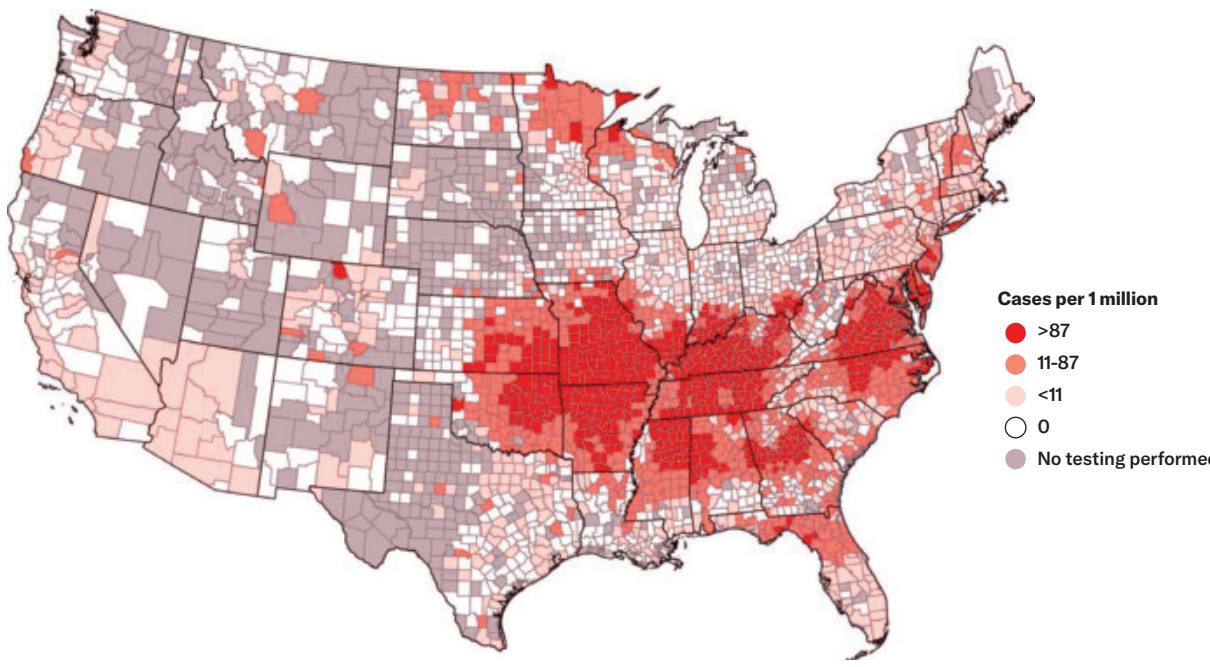
Doctors in the dark

Many doctors, nurses and physician assistants have never even heard of alpha-gal syndrome. In 2023, Salzer and colleagues reported the results of a nationwide survey of 1,500 health care providers: 42 percent were not aware of the allergy.

Among those who were, about a third didn't know how it was acquired and nearly half didn't know what tests to order to diagnose it. "There are some large gaps in health care provider knowledge," Salzer says. Increasing their awareness could help patients by shortening the time to diagnosis, she says.

Alpha-gal syndrome appears to be relatively rare, though numbers are hard to pin down. Salzer and colleagues tallied about 110,000 suspected cases in the United States from 2010 to 2022. It's possible this is an undercount, the researchers reported, and as many as 450,000 people may have been affected during this time period.

SUSPECTED U.S. ALPHA-GAL SYNDROME CASES, 2017–2022



Suspected cases of alpha-gal syndrome in the United States mostly cluster in the South, parts of the Midwest and the mid-Atlantic region. ↓

J. M. THOMPSON *ET AL*/*MMWR* 2023

The best defense against ticks

For Oltean, taking appropriate precautions means avoiding tick bites entirely. She knows that can be difficult, especially during tick season, which generally runs early spring to late fall, depending on location. In Washington state, where she lives, "March through May is when we see ticks coming out and questing, or seeking blood meals."

After being outdoors, many people rely on tick checks, scanning their bodies to ensure they're not inadvertently carrying any bloodsucking critters. For tickborne illnesses like Lyme disease, Rocky Mountain spotted fever and anaplasmosis, quick identification and tick removal can prevent disease. That's because the tick must be attached to a person's body for hours or days to transmit disease-causing bacteria. "That does not seem to be the case with alpha-gal syndrome," Oltean says. There are no bacteria being transmitted in this condition. Instead, it's an allergic response. So it's possible that a single bite from a tick, even one yanked away immediately, could spark the condition.

Oltean is brimming with tips to prevent ticks from biting. Walk in the center of trails, she says. Avoid tall brush and grassy areas. Wear tightly woven clothing, which can prevent ticks from attaching, and light colors, which make ticks easy to spot and pick off. She recommends buying clothes pretreated with the insecticide permethrin, applying a U.S. Environmental Protection Agency–registered tick repellent to exposed skin and showering soon after being outdoors to wash off any unattached ticks.

Salzer thinks that bites from lone star ticks, not black-legged or western black-legged, are the primary drivers of alpha-gal syndrome. In her 2023 analysis, the map of suspected cases largely overlapped with the distribution of lone star ticks in the United States.

Taking steps to avoid bites could protect people from later developing the condition — as well as a slew of infectious diseases. "Preventing that bite is really the main message," Salzer says.

Unanswered questions

Alpha-gal syndrome is a relatively newly described condition, first reported in 2009. That means there's still a lot to learn, scientists say. "Why are some people bitten by ticks all the time and they never develop alpha-gal syndrome?" Salzer asks. She also wants to know exactly how long a tick must be attached for someone to get the condition.

Oltean is interested in tick biology; specifically, why lone star ticks seem to be more adept than other tick species at stimulating an immune response to the alpha-gal sugar. "What's different about these ticks?" And do multiple tick bites over time make a person more likely to develop the condition?

For people with alpha-gal syndrome, McGill wonders why the allergic response to red meat is so delayed. "You're getting sick hours later," she says. "That's not typical."

As for Raley, she now takes precautions before hiking, like spraying hiking clothes with repellent and keeping her dog on tick medication year-round. She's also careful with her diet and has avoided red meat, and any resulting reactions, for the last eight years. She's OK eating dairy but stays away from red meat–based broths and sauces, food made with lard, and desserts with gelatin. "It's an odd thing to think about," she says. ✖

↗
Western black-legged tick (*Ixodes pacificus*)

Linked to: Alpha-gal syndrome (suspected), Anaplasmosis, Hard tick relapsing fever and Lyme disease

FROM LEFT: CDC; XZISE/WIKIMEDIA COMMONS

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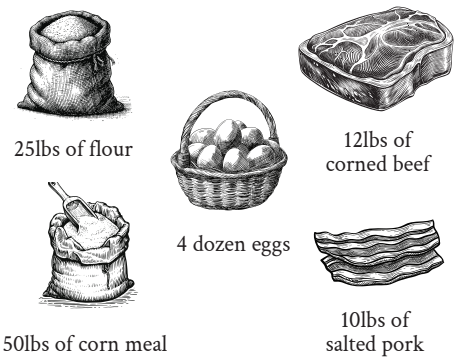

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Curiosities

R. HOOKE/WIKIMEDIA COMMONS

LIFE

A 'VERY PRETTY' BOUQUET OF FUNGI

● What looks like a bouquet of flowers is actually the first drawing of a fungus seen through a microscope. When English scientist Robert Hooke published this illustration in his 1665 book *Micrographia*, he called the fungal spores "very pretty." Today, we know the fungus belongs to the common mold genus *Mucor*. *Mucor* is mostly harmless, but in rare cases causes the potentially fatal infection mucormycosis. There are few effective treatments for fungal infections, a concern as fungi expand their reach as a result of climate change (see Page 62). —*Lisa Grossman*

SEAL POPULATIONS HAVE REBOUNDED — AND SO HAVE THEIR CONFLICTS WITH HUMANS

By Aaron Tremper

A YEAR WITH THE SEALS | *Alix Morris*
Algonquin Books | $30

"Hello there!" "Hey, you!" "Get outta there!" These are only a few of the phrases that brought tourists flocking to Boston's New England Aquarium to see its chattiest resident: Hoover the harbor seal. Before joining the aquarium in 1971, Hoover was under the care of Maine fisherman George Swallow and his wife, Alice. The couple kept the orphaned seal in their backyard pond after discovering that the pup's mother had been fatally shot by another fisherman.

George informed aquarium staff that Hoover could mimic human speech. They, naturally, were skeptical, and Hoover seemed quiet enough when he arrived. But things changed in 1978, when staff members witnessed Hoover say his own name in George's gruff, New England accent. That single utterance soon turned into a full repertoire of shouts and belly laughs that entertained crowds until Hoover's death in 1985.

Hoover is one of many characters in Alix Morris' new book, *A Year with the Seals*. Season by season, the science writer hits the road to itch her curiosity regarding the recovery of these creatures, which were once endangered in North America. But Morris' book isn't your typical conservation read. Instead of detailing the plight of species at risk, it examines what happens when conservation efforts succeed.

By the mid-20th century, the United States' two resident seal species, the gray and the harbor, were hunted to the brink of extinction because they were considered direct competitors of the fishing industry. Since the enactment of the Marine Mammal Protection Act of 1972, their numbers have bounced back. But "as seal populations have rebounded," Morris writes, "so too have conflicts with humans — particularly fishermen." Easing such tensions is no easy task. The 253-page book looks mainly to New England for answers, with occasional excursions to the Pacific Northwest and Nova Scotia.

In Tacoma, Wash., Morris meets members of the Puyallup Tribe, who are competing with seals and their larger cousins, sea lions, for a diminishing wild salmon stock, a vital traditional food source. Along New England's coasts, rising white shark populations are rattling communities, despite the rarity of attacks on humans. Federal protections for the sharks, established in the 1990s, are behind the boom. But frustrated locals blame seals, a key white shark prey, and are calling for culls.

Sometimes, it's the people who want to help seals the most who do the most harm. In one harrowing outing, Morris tags

"Perhaps the question shouldn't be whether or how to control nature, but how to control ourselves."

— Alix Morris

along during a rescue call for an abandoned seal pup. When the team arrives on the scene, the caller is taking a selfie with the seal under his arm. Such seal handling is considered harassment and is illegal. A week later, Morris learns the pup died, most likely due to dehydration and malnutrition from abandonment. The stress from the harassment probably didn't help.

Morris never does learn the secret to mediating tensions between seal conservationists and their critics. Instead, *A Year with the Seals* reassesses the very question in need of asking: "Perhaps the question shouldn't be whether or how to control nature, but how to control ourselves." ✖

IS NUCLEAR ENERGY GOOD? IT'S A COMPLEX QUESTION

By Alka Tripathy-Lang

ATOMIC DREAMS | *Rebecca Tuhus-Dubrow*
Algonquin Books | $30

Toxic sludge. A glowing radioactive rat. A three-eyed fish named Blinky. These are all elements in a 1990 episode of the long-running television show *The Simpsons*, in which protagonist and oaf Homer is a safety inspector at the fictional Springfield Nuclear Power Plant. The imagined horrors of the plant reflect concerns many real people have had about nuclear energy over the course of its young history, which began with the first sustained nuclear reaction in 1942.

Despite those concerns, U.S. nuclear power plants seem to foster a strong safety culture, observes journalist Rebecca Tuhus-Dubrow, author of *Atomic Dreams*. During her tour of Diablo Canyon Power Plant — California's last operational source of nuclear energy — she is checked for traces of explosive compounds on the way in and scanned for radiation on her way out. A sign at the plant reads "Safety Is No Accident."

Diablo Canyon, whose story serves as the foundation of Tuhus-Dubrow's narrative, has been the center of controversy since the site was selected in the 1960s. The book recounts the plant's history, from arguments among nearby residents and experts over where to build it to ongoing efforts to shut it down. But the pleasure of reading is in the path Tuhus-Dubrow takes and the people she talks to as she asks a simple question with a complicated answer: Is nuclear power good or not?

Nuclear energy's advantages, Tuhus-Dubrow writes, "cannot be lightly dismissed." Nuclear plants generate electricity without emitting greenhouse gases. They require less raw material and land than renewables to produce the same amount of energy. And they provide a stable source of electricity immune to the weather's whims, unlike solar and wind energy.

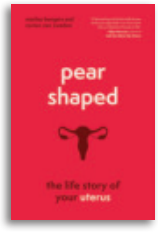
But the cons also seem obvious. Nuclear plants have high upfront costs and take sometimes a decade or more to construct. The highly radioactive enriched uranium that goes into reactor cores could be weaponized by bad actors. Then, there's the risk of accidents from human mistakes or poor oversight.

Perhaps the knottiest problem of all: nuclear waste. There is no permanent repository for the radioactive spent fuel from the reactor core. So it's stored on-site — even at plants that no longer provide power. That means nuclear waste sites pepper the country. Some believe the waste is safely stored and best left where it is, but others are terrified of the risk of radiation release, especially as a result of earthquakes or tsunamis.

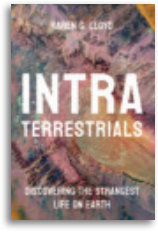
The book introduces many people "who hold passionate opinions about this peculiar energy source." A surfing grandmother in Laguna Beach fights to move nuclear waste stored near her home. Two "tree hugger moms" run an organization called Mothers for Nuclear. A Brazil-born model and "nuclear influencer" describes growing up with energy insecurity.

In the end, Tuhus-Dubrow's question morphs from "Is nuclear good?" to "Is energy use good?" Electricity usage is expected to soar. And as one source observes, "I don't see anybody getting a smaller phone, a smaller TV." ✖

OTHER BOOKS ON THE SHELF



PEAR-SHAPED | *Marlies Bongers and Corien van Zweden*
Greystone Books | $28
Despite nurturing all human life, the uterus remains a mysterious and taboo topic for many people. A gynecologist and a journalist team up to illuminate this organ's many functions, as well as the array of diseases and complications that can afflict it, including endometriosis, PCOS and fibroids.



INTRATERRESTRIALS | *Karen G. Lloyd*
Princeton Univ. | $27.95
Deep within the darkest crevices of Earth's crust, alienlike life-forms thrive in extreme environments. A microbiologist unravels how microbes "breathe" rocks, live for thousands of years and exist in boiling water and pure acid. What we learn may hold clues to the search for life beyond our planet.

REEFS OF TIME | *Lisa S. Gardiner*
Princeton Univ. | $29.95
A science writer investigates how the fossil record could guide efforts to preserve coral reefs and the ecosystems they sustain. Studying how ancient reefs weathered changes in sea level and temperature may offer glimpses at how today's reefs can survive climate change, ocean acidification and more. ✖

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According to Bennet, in lieu of becoming a science teacher, donating to Society for Science is one of the best ways to help cultivate scientific thinking in future generations. Through science, we can understand the world and improve lives. That is why Bennet gives to the Society through his donor advised fund at Vanguard Charitable.

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75th Annual Regeneron ISEF Honors Teens From Around the World

Adam Kovalčík (center in the photo above), a 19-year-old from Dulovce, Slovakia, won the $100,000 top award in the Regeneron International Science and Engineering Fair (ISEF), a program of Society for Science, for developing a less expensive way to produce an antiviral drug. Held in May in Columbus, Ohio, Regeneron ISEF is the world's largest STEM competition for high school students. This year, it brought together nearly 1,700 young scientists and engineers representing 48 U.S. states and more than 60 countries, regions and territories. In total, more than $9 million in awards and scholarships was distributed.

Kovalčík's project centered on the investigational antiviral drug galidesivir. Early clinical trials have shown this drug to be safe in humans, and animal tests show it may be effective against a broad spectrum of viruses. But it is expensive to produce. Kovalčík designed a shorter, more efficient way of making galidesivir by starting with cheap materials from corn husk waste.

Benjamin Davis (left) of Wrentham, Mass., and **Siyaa Poddar** (right) of Chandler, Ariz., both 16 years old, each won the second-place $75,000 Regeneron Young Scientist Award. Davis created a desktop plastic recycling system that can recycle 3-D printer waste and other plastics, turning them into filaments for 3-D printing. Poddar developed two devices that rapidly detect toxic dusts using chemicals that change color when they react with uranium or silica. In the U.S. Southwest, toxic silica and uranium dusts from abandoned mines are a public health challenge.

Regeneron ISEF finalists undergo a rigorous judging process, in which they interact with professional scientists, engineers and mathematicians from around the world. They also have the opportunity to share their passion for science with peers.

Through Regeneron ISEF and other STEM programming, Regeneron and the Society are fostering the next generation of STEM leaders who are pioneering solutions to improve our world.

SOCIETY FOR SCIENCE

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Society for Science is a nonprofit organization best known for our award-winning journalism, world-class STEM competitions and suite of STEM Outreach programming activities. 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.

VOL. 207 NO. 07 | JULY 2025

Hunting hints

● *An ancient ambush of wild horses at a German archaeological site called Schöningen around 300,000 years ago suggests that communal hunting, along with complex social and mental skills, evolved much earlier in human history than thought, behavioral sciences writer Bruce Bower reported in "Smart hunters."*

Bower also noted that Neandertal ancestors in what's now Spain conducted communal bison hunts around 400,000 years ago. The groups would drive bison herds to the edge of an underground cave, where the animals plunged to their deaths.

As a 7-year-old, reader Gary Rea saw an illustration related to that hunting tactic in "The Epic of Man," a series of articles about the evolution and history of humans, published in *Life* magazine in the late 1950s. "'The Epic of Man' and reading about the then-current work of [paleoanthropologists Mary and Louis Leakey] inspired me to want to become an archaeologist when I grew up," Rea wrote. Rea took a different career path, but Bower's story inspired some reflections: "Due to ancient DNA, we're having to revise our perceptions of Paleolithic people, and the work being done by those researching the Schöningen site is another addition" to our changing views.

A reader named Barbara wondered how scientists determined the positions of ancient hunters during communal horse hunts.

The exact positions are unknown, but the hunters probably did not have hard-and-fast positions, Bower says. The illustration that opens the story "presents a hypothetical but plausible moment in time when a hunting group kept a horse family moving toward an ambush," Bower says. "As the story points out, analyses of excavated artifacts, including the spears, and animal bones indicated that horses had been driven to a lakeside ambush spot. Information on recent and historical hunting involving communal ambushes was used to reconstruct how Schöningen hunters must have operated."

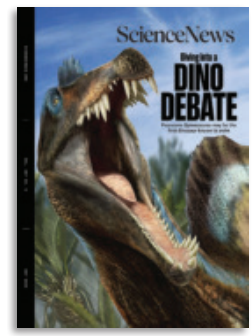
Weighing in

● *A DNA analysis of more than 200 Labrador retrievers revealed multiple genes associated with obesity in the dogs, former* Science News *intern Alex Viveros reported in "Five genes may raise obesity risk in labs."*

On Reddit, user Alarming-Recipe7724 noted, "Studying genetic obesity in an animal population can help to problem-solve human obesity issues." Indeed, Viveros reported that one of the genes is also associated with higher body mass indexes in humans.

Meanwhile, user Magooose dished about their own dog's eating habits: "I am convinced that if left alone with a bag of food, my lab would continue eating until she popped."

May 2025



"Due to ancient DNA, we're having to revise our perceptions of Paleolithic people."

Narwhal news

● *Drone videos show that narwhals may use their tusks to play with their food, including prodding and flipping a fish, freelance writer McKenzie Prillaman reported in "Narwhals seem to use their tusks to play."*

The story struck a chord with thousands of TikTok users.

User Hully Fonseca wrote: "The fact that we're still learning new things about animals in the ocean is so wild and so cool."

Though Prillaman reported that the play seems to come out in low-stress environments, user Miguel Lopez quipped that it's "probably a high-stress situation for the fish."

FUNGI CAN'T ZOMBIFY HUMANS, BUT THEY'RE STILL A THREAT

BY TINA HESMAN SAEY

Season two of the hit series *The Last of Us* has wrapped on HBO Max, after once again immersing viewers in a world where people combat zombies puppeteered by a mind-controlling fungus. At the heart of the show is a girl named Ellie who is immune to the pandemic fungus. The tragic events of this season stemmed from Ellie's guardian Joel killing doctors who wanted to remove her brain to create a cure.

That questionable approach aside, the science behind *The Last of Us* is chillingly real in some respects. While it's unlikely that the *Cordyceps* fungi capable of controlling insects or spiders could evolve to zombify humans, fungal infections that harm humans are on the rise and spreading, in part due to climate change. And scientists are racing to develop vaccines and cures.

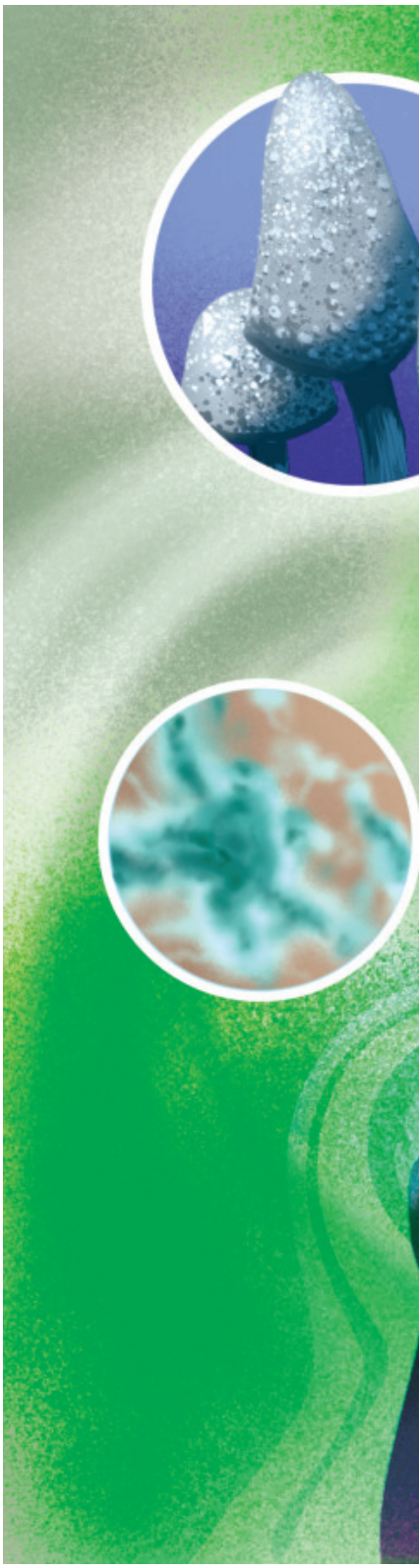
Nearly everyone breathes in at least a few fungal spores regularly, and the immune system can keep those from establishing a full-blown infection. But as the microbes expand their ranges and humans build more in deserts, scrubland and other places where fungi thrive, people are encountering more fungi, says veterinarian Edward Robb, chief strategy officer for Anivive, a pet pharmaceutical company in Long Beach, Calif.

The most susceptible people are those who have a lot of exposure to spores, he says, "which could be somebody working in landscaping or construction, somebody going camping."

People new to areas where fungal diseases such as valley fever (coccidioidomycosis) are common may also be at higher risk because their immune systems haven't been trained to take on the fungi.

People can develop immunity to some disease-causing fungi but not others. "Precisely what it would take to become immune to a fanciful fungus like in *The Last of Us*, I haven't got a clue," says John Rex, chief medical officer of F2G Ltd., a pharmaceutical company that's developing antifungal drugs. That immunity probably wouldn't be found in the brain.

With valley fever, for instance, once the infection reaches the brain,



ARIK ROPER

"it's incurable," Rex says. "You can slow it down with existing drugs, but you can't cure it."

But like in *The Last of Us*, researchers are looking to develop new treatments and vaccines, especially since there are no antifungal vaccines yet approved for people.

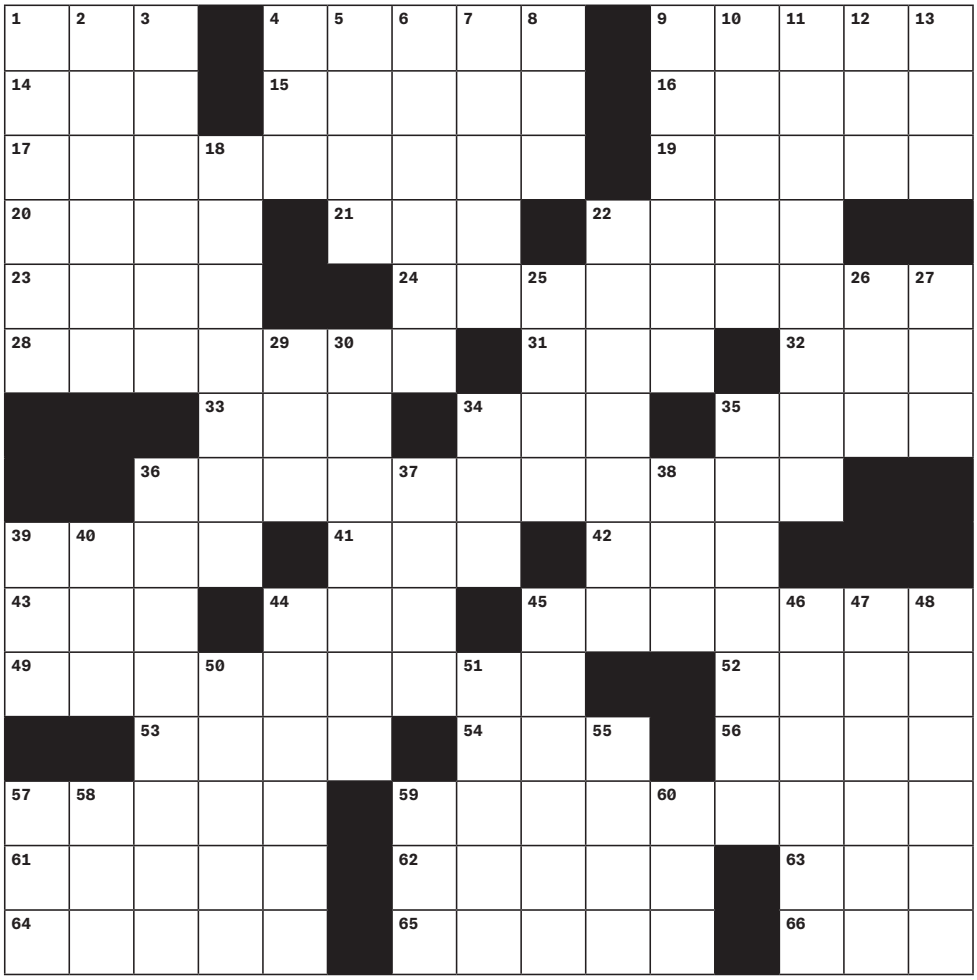
Anivive is developing vaccines against valley fever and blastomycosis. Those infections may cause flulike symptoms or chronic disease. The company intends the valley fever vaccine to be for dogs and humans. It uses a genetically altered form of the fungus, which is not harmful but can still train the immune system.

As for treatments, there are few options, and some fungi are developing resistance against them, the World Health Organization warned earlier this year.

For bacterial infections, doctors usually have a variety of antibiotics to choose from. But "our collection of [antifungal] drugs has never been as thorough," Rex says. "There are fungal infections you can get for which we have no current licensed therapy whatsoever."

F2G is in the final stages of clinical trials for an antifungal drug called olorofim. It prevents fungi from making pyrimidines, a type of building block for DNA and RNA. Interfering in that process prevents fungi from replicating and can kill some dangerous types, including *Aspergillus* species. But it's taken decades to develop, and the drug is still awaiting approval by the U.S. Food and Drug Administration. And only two other new antifungal drugs are as far along in development.

That long road is just one reason there are so few antifungal options, Rex says. "If you want a new antifungal, you should have started 25 years ago." ✖



BABY'S FIRST WORDS

BY ERICA HSIUNG WOJCIK AND SHANNON RAPP

ACROSS

1 Fireplace residue
4 Fruit with Honeycrisp and Granny Smith varieties
9 Places for precious possessions
14 Kung ___ (spicy preparation)
15 ___ through (gets past easily)
16 Cocky
17 Beans used in making hummus ("peep!")
19 Familiar address for a family member
20 Corned beef diner dish
21 Brachial limb
22 Planets, to the poets
23 Great Lake near London, Ontario
24 Lower leg exercise ("moo!")
28 Aquatic mammal related to the elephant
31 Curiosity in the sky, briefly
32 Fisher-Price product
33 Item in a server's apron
34 Hookup spot for a phone charger
35 Give up
36 Shoes with a little bit of lift ("meow!")
39 Bit of inheritance
41 In the past
42 Alternative to MLA style
43 Limón who wrote "In Praise of Mystery: A Poem for Europa"
44 Like some celebrity egos
45 Pollen producers
49 Youthful crush ("arf!")
52 Natural burn soother
53 Floating vessels ridden while upright (Abbr.)
54 Peace activist Yoko
56 Brand of outdoorsy sandals
57 "Schitt's Creek" actor Catherine
59 Gentle treatment ("maa!")
61 Goes back and forth
62 Word after solar or road
63 "Before and After Science" musician Brian
64 Toddlers
65 Like hardened mud on hiking boots
66 Granny, to some Brits

DOWN

1 Intensive high school science course (Abbr.)
2 Desert where Berber and Semitic languages can be heard
3 Sauce served with moo shu pork
4 Pose, as a question
5 Dad, in some languages
6 Make a hole in, as an earlobe
7 "___ ___ Red Pajama" (picture book)
8 "Darryl" author Jackie
9 Food court pizza place
10 Caribbean island included in the Kingdom of the Netherlands
11 Wookieepedia and others
12 Is in French class?
13 Like the new kid in class, perhaps
18 Inexpensive thing
22 Kinda kooky
25 Thick with vegetation
26 Outfield cover
27 One of eight for a spider
29 Vietnamese festival
30 Involves
34 Game with a spin-off called "Dos"
35 Ingredient in a Caesar
36 Hiker's pack
37 Frozen waffle brand
38 Org. concerned with water quality
39 "Mind the ___"
40 End of a college address?
44 Go around
45 "Where the Wild Things Are" author Maurice
46 Maximum number of players from a team allowed on a soccer pitch
47 Christian prayer named for its nine-day length
48 Add flavor to
50 Baby's first food, often
51 "Ta-da!"
55 Troll-like baddie
57 Go (for)
58 Horse food
59 Popeyes competitor
60 Was ahead

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