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ScienceNews

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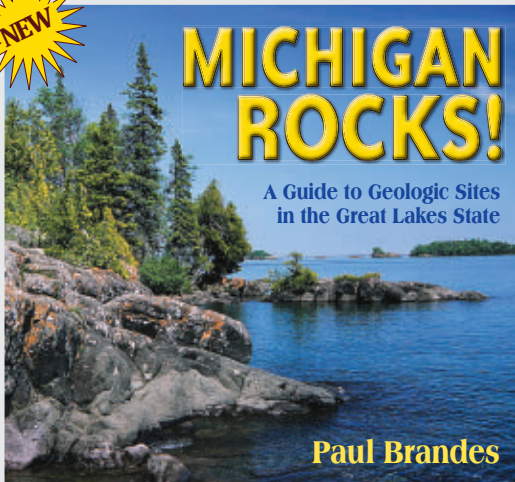
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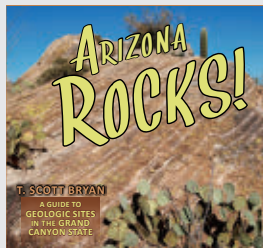
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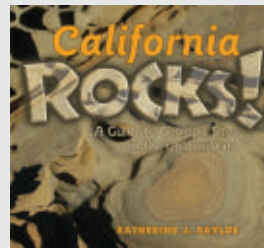
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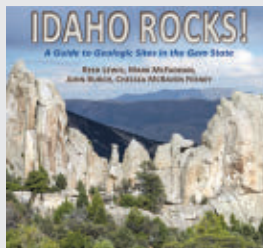
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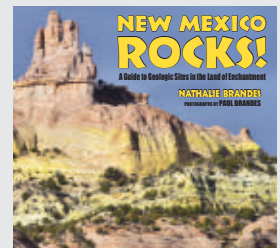
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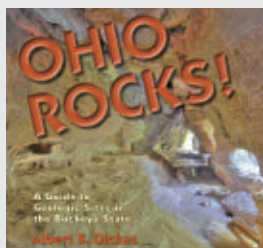
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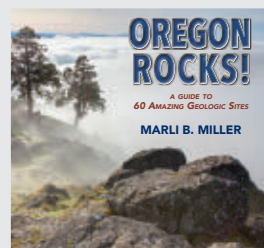
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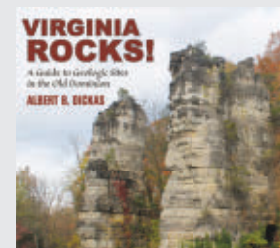
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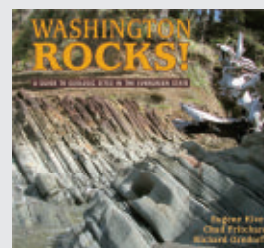
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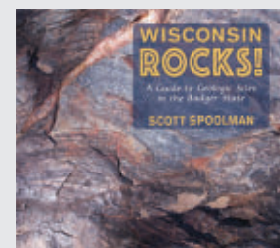
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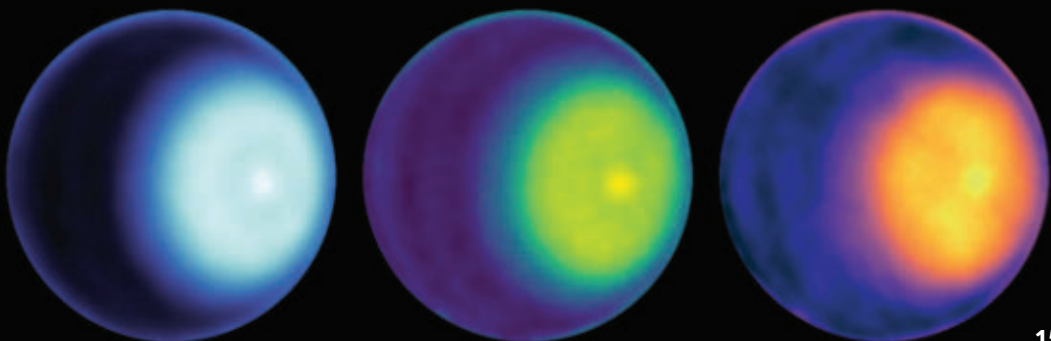
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COVER Boys tend to experience depression differently than girls, and those signs may be overlooked. *Jasmin Merdan/Moment/Getty Images Plus*



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FROM TOP: ROBERTO SCHMIDT/AFP VIA GETTY IMAGES; CLIVE ROSE/GETTY IMAGES; JPL-CALTECH/NASA, VLA



Boys and girls are suffering, but in different ways

Earlier this year, the U.S. Centers for Disease Control and Prevention released a blockbuster report: Teenage girls in the United States are experiencing record-high levels of despair, with almost two-thirds reporting that they felt persistently sad or hopeless, typical signs of depression. By contrast, almost one-third of teenage boys reported those struggles.

That gap caught our attention. Why is it so large? Are boys able to cope with the challenges of adolescence in ways that girls somehow are not? We wanted to find out. Our social sciences writer Sujata Gupta dug into the data. The truth, she found out, is much more complicated. Recognizing those complications could point to ways to make life better for all teens (Page 18).

It turns out that it matters how doctors and scientists ask someone if they're depressed. Girls and women are more likely to experience depression as sadness or hopelessness. Boys and men are more apt to experience it as irritation or anger. But traditional questionnaires used to screen for depression tend to use the sad/hopeless language and not irritable/angry. Thus, the suffering of many boys may be missed on surveys like the CDC's. In fact, studies suggest that typical screening tools might fail to identify male depression 10 percent of the time. Questionnaires that include language aligning with males' experiences are more likely to close that gap.

Most struggling teenagers will survive adolescence, but some, tragically, do not. Suicide rates among teens have risen since the beginning of the pandemic. The CDC report, based on data collected in 2021, found that teenage girls are more likely than boys to contemplate suicide, plan it or attempt it. But other national data show that teenage boys are more likely to die of suicide. Teenage boys' unrecognized mental health struggles may play a role in explaining that discrepancy, as might the fact that boys are more likely to use a firearm in a suicide attempt. Impulsivity may also be a factor. Males who are depressed are more likely to engage in impulsive, risky or violent acts than those who are not depressed, some research shows.

In focusing on the mental health of boys, Gupta took care to not minimize the crisis among girls. "That was the trickiest emotional aspect of this story," she says. "Actually, nobody's doing well."

Ultimately, the teen mental health crisis won't be solved by focusing on just one group. Everyone needs help. But it can be very difficult for parents to find counseling and other mental health support for struggling teens. The CDC says that schools can help fill that gap. "Schools can provide education that equips teens with essential skills, such as understanding and ensuring true sexual consent, managing emotions and asking for what they need," the agency noted in a press release announcing its survey findings.

But presuming that schools struggling with tight budgets can supply those supports sounds naïve. All parts of society need to step up. We can no longer pretend that the kids are all right, or stigmatize them for admitting they are struggling and asking for help. And we need to recognize that each suffering young person is suffering in their own way. — Nancy Shute, Editor in Chief

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SACRED STONE OF THE SOUTHWEST IS ON THE BRINK OF EXTINCTION



Centuries ago, Persians, Tibetans and Mayans considered turquoise a gemstone of the heavens, believing the striking blue stones were sacred pieces of sky. Today, the rarest and most valuable turquoise is found in the American Southwest—but the future of the blue beauty is unclear.

On a recent trip to Tucson, we spoke with fourth generation turquoise traders who explained that less than five percent of turquoise mined worldwide can be set into jewelry and only about twenty mines in the Southwest supply gem-quality turquoise. Once a thriving industry, many Southwest mines have run dry and are now closed.

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Excerpt from the July 14, 1973 issue of *Science News*

50 YEARS AGO

Good to the last drop

[Hyperactive] children are sometimes given amphetamines to calm them down.... [A researcher] took 11 such children off medication and gave them one cup of coffee at breakfast and lunch.... Teachers and parents rated the children as less hyperactive during the three-week period they were getting coffee instead of amphetamines.

UPDATE: Attention-deficit/hyperactivity disorder affects about 6 million U.S. children. Most medical professionals recommend managing symptoms with talk therapy and stimulant medications. For people with ADHD, stimulants boost levels of dopamine and norepinephrine in the brain to improve impulse control, focus and working memory. Caffeine also boosts dopamine, but evidence that coffee or other caffeinated foods relieve ADHD symptoms is sparse and inconsistent. A few studies in children with ADHD hint that caffeine improves attention and impulse control compared with no treatment, while other studies suggest the opposite. Pediatricians generally advise against giving kids caffeine due to its effect on sleep.

THE SCIENCE LIFE

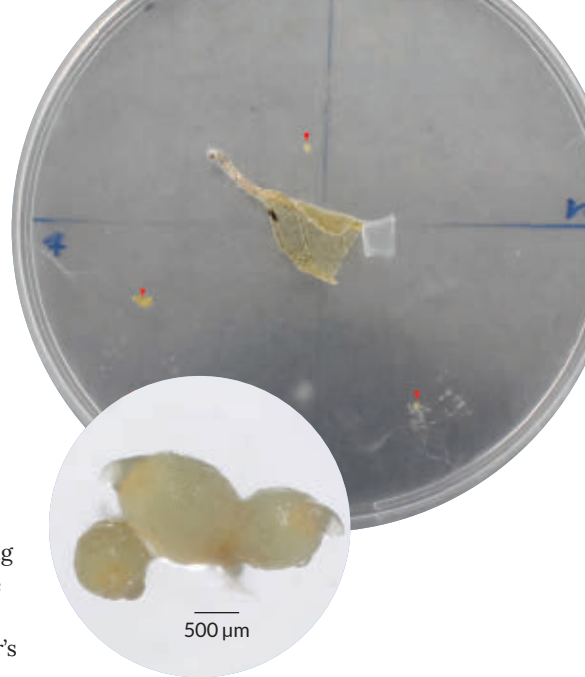
A hunt for fungi might save this rare orchid

If you ever come across a Cooper's black orchid in the wild, you probably would mistake it for a stick. This delicate flower is devoid of lush green leaves and flashy petals. Its stem lies on the floor of New Zealand's broadleaf forests for most of the year, only popping up during the summer months to blossom with pendulous brown and white blooms. And rather than growing a tangle of roots, the orchid sprouts a pale brown tuber.

But the chances of encountering Cooper's black orchid (*Gastrodia cooperae*) are getting slimmer. Fewer than 250 adult plants have been found across just three sites since botanist Carlos Lehnebach and colleagues identified the species in 2016. Predation by invasive feral pigs and deforestation prompted New Zealand's Department of Conservation to declare the orchid at high risk of extinction.

At the Lions Ōtari Plant Conservation Laboratory in Wellington, Lehnebach's team is working to bring the species back from the brink. Early in life, most orchids rely on fungi for essential nutrients and minerals. Identifying the fungus that Cooper's black

Cooper's black orchid, a rare species found only in New Zealand, relies on fungi to sprout. Scientists are working to identify the fungi to keep the orchid from dying out.



White-rot fungus (shown feeding on a leaf in a lab dish) helped seeds of a rare orchid (red arrows) sprout. Whether the fungus supports the orchid's tubers (inset) as they mature is unclear.

orchid requires will bring the researchers a step closer to their ultimate goal: seeding forests to boost the population.

From one of the lab's incubators, conservationist Jennifer Alderton-Moss pulls out dozens of petri dishes containing speck-sized seeds and tubers.

The researchers dissect the tubers under a microscope to look for fungi that might aid germination. Once DNA testing confirms potential candidates aren't orchid pathogens, the team transfers the fungi to petri dishes with orchid seeds.

To be extra safe, researchers first tested these methods on a common relative of Cooper's black orchid. "If we get it wrong, at least we're not causing extinction," says conservationist Karin van der Walt.

It took the researchers more than a year of trial-and-error to find the right germination method for Cooper's black orchid and get the seeds to sprout.

In a dish that Alderton-Moss pulled out, a fungus feeds on an orchid leaf and a few seeds have developed into tuberlike grains. The team may have finally found the perfect match for Cooper's black orchid in *Resinicium bicolor*, or white-rot fungus. The next step is to grow orchid plants from seedlings, which will reveal whether the fungus also sustains the adult plant. — Rina Diane Caballar

THE -EST

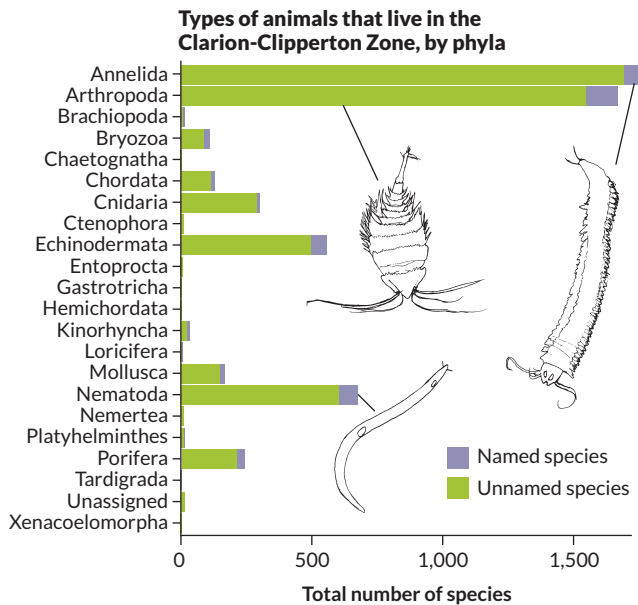
Stone toilets hold the oldest known traces of a dysentery parasite

Giardia has plagued people for a long time. The parasite can bring about dysentery — a miserable and occasionally deadly mixture of diarrhea, cramps and fever. Scientists have now uncovered traces of *Giardia duodenalis* in the remains of two roughly 2,600-year-old toilets once used by the wealthy denizens of Jerusalem. The remains are the oldest known biological evidence of giardia anywhere in the world, researchers report May 25 in *Parasitology*.

Today, the single-celled parasite can be found in human guts around the planet. This wasn't always the case, but working out how pathogens made their debut and spread isn't easy (SN: 3/12/22, p. 5). Unlike some parasites that can be preserved in the ground for centuries, giardia degrades fast, making it difficult to spot even with a microscope.

In 1991 and 2019, archaeologists reported finding ancient stone toilet seats in the remains of two mansionlike homes in Jerusalem. These “were quite posh toilets” used by “swanky people,” says paleoparasitologist Piers Mitchell of the University of Cambridge. Previous microscopy work found traces of roundworms and tapeworms in soil samples from beneath the seats. Mitchell's team searched the samples for more fragile intestinal parasites using antibodies that glom on to the remnants of parasites' proteins.

The idea that giardia, which can spread via contaminated water, may have plagued Iron Age Jerusalem makes sense given the limited water supply, Mitchell says. — *Freda Kreier*



SCIENCE STATS

Ocean zone harbors lots of unknowns

Of some 5,500 animal species recorded in a pristine part of the deep Pacific Ocean, about 90 percent are unknown to science (green in the graph above), scientists report May 25 in *Current Biology*. Most species are annelids and arthropods, like worms and crustaceans (illustrated). Sponges, sea cucumbers and corals call the Clarion-Clipperton Zone home too. This vast area's minerals are highly sought after, so getting a biodiversity baseline is key before mining begins, the team says. — *Jude Coleman*

HOW BIZARRE

Race car drivers blink at the same spots in each lap

The world goes dark for about one-fifth of a second every time you blink, a fraction of an instant that's hardly noticeable to most people. But for a race car driver traveling up to 354 kilometers per hour, that one-fifth means almost 20 meters of lost vision. Considering that people generally blink up to 30 times each minute, a driver could lose as much as 590 meters worth of visual information per minute due to blinking.

People are often thought to blink at random intervals, but researchers found that wasn't the case for three formula drivers. Instead, the drivers tended to blink at the same parts of the course during each lap, cognitive neuroscientist Ryota Nishizono of NTT Communication Science Laboratories in Atsugi, Japan,

and colleagues report in the May 19 *iScience*.

The team mounted eye trackers on the helmets of three drivers and had them drive three different formula circuits in Japan for a total of 304 laps. Where the drivers blinked was surprisingly predictable, the researchers found.

Race car drivers unconsciously time their blinks during crucial parts of races (the 2022 Formula One Japanese Grand Prix shown).



The drivers had a shared pattern of blinking that had a strong connection with acceleration. Drivers tended not to blink while changing speed or direction — like while on a curve in the track — but did blink while on relatively safer straightaways.

The finding highlights the trade-off between keeping our eyes moist and not losing vision during crucial tasks, says neuroscientist Jonathan Matthis of Northeastern University in Boston. “We think of blinking as this nothing behavior,” Matthis says, “but it's not just wiping the eyes. Blinking is a part of our visual system.”

Nishizono next wants to explore what processes in the brain allow or inhibit blinking in a given moment, he says, and is also interested in how blinking behavior varies among the general population. — *Darren Incorvaia*

FROM TOP: M. RABONE ET AL./CURRENT BIOLOGY 2023; CLIVE ROSE/GETTY IMAGES

Homo naledi may have buried its dead

Claims of humanlike activities by the ancient species stir debate



Homo naledi may have engraved this crosshatched design in a passageway that connects underground chambers in a cave system in South Africa.

“These are remarkable discoveries of a [Homo] species that had brains one-third the size of ours yet buried their dead and carved meaning-making symbols on cave walls,” Berger said June 1 at a news conference.

He and his colleagues report the new *H. naledi* findings in three papers posted online at bioRxiv.org and accepted for publication in *eLife*.

The oldest known *H. sapiens* grave, found in Kenya, dates to about 78,300 years ago (SN: 6/5/21, p. 7). Contested Neandertal graves in Iraqi Kurdistan are roughly 70,000 to 60,000 years old (SN: 3/28/20, p. 17). In South Africa’s Blombos Cave, a crosshatched design on a rock dates to around 73,000 years ago and geometric patterns incised on pigment pieces date to as early as about 100,000 years ago (SN: 10/13/18, p. 6).

“I think that deliberate burial of the dead by *Homo naledi* is clear, although it is unlikely that the evidence so far presented will satisfy all scholars,” says archaeologist Michael Petraglia of Griffith University in Brisbane, Australia, who is not part of Berger’s team.

In 2018, the team found the remains of an adult *H. naledi* in a pit that apparently had been dug in Dinaledi Chamber, an underground space in South Africa’s Rising Star Cave System where *H. naledi* fossils had previously been found. The team found the bones detached, which probably occurred as the body decomposed in dry sediment that collapsed in on it. That process, or the digging of other burials, caused bone fragments of at least one other individual to enter the grave.

In 2017, the researchers removed three blocks of sediment containing *H. naledi* remains from an adjacent underground space called the Hill Antechamber.

BY BRUCE BOWER

A small-brained hominid known as *Homo naledi* intentionally buried its dead in two underground cave chambers 160,000 years or more before the earliest evidence of deliberate interments by *Homo sapiens* or Neandertals, an international team of researchers says. But that conclusion has generated skepticism and calls for more thorough investigations of the newly reported finds.

H. naledi, which lived in southern Africa between roughly 335,000 and 236,000 years ago (SN: 6/10/17, p. 6),

also engraved marks on the side of a corridor that connects the adjacent cave chambers, contend Lee Berger, a paleoanthropologist at Wits University in Johannesburg and a National Geographic Explorer in Residence, and his colleagues. Many of these engravings consist of isolated lines or lines that form crosshatches, squares, triangles, crosses and X shapes.

If correct, the team’s interpretations would indicate that mortuary and symbolic activities aren’t unique to larger-brained hominids such as *H. sapiens*.

CT scans identified skeletal remains of a roughly 13-year-old *H. naledi* in one of the blocks. The scans provided evidence that the body had been placed in a shallow, dug-out depression and covered with dirt, the team argues. Scattered teeth of two other *H. naledi* individuals also detected in the block possibly entered via sediment disturbances or as *H. naledi* buried others in the space, the scientists suspect.

María Martín-Torres, director of the Spanish National Research Center on Human Evolution in Burgos, isn't convinced that *H. naledi* intentionally buried its dead. She suspects that bodies were deliber-

ately placed in surface-accessible shafts and later fell through or were left on the floors of underground caves. Trampling or other *H. naledi* activities could have produced the fossil fragments, says Martín-Torres.

Water seepage into the underground caves could have helped move *H. naledi* corpses down sloping cave floors until they came to rest in natural depressions that Berger's team suggests are intentional burial sites, says Paul Pettitt, an archaeologist at Durham University in England.

A crescent-shaped stone identified among the encased fossils includes a point, sharp edges and other

signs of having been some kind of implement, Berger's team says. But scans revealed no clear evidence of intentional modifications, Pettitt notes. The stone should be examined closely after it's removed from sediment, he says.

Though it is too early to say what the stone may have been used for, *H. naledi* must have wielded a tool capable of chiseling hard rock to make the designs, which appear on the walls of a corridor connecting Dinaledi Chamber to the Hill Antechamber, Berger said. Later cave art by Neandertals and *H. sapiens* includes similar drawings. And there is no evidence that modern people have created comparable engravings in the caves, he said.

Since the engravings remain undated, Pettitt says, it's unclear whether *H. naledi* or later *H. sapiens* visitors created them. ■

"I think that deliberate burial of the dead by *Homo naledi* is clear, although it is unlikely that the evidence so far presented will satisfy all scholars."

MICHAEL PETRAGLIA

ASTRONOMY

How dying stars make ripples

Debris could be a source of incoherent gravitational waves

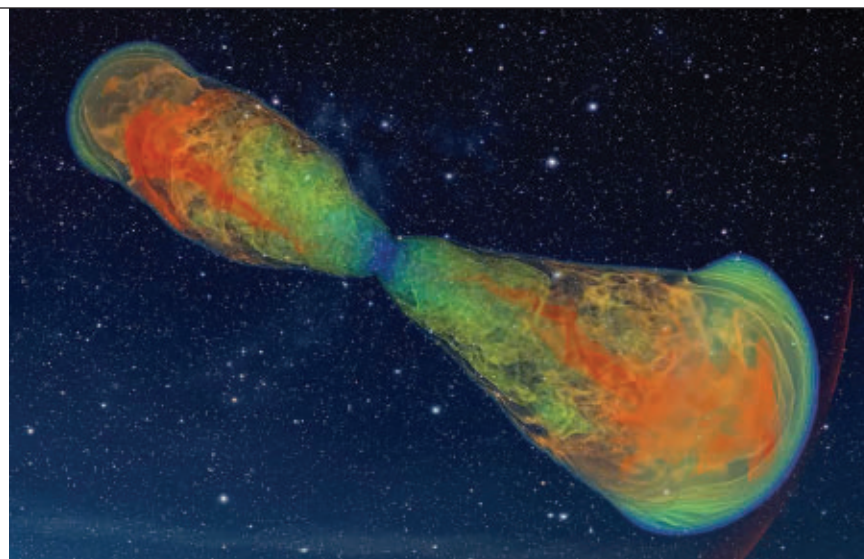
BY LISA GROSSMAN

Cocoons of debris around dying stars could shake ripples in spacetime unlike any astronomers have ever seen.

"This is a potential source of gravitational waves that has never been investigated," astrophysicist Ore Gottlieb said June 5 in a news conference at the American Astronomical Society meeting in Albuquerque.

Such waves could be picked up by the U.S. observatory LIGO. Catching them could give scientists their first glimpse into the innermost parts of dying stars, said Gottlieb, of Northwestern University in Evanston, Ill.

Every gravitational wave detected thus far has come from the spiraling death dance of two compact objects — black holes, neutron stars or both. These events give off what are called coherent gravitational waves. "Think of it as an orchestra playing harmonically," Gottlieb said.



A dying star (blue, center in this picture of a simulation) can emit jets (red) surrounded by asymmetric gaseous cocoons (yellow and green). The motion of this material could emit an elusive type of gravitational wave that LIGO can detect, researchers suggest.

Supernovas and some other stellar explosions are expected to produce incoherent gravitational waves, which are akin to instruments playing different songs at the same time. Since these events give off relatively slow waves in all directions, they are difficult for LIGO to detect.

Gottlieb and colleagues studied a type of stellar death called a collapsar. Massive stars collapsing into black holes emit jets of material that travel at nearly the

speed of light. Simulations of how the jets form found that asymmetric cocoons of hot gas and debris surround them. As the cocoons expand and push through the star, they could produce incoherent gravitational waves, the team says.

LIGO and other observatories in Italy and Japan have about a 1 percent chance of catching cocoon gravitational waves. That chance will go up in future runs with improved detectors. ■

PHYSICS

Nuclear clocks inch closer to reality

Scientists precisely measure the energy needed to kick off ticking

BY EMILY CONOVER

Hickory dickory dock, this nucleus could make a great clock.

A special variety of the element thorium hosts an atomic nucleus that could be used to keep time, scientists say. In a first, researchers have measured a type of decay of this thorium nucleus that releases a single particle of light. The measurement of the energy released in the decay is seven times as precise as estimates based on different types of decays, researchers report in the May 25 *Nature*. The improved energy measurement could galvanize work toward the first nuclear clock, which would follow in the footsteps of atomic timepieces.

“We have already amazing atomic clocks which run very precisely,” says nuclear physicist Sandro Kraemer of KU Leuven in Belgium. Those atomic clocks are based on the physics of the electrons that surround an atom. A nuclear clock would be based on the atom’s nucleus. Some scientists think nuclear clocks could be even more precise than atomic clocks, which are already such powerful tools that they’re used in everything from GPS satellites to experiments that test the fundamental laws of physics (SN: 7/3/21 & 7/17/21, p. 12).

The well-established technology of atomic clocks is based on how an atom’s electrons jump into a higher energy state. It takes a specific frequency of light, with just the right amount of energy, to initiate the jump. The oscillation of that light acts like the ticking of a clock. A nuclear clock would be based on similar energy jumps made by a nucleus.

Most atomic nuclei have energy levels that are too far apart for scientists to set the jump off with a laser—a necessity for building a clock. But a particular variety, or isotope, of thorium called thorium-229 has two energy levels that are unusually close—about eight electron volts. Still, no one has been able to initiate the jump with a laser because the size of that energy gap wasn’t precisely known until now.

Kraemer and colleagues measured the energy released when thorium-229 nuclei decayed, jumping down in energy from its higher energy state. First, the team had to get thorium-229 into that high-energy state, which is called an isomer. One way to do that is to start from another element that can decay into the thorium isomer. Using a radioactive beam at the ISOLDE facility at the European physics

lab CERN near Geneva, the team embedded actinium-229 into crystals of calcium fluoride and magnesium fluoride. The actinium-229 decayed, producing the thorium-229 isomer.

This technique helped scientists sidestep a sticking point. Thorium-229 normally decays in a way that makes the energy difficult to measure, by transferring its energy to an electron and kicking it out of the atom. A decay that emits a particle of light, or photon, is much easier to measure, but it normally happens only once in a billion decays.

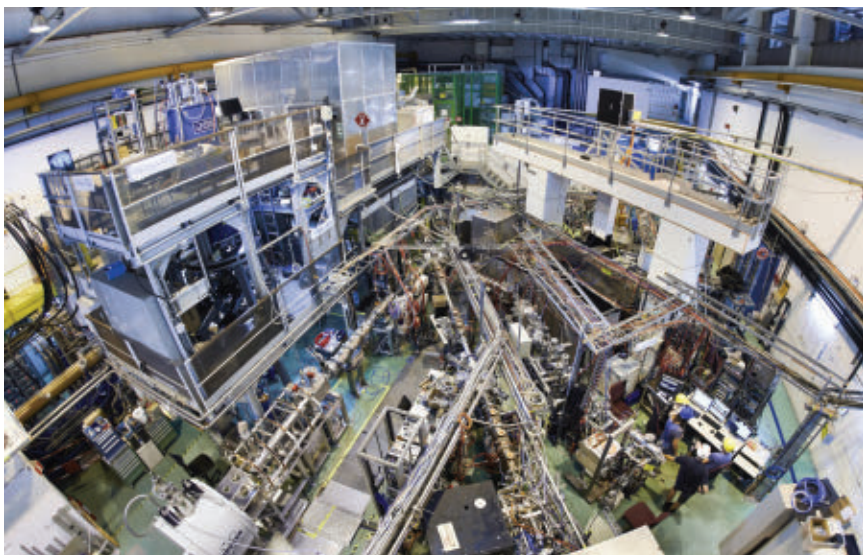
Embedding thorium-229 into the crystals suppressed the decay that is more difficult to measure, making the single-photon decay dominate. That allowed the team to detect the single photons from isomer decays and measure their energy. The researchers estimated the decay had an energy of 8.338 electron volts. That figure agrees with earlier measurements of how far apart the two energy levels are, but is much more precise.

“This is a milestone that people have been looking for,” says quantum physicist Simon Stellmer of the University of Bonn in Germany. Previous claims of detecting this type of decay haven’t held up, Stellmer says. “This seems to be the first true and real observation of this isomer decay.”

Physicists are now working to use a laser to set off the energy transition, going from the low-energy state to the higher-energy isomer, in the next step toward creating a nuclear clock.

A nuclear clock could provide a new angle on physics phenomena. “It would be very interesting to compare conventional atomic clocks and nuclear clocks because the underlying physics...is different,” says physicist Ekkehard Peik of the National Metrology Institute of Germany in Braunschweig. For example, nuclear clocks could reveal subtle variations in fundamental constants of nature (SN: 11/12/16, p. 24).

Another bonus of going nuclear: The clocks could be made with nuclei inside a solid material, as opposed to atomic clocks, in which atoms must be suspended inside a vacuum chamber. That means a nuclear clock could be more stable and make measurements more quickly, Kraemer says. ■



At the nuclear physics facility ISOLDE at CERN near Geneva, scientists observed a type of radioactive decay that’s a key step toward building the first nuclear clock.

CLIMATE

What will this hurricane season bring?

El Niño and warm waters in the Atlantic Ocean add uncertainty

BY CAROLYN GRAMLING

It's hard to know how busy this year's Atlantic hurricane season will be, because of a rarely observed combination of ocean and climate conditions.

On the one hand, the Atlantic Ocean is in an active storm era, a yearslong period of increasing storm activity. And sea surface temperatures there are higher than usual this year, which can fuel storms, Matthew Rosencrans, the lead hurricane forecaster for the U.S. National Oceanic and Atmospheric Administration, said May 25 at a news conference.

But this year also marks the onset of an El Niño phase of the El Niño-Southern Oscillation ocean and climate pattern, which tends to suppress hurricane formation. This combination of phenomena is not a scenario that has occurred in historical records often, Rosencrans said. "It's definitely kind of a rare setup for this year."

He and colleagues reported that there's a 40 percent chance that Atlantic hurricane activity will be near normal this year, which is unusually high for an El Niño year. But there's also a 30 percent chance

that activity will be above normal and a 30 percent chance it'll be below normal.

Overall, NOAA predicts that 12 to 17 named storms will develop over the Atlantic Ocean this hurricane season, which officially began June 1 and ends November 30. Five to nine of those storms are predicted to become hurricanes, with sustained wind speeds of at least 119 kilometers per hour. Between one and four of those hurricanes could be Category 3 or greater, with wind speeds of at least 178 km/h.

There's little consensus among other groups' predictions, in part due to the uncertainty of what role El Niño will play. In May, the U.K. Meteorological Office announced that it predicts an extremely busy hurricane season, with roughly 20 named storms, including 11 hurricanes. Five of them could be Category 3 or greater. In June, Colorado State University updated its prediction from a below-average season to a near-average season, with 15 named storms, including seven hurricanes. The long-term average from 1991 to 2020 is 14 named storms per season.

So far, 25 groups have submitted predictions for the hurricane season to an online platform hosted by the Barcelona Supercomputing Center. There's a large spread among the predictions, ranging "from below average to well above average," says Philip Klotzbach, an atmospheric scientist who is responsible for Colorado State University's seasonal Atlantic hurricane forecasts.


The spread is probably the result of two big sources of uncertainty: the strength of the El Niño (and when during the year it's expected to develop) and whether the Atlantic's sea surface temperatures will stay above average, Klotzbach says.

An emerging El Niño phase is signaled by abnormally warm waters in the eastern equatorial Pacific Ocean, which in turn is tied to shifts in wind strength and humidity around the globe. One of the ways that El Niño tinkers with climate is that it alters the strength of winds in the upper atmosphere over the northern Atlantic Ocean. Those stronger winds can shear off the tops of developing storms, hampering hurricane formation.

But warmer ocean waters like those right now in the Atlantic fuel hurricanes by adding energy to storm systems. How active a season it will be depends on which of those two forces prevails.

For example, climate simulations from the U.K. Meteorological Office suggest that the wind shear due to this year's El Niño will be relatively weak, while surface ocean temperatures will remain well above average. Similarly anomalous warm waters were found to be the primary cause behind the glut of intense Atlantic hurricanes in 2017.

In the future, hurricane forecasts could become even more uncertain. Just how climate change will affect large-scale ocean and climate patterns such as the El Niño-Southern Oscillation is unknown (SN: 9/14/19, p. 7). As the atmosphere warms, the ways that global climate patterns currently interact may change, also making them potentially harder to predict, computer simulations suggest (SN: 3/11/23, p. 9). Climate change is also expected to increase ocean temperatures. ■



MATH

A 'vampire einstein' tile one-ups a recent find

Einstein, meet "vampire einstein."

It's been mere months since researchers reported the first "einstein," a single tile that can cover an infinite plane with a pattern that never repeats (SN: 4/22/23, p. 7). Now, the team has found a shape that's even more special.

The first einstein made a pattern with the shape and its mirror image. The new tile can also make an infinite nonrepeating pattern (shown above), but without such reflections, computer scientist Craig Kaplan of the University of Waterloo in Canada and colleagues report May 28 at arXiv.org. Because of this quality, the tile has been dubbed a "vampire einstein." To create it, the team started from a shape related to the first einstein and curved the edges in such a way that the tile's reflection no longer fit with the original shape. — *Emily Conover*



Bowhead whales (a mother and calf shown) have an enhanced ability to repair DNA, which may explain why they can live for 200 years.

ANIMALS

Cells hint at whales' secret to a long life

A robust ability to repair DNA could help bowheads avoid cancer

BY MEGHAN ROSEN

Near the northern tip of Alaska, in the Arctic Ocean, bowhead whales have given scientists a glimpse into longevity.

The gigantic marine mammals can live more than 200 years — and tissue samples collected from the animals reveal a fix-it superpower that might explain how. Bowhead whales' cells are whizzes at repairing damaged DNA, scientists report in a study posted online May 8 at [bioRxiv.org](https://doi.org/10.1101/2023.05.08.541111).

That ability means the animals might mend damage that could otherwise lead to cancer-causing genetic glitches, says Orsolya Vincze, an evolutionary ecologist at the French National Center for Scientific Research in Paris, who was not involved with the research. Scientists have previously reported other animals' biological strategies for avoiding cancer. But the new work, Vincze says, "shows that the whales approach cancer resistance from a very new perspective."

Bowhead whales (*Balaena mysticetus*) can grow to roughly 18 meters long and are among the heaviest mammals on Earth. At more than 80,000 kilograms, a bowhead whale weighs about as much as six fully loaded school buses. All that body mass adds up to a vast number of cells. And every time a cell divides, there's a chance

that a dangerous mutation can arise.

But somehow, large-bodied animals are especially cancer resistant, a puzzle known as Peto's paradox. That suggests the animals must have strong cancer defenses, says Lisa Abegglen, a cell biologist at the University of Utah Health in Salt Lake City who was not part of the new work.

Her team discovered that elephants, which can live nearly as long as humans and rarely die from cancer, have extra copies of a tumor-blocking gene called *TP53* (SN: 11/14/15, p. 5). This gene and another may help elephants deal with DNA damage by clearing out afflicted cells, other scientists have reported (SN: 9/15/18, p. 8).

That's one way to ward off trouble from damaged DNA, says Marc Tollis, an evolutionary biologist at Northern Arizona University in Flagstaff who did not participate in the new study. Another strategy is to "take the hit," he says, "and then try to fix it."

First published nearly a decade ago, the bowhead whale genome has provided hints that the mammals may use this alternate strategy. "But you need actual experiments to actually validate those predictions," Tollis says.

In a lab at the University of Rochester in

New York, Vera Gorbunova and colleagues ran experiments on cells harvested from bowhead whale tissue, as well as on cells from humans, cows and mice.

The whale cells were both efficient and accurate at repairing double-strand breaks in DNA, damage that severs both strands of the DNA double helix and can cause genetic errors that lead to cancer. Whale repair restored broken DNA to like-new condition more often than cells from other mammals, the team found. In those animals, mends to the genome tended to be sloppier, like a poorly patched pair of jeans.

The team also identified two DNA repair proteins, CIRBP and RPA2, present at high levels in bowhead whale cells.

Discovering how animals fend off cancer is "incredibly exciting," Abegglen says, "because all of these strategies have potential to be translated into effective treatments for people with cancer." Though that day may be far off, the new findings underscore the importance of studying animals with low cancer rates, she says. Abegglen wants to test whether the team's results hold up in humpback whale and dolphin cells — or if those animals have different defenses.

There's so much to learn from animals with large bodies and long life spans, Vincze says. "We probably have the solution to cancer medicine out there in nature already," she says. "We just have to find it." ■

ANIMALS

A new vaccine for Lyme targets mice

The vaccine may help reduce exposure for people and pets

BY REBECCA DZOMBAK

A vaccine to fight Lyme disease has received a temporary green light for use in the United States. But it's not for people, it's for mice.

Delivered via edible pellets, the vaccine makes mice develop antibodies that neutralize *Borrelia burgdorferi*, the bacterium that causes most U.S. cases of Lyme disease. When ticks bite a vaccinated mouse, the idea goes, they won't pick up bacteria from the blood and so can't transmit the pathogen to people or other animals.

Mice are "one of the most important reservoir hosts for Lyme disease," says Jean Tsao, a disease ecologist at Michigan State University in East Lansing who wasn't involved in the vaccine's development.

On April 29, the U.S. Department of Agriculture granted Memphis-based biotech company US Biologic a conditional license for the vaccine. That means it is available on request by groups such as federal and state health agencies for roughly one year, with the possibility of renewal.

A vaccine for humans was available from 1998 to 2002, but it was taken off the market due to low consumer demand, which was probably related to fears over the vaccine's safety. Some vaccinated people reported developing arthritis, but the U.S. Food and Drug Administration found no meaningful difference in joint problems in vaccinated versus control groups. A new vaccine for humans from Pfizer and the French biotech company Valneva is now being tested in several thousand people in a clinical trial in the United States and Europe.

Both the mouse and human vaccines use a protein called OspA, found on the surface of *B. burgdorferi*, to spur antibody production and prevent infection.

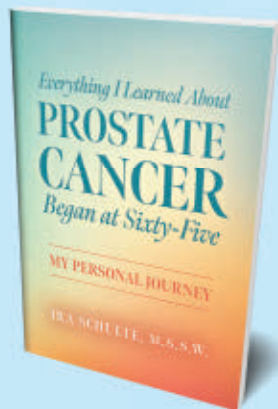
Biologist Maria Gomes-Solecki co-led

the development of the mouse vaccine at US Biologic, which she cofounded. Her team distributed an early version to areas in New York state from 2007 to 2011. *B. burgdorferi* has a two-year life cycle in ticks. That means it takes time to see meaningful reductions in infections, says Gomes-Solecki, also of the University of Tennessee Health Science Center in Memphis. Two years of vaccinations reduced the proportion of infected ticks by 23 percent compared with control sites. Five years of vaccinations reduced the proportion of infected ticks by 76 percent.

That early version delivered OspA using live *E. coli*. The green-lighted version uses inactive *E. coli*. It reduced the proportion of infected ticks by 30 percent after two years of vaccinations, a 2020 study found.

The vaccine works, but "it's not spectacular," says epidemiologist Sam Telford III of Tufts University in Grafton, Mass. Whether it will lower Lyme risk for humans is uncertain. "With additional studies... we'll see more data on how well it does," he says. "It's certainly a step in the right direction." ■

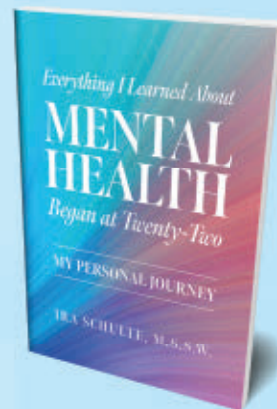
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GENETICS

Pollution filters snag airborne DNA

Air quality control stations could help scientists track biodiversity

BY ERIN GARCIA DE JESÚS

The ability to track animals and plants is up in the air — literally — thanks to help from an unexpected source.

Around the world, many air quality control stations filter air through small paper disks on a daily or weekly basis, allowing scientists to ensure concentrations of hazardous pollutants are below certain levels. But the filters also pick up plant and animal DNA that has been scattered into the wind, researchers report in the June 5 *Current Biology*.

The environmental DNA, or eDNA, on those filters could make air quality control stations a treasure trove for cataloging local animals and plants. Such records could help researchers track biodiversity at a larger scale than ever before and more easily catch species declines or track how ecosystems are changing.

“It’s this incredible system...and we’re effectively piggybacking on it for a totally new use,” says Elizabeth Clare, a molecular ecologist at York University in Toronto. The facilities are widespread across North and Central America, Europe and Asia, but are less dense farther south.

“It never occurred to us that these filters capturing particulate matter could

even be analyzed for environmental DNA,” says James Allerton, an air quality scientist at the National Physical Laboratory in Teddington, England. That changed when Allerton read a news story about two studies where scientists vacuumed animal DNA out of thin air at two zoos, one in England and another in Denmark (SN: 2/26/22, p. 4).

Learning about the potential for capturing eDNA sparked a “lightbulb moment,” Allerton says. He contacted Clare, who had led the eDNA research at a zoo in England, to collaborate. The Teddington facility holds onto its pollution-monitoring filters for a year in case scientists need to do repeat measurements, meaning there could be a year’s worth of eDNA to claim, he realized.

Clare, Allerton and colleagues analyzed filters from the Teddington facility that were exposed to ambient air for one hour, one day or one week. The team also examined 8-month-old filters from an air quality control station in Scotland that had each been exposed to air for a week.

Genetic material in the filters revealed the presence of over 180 different types of local life, including pine trees, badgers, owls, newts and fungi. That volume

is surprising given that the filters and storage conditions weren’t set up with eDNA in mind, says biologist David Duffy of the University of Florida’s Whitney Laboratory for Marine Bioscience in St. Augustine. That the researchers recovered so much eDNA from a system designed to monitor air quality shows how prevalent airborne DNA is and how much biodiversity data could be up for grabs, Duffy says.

The filters picked up plenty of plant life, even on disks exposed to air for only an hour. Birds and mammals, on the other hand, were more likely to pop up in filters exposed for longer periods of time. That’s probably because plants are stationary while animals are constantly moving around, so it takes more time to detect them, Clare says.

Even older samples might exist, Clare says. There are numerous filter-using stations worldwide, some of which have never thrown any of their disks away. “We do know of some places where there are potentially 50 or 60 years of these stored,” she says. It’s unclear if those samples are viable, but the idea of being able to track biodiversity that far back is “unbelievable.”

Not every air quality control station uses filters to monitor pollution, says Fabian Roger, an ecologist at ETH Zurich. Many stations rely on sensors that can detect airborne particles in real time. Those sensors can’t capture eDNA, so the number of suitable facilities to extract such genetic material will vary from place to place.

But air quality control stations that do rely on filters certainly have great potential, Roger says. Researchers now need to figure out how useful the genetic information is. It’s unclear how closely the DNA from filters matches local fauna, he says. How far away sources of DNA might be, whether it’s a few blocks, a few kilometers or even farther, is also unknown.

Answering those questions is a priority, Clare says. Still, if an air quality control station “has the potential to produce data that’s this rich over and over and over and over again, that is an unbelievable treasure of biodiversity information that we have never noticed.” ■



Paper filters from the Auchencorth Moss air quality monitoring station in Scotland (shown) were chock-full of airborne genetic material from local animals and plants. Similar facilities around the globe could help researchers track biodiversity on an unprecedented scale.



HEALTH & MEDICINE

Taurine helps mice live longer

What effect the amino acid has on human health is unclear

BY LAURA SANDERS

An ingredient common in energy drinks and baby formula makes mice healthier and extends their life spans. It also appears to make worms live longer and improves the health of middle-aged monkeys, a large international group of scientists reports in the June 9 *Science*.

The ingredient, an amino acid called taurine, is made by our bodies, and we eat it in meats. It's not known whether taking extra taurine slows aging in people or if it is even good for us, though the new study turned up an association between lower levels of the amino acid and conditions such as diabetes and obesity in people.

Aging "is one of the great biological unknowns," says biologist and cardiologist Toren Finkel of the University of Pittsburgh. "So any way you can chip away at that edifice is great. And this is a new set of findings that deserves to be followed up."

The results, 11 years in the making, center on taurine in part because scientists found its levels fall with age in the blood of mice, monkeys and humans. As far as amino acids go, taurine is an oddball:

Unlike other more familiar amino acids, it doesn't get incorporated into proteins. But it has a range of suspected jobs in the body, from aiding brain, eye and gut function to helping cells generate energy.

Molecular physiologist Vijay Yadav of Columbia University Irving Medical Center and colleagues found that extra taurine extended the median life span in mice by about 10 to 12 percent. The median life span for female mice that didn't get extra taurine was around 29 months. With taurine, it increased to nearly 33 months. Taurine led to a similar boost for shorter-lived worms. *Caenorhabditis elegans* went from a median life span of almost 20 days to about 23 days on the highest doses tested.

Taurine was also linked with signs of better health in mice and female monkeys. Extra taurine led to improvements in aspects of bone strength, muscle coordination and memory in experiments with groups of five to 10 mice. Six middle-aged rhesus macaques fed extra taurine for six months seemed healthier, weighed less, had denser bones and showed signs of better metabolic health compared with five monkeys that didn't get extra taurine.

The mice experiments used taurine levels that would be equivalent to about 3 or 6 grams per day for an adult human, Yadav says. A can of a typical energy drink contains 1 gram. There aren't obvious, known risks of taurine, but thorough

The amino acid taurine, available in certain foods like energy drinks, boosts health and longevity in mice. There is no evidence yet that taking extra taurine can help humans.

long-term studies at these high doses for people have not been done.

Yadav and colleagues did look at data of nearly 12,000 people and found that individuals with obesity or diabetes had less taurine in their blood than people without the conditions. But it's not known whether low taurine had a part in causing those conditions.

In a separate experiment, an intense bout of exercise led to more taurine in people's blood. As for whether taurine supplements are safe and improve people's health, "we need to wait for a clinical trial," Yadav says.

For now, taurine "is promising as a life span and health span intervention," says John Tower, a molecular biologist and geneticist who studies aging at the University of Southern California in Los Angeles. But many questions remain, Tower says, including what taurine actually does in the body and whether it works similarly in different animals, including people. "We've got a long way to go."

Finkel is also circumspect. Because aging is so complex, a singular fountain of youth probably doesn't exist. "I think there are going to be many tributaries of youth," he says. "And so maybe this is a tributary, not a fountain." ■

MICROBES

Bacteria may be underestimated

A census in Pacific reefs hints that global appraisals are off

BY ERIN GARCIA DE JESÚS

Coral reefs are hot spots for more than fish and other sea life visible to the naked eye.

Reef communities across the Pacific Ocean may harbor nearly 3 million varieties of bacteria, researchers report June 1 in *Nature Communications*.

That means scientists are vastly underestimating Earth's microbiome, Pierre Galand, a microbiologist at Sorbonne University in Paris, said May 31 at a news conference. The new count of bacteria in Pacific reefs alone falls within the range of current estimates for Earth's total microbial diversity, suggesting that there are exponentially more bacteria living on the planet than previously thought.

Coral reefs are among the most diverse ecosystems on Earth. Microbes on or in larger creatures that call the reefs home

are crucial for health. For instance, bacteria on corals can protect them from heat stress and help them get nutrients.

But the biodiversity of these reef-dwelling microbes has been unclear. Most studies examine the microbiomes of animal species in a small area or focus on that of only one species. And global surveys are hard to do.

During the Tara Pacific Expedition from 2016 to 2018, Galand and colleagues visited 99 coral reefs. At each site, the team collected samples from plankton, three coral species and two fish species, amassing a total of 5,392 samples. Researchers then categorized how many varieties of bacteria they could find in each sample, based on genetic differences among microbes.

"The word species doesn't really work well for microbes," says Jennifer Biddle, a microbial ecologist at the University of Delaware's campus in Lewes who was not involved in the work. It's difficult to compare physical characteristics like shape or color to separate microscopic organisms into distinct species.

The new genetic analyses identified more than 540,000 bacterial varieties on

the three types of organisms. That number alone—from a tiny fraction of Pacific reef fauna—overlaps with up to about 20 percent of current estimates of all Earth bacteria, which range from 2.72 million to 5.44 million. Based on how many fish and coral species live in the western and central Pacific, coral reefs from that ocean alone may harbor at least 2.8 million kinds of bacteria, the team calculated.

Such diversity may be a kind of "ecological insurance" for reefs, Galand said. For instance, multiple types of bacteria may help coral polyps in the same way, such as making sure the reef-building creatures get a key nutrient. With so much diversity, some bacteria may easily be able to replace others that are in trouble when something like high temperatures cause the bacterial population to crash (SN: 4/28/18 & 5/12/18, p. 20).

The estimates may still be lowballing microbial diversity in Pacific reefs, Biddle says. Molecular tools to look at genetic material often exclude organisms that scientists are unaware of. "We're always undercounting microbes with the methods we're using." ■

ARCHAEOLOGY

This bottle reveals what ancient Romans smelled like

A surprisingly well-preserved perfume bottle is offering a rare whiff of ancient Rome — and the smell is familiar. Chemical analyses of the contents of a 2,000-year-old bottle (right) reveal that one of its ingredients was patchouli, researchers report in the June *Heritage*. Derived from *Pogostemon* plants in South and Southeast Asia, the earth-scented compound is a staple in modern perfumes, but its use by the Romans was unknown.

The essence, in a 7-centimeter-long quartz flask dating to the first century, was found in 2019 in a Roman burial in the southern Spanish town of Carmona, once an important Roman settlement. The small size and exquisite detail of the flask already made it a rare find at a burial site. Even more unusual is that it was tightly sealed with a dolomite top covered in a tarlike substance called bitumen, which preserved the contents inside.

Subjecting the perfume, now a solid mass, to gas chromatography and mass spectrometry identified multiple substances typically found in patchouli essential oil, notably patchouli alcohol. An analysis of bits of bitumen that had fallen into the bottle revealed perfume molecules trapped within. That enabled researchers to confirm patchouli's chemical signature.

The burial site's extraordinary condition also helped preserve the perfume. Total darkness allowed the fragrance "to make it to our days," says study coauthor José Rafael Ruiz Arrebola, a chemist at the University of Córdoba in Spain. Had the tomb collapsed, the perfume wouldn't have survived. "Light is the worst enemy to this type of chemical," Ruiz Arrebola says.

The discovery fits into a growing trend of piecing together a multidimensional picture of ancient life, including its sounds and smells. For companies interested in re-creating ancient beauty products, Ruiz Arrebola says, the find is a "very important clue." — *Javier Barbuzano*



JUAN MANUEL ROMÁN

Uranus shows off its polar cyclone

Telescopes give the first direct proof of a storm at the north pole

BY ALLISON GASPARINI

Though it looks like a smooth, solid, pale blue orb, there's more going on beneath the clouds of Uranus than meets the eye.

For the first time, a polar cyclone has been spotted on the planet, researchers report in the May 28 *Geophysical Research Letters*. Observed with radio telescopes, the find is the first direct evidence of a cyclone at Uranus' north pole. Previously, a spacecraft flyby hinted at a similar storm at the planet's south pole.

"It's really exciting to see this polar structure come into view," says Michael Roman, a planetary scientist at the University of Leicester in England who was not involved with the research. The observations "show a rather unique structure that we simply have never been able to study before."

In 1986, NASA's Voyager 2 spacecraft revealed that winds at the center of Uranus' south pole were moving faster than those in neighboring areas and were rotating. This evidence pointed to something dynamic like a cyclone occurring at the pole. But the spacecraft's instruments weren't sensitive enough to confirm the storm.

In recent years, as the north pole of Uranus has turned more toward Earth, scientists have been able to probe the other side of the ice giant, where they spotted similar hints of a swirling storm. Using the Very Large Array radio

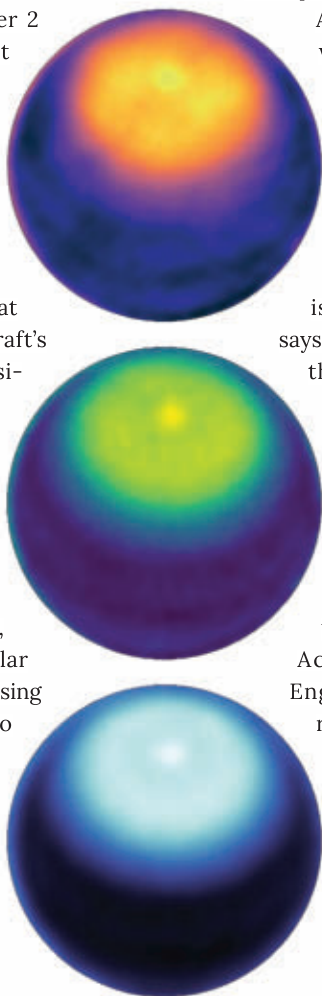
observatory in New Mexico, planetary scientist Alex Akins and colleagues took the temperature under the clouds for more clues. "What we saw with the VLA was kind of the last piece of [evidence]," says Akins, of NASA's Jet Propulsion Laboratory in Pasadena, Calif.

Thermal emissions observations collected in 2021 and 2022 reveal a spot on the north pole where the gas beneath the clouds is warmer and drier than its surroundings, suggesting the presence of a low-pressure region in the midst of those spinning winds. "These contrasts look similar to what we see in hurricanes on Earth," Akins says.

All the planets in our solar system except Mercury have now been observed hosting some kind of swirling air mass at their poles (SN: 11/8/08, p. 9).

Akins plans to continue watching the cyclone on Uranus to see how it changes. Comparing the new observations with data from 2015 suggests that the storm is growing stronger. Since the planet's atmosphere is relatively stable, Akins says, scientists wouldn't expect the circulation to change over such a short time. If the cyclone continues to strengthen, then there might be more to learn about how Uranus' atmosphere works.

In 2022, experts convened by the U.S. National Academies of Sciences, Engineering, and Medicine recommended that NASA send a probe to the planet. "The more we can learn about Uranus," Roman says, "the better we can focus our planning" for future missions. ■



A cyclone at Uranus' north pole appears as a bright spot within a larger halo in these false-color images of the planet taken at three wavelengths of radio waves.

JPL-CALTECH/NASA, VLA

Saturn's icy moon spews water super far

Enceladus' famous plume dwarfs the moon itself.

Geysers around the south pole of Saturn's icy moon spray water vapor nearly 10,000 kilometers into space, a distance about 19 times the diameter of Enceladus, scientists report in a paper to appear in *Nature Astronomy*.

NASA's Cassini spacecraft discovered almost two decades ago that Enceladus ejects salty water from a subsurface reservoir. But Cassini's orbit around Saturn meant the spacecraft was too close to the moon to see the plume's full extent.

In November, the James Webb Space Telescope, or JWST, turned its infrared camera on Enceladus, gazing at the moon for about four minutes. JWST's vantage point from across our solar system let it see the plume extending at least 9,600 kilometers.

"Seeing it so big, water being everywhere, it was kind of a surprise," says planetary scientist Geronimo Villanueva of NASA's Goddard Space Flight Center in Greenbelt, Md.

JWST's observations also reveal how much water the plume pumps out and where those molecules end up. Enceladus spews the same amount of water as it did when Cassini arrived at Saturn 19 years ago: about 10 million billion trillion molecules per second. That's equivalent to roughly two bathtubs' worth of liquid water per second.

Nearly a third of the molecules feed into a doughnut-shaped ring around Saturn and its inner moons. The remaining water either helps create one of the planet's icy rings, or gets blown across the system, where the water may affect the atmospheres of Saturn and its moons.

The plume's consistency gives Villanueva hope that the geysers will be active during future missions to Enceladus. Until then, JWST will keep checking up on the moon and its plume.

— Lisa Grossman



ANIMALS

These desert ants head for the hills

Colonies build landmarks to help foragers find their way home

BY SOUMYA SAGAR

Some ants have figured out how to keep from getting lost: Build taller anthills.

Desert ants that live in the hot, flat salt pans of Tunisia spend their days looking for food. Successful grocery runs can take the insects more than a kilometer from their nests. So some of these ants build towering hills over their nests that serve as a landmark to guide the way home, scientists report May 31 in *Current Biology*.

“I am surprised and fascinated that ants have visual acuity at the distances implied in this work,” says ecologist Judith Bronstein of the University of Arizona in Tucson who was not involved in the work. The finding implies that “ants regularly assess the complexity of their local habitat and change their decisions based on what they conclude about it,” Bronstein says.

Cataglyphis ants use a navigation system called path integration, relying on the sun’s position

and counting their steps to keep track of where they are relative to their desert nests (SN: 2/18/17, p. 18). But this system becomes increasingly unreliable as distance from the nest increases, which is particularly a problem in vast, almost featureless salt pans that look nearly the same in every direction.

“We realized that whenever the ants in salt pans came closer to their nest, they suddenly pinpointed the nest hill ... from several meters’ distance,” says Markus Knaden, a neuroethologist at the Max Planck Institute for Chemical Ecology in Jena, Germany. “This made us think that the hill functions as a nest-defining landmark.”

Knaden and colleagues captured ants (*C. fortis*) from nests in the middle of salt pans and from along their shorelines. Only nests from salt pan interiors had distinct hills, which can be up to 40 centimeters tall. The hills on shoreline



Desert ants that live in the interior of salt pans in Tunisia build tall anthills (top) that help foragers find their way home. Ants that live near salt pan shorelines, which have more visual landmarks, build shorter nests with a small hole for an entrance (bottom).

A desert ant stands on a sandy salt pan in Tunisia. Foraging can take these ants more than a kilometer from the nest, so colonies build tall hills that serve as guideposts.

nests were much shorter or barely noticeable.

Next, the team removed any hills and placed the captured insects some distance away from their nests. Ants from salt pan interiors struggled to find home more than shore ants did. Since shore ants typically also use shorelines for guidance, they weren’t as affected by the hill removal, the researchers conclude.

The team wanted to know if the ants deliberately build taller hills when their surroundings lack any visible landmarks. In another experiment, the researchers removed the hills of 16 salt pan nests and installed two 50-centimeter-tall black cylinders apiece near eight of them. The other eight nests were left without any artificial visual aid.

After three days, ants from seven of the unaided nests had rebuilt their hills. Ants from only two of the nests with cylinders had bothered to rebuild.

“These desert ants already told us about path integration and step counting for orientation.... But this business of building your own visual landmark, incredible,” says entomologist John Longino of the University of Utah in Salt Lake City who was not involved in the research. “Are they sitting down to a council meeting to decide whether they need a bigger landmark? Is this somehow an evolved behavior in this one desert ant species?”

For now, it’s unclear how the ants from salt pan interiors decide to build, or not to build, a hill. Nest building is usually performed by younger ants that are not yet foragers, Knaden says, and have not yet experienced the difficulty in finding a nest in the absence of a hill. That suggests there is an exchange of information between veteran foragers and their novice nest mates, he says.

Bronstein wonders about the risks of building the tall structures. “For instance, isn’t it a clear cue to ant predators that food can be found there?” she says. ■

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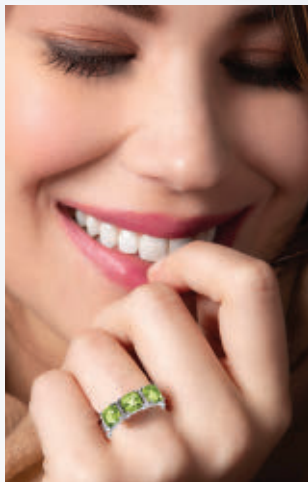


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The boys are not OK

A U.S. survey raised alarm over increased despair among girls. Screenings may miss struggling boys **By Sujata Gupta**

Teenagers in the United States are in crisis. That news got hammered home earlier this year following the release of a nationally representative survey showing that over half of high school girls reported persistent feelings of “sadness or hopelessness”—common words used to screen for depression. Almost a third of teenage boys reported those same feelings.

“No one is doing well,” says psychologist Kathleen Ethier. She heads the U.S. Centers for Disease Control and Prevention’s Division of Adolescent and School Health, which has overseen this biennial Youth Risk Behavior Survey since 1991.

During the latest round of data collection, in fall 2021, over 17,000 students from 31 states responded to roughly 100 questions related to mental health, suicidal thoughts and behaviors, sexual behavior, substance use and experiences of violence.

One chart in particular garnered considerable media attention. From 2011 to 2021, persistent sadness or hopelessness in boys went up 8 percentage points, from 21 to 29 percent. In girls, it rose a whopping 21 percentage points, from 36 to 57 percent.

Some of that disparity may arise from the fact that girls in the United States face unique stressors, researchers say. Compared with boys, girls seem more prone to experiencing mental distress from social media use, are more likely to experience sexual violence and are dealing with a political climate that is often hostile to women’s rights (SN: 7/16/22 & 7/30/22, p. 6).

But the gap between boys and girls might not be as wide as the numbers indicate. Depression manifests differently in boys and men than in girls and women, mounting evidence suggests. Girls are more likely to internalize feelings, while boys are more likely to externalize them. Rather than

crying when feeling down, for instance, boys may act irritated or lash out. Or they may engage in risky, impulsive or even violent acts. Inward-directed terms like “sadness” and “hopelessness” miss those more typically male tendencies. And masculine norms that equate sadness with weakness may make males who are experiencing those emotions less willing to admit it, even on an anonymous survey.

Consequently, screening tools, such as the one used by the CDC’s survey, may miss depression in about 1 in 10 males, research suggests.

“We need to have more of a recognition that boys and men, some of them, not all of them, are suffering,” says clinical psychologist Ryon McDermott of the University of South Alabama in Mobile. “And we miss them. We miss them in our assessments, and we miss them in our discussions.”

The face of male depression

The idea of overlooked depression in men is not new. Take what happened on the Swedish island of Gotland. In the 1960s and ’70s, suicide rates were high. So in 1983, health officials launched an education program for Gotland doctors on depression treatment and suicide prevention.

At first, the program looked like a resounding success. The island’s overall suicide rate dropped from roughly 20 out of every 100,000 people in 1982 to roughly 7 out of every 100,000 people by 1985, researchers reported in the 1992 *Acta Psychiatrica Scandinavica*.

But a subsequent, deeper analysis showed that the decline was almost entirely among women. In the 2½ years before and after the program, the number of women dying by suicide decreased from 11 to two, while the number of men dying by suicide mostly stayed steady, seeing a marginal decline from 16 to 15.

Men struggling with suicidal thoughts appear less likely to seek help and more likely to have doctors ignore their depressive symptoms when they do seek help, Wolfgang Rutz, then a psychiatrist at a Gotland hospital, theorized in 1996 in the *Nordic Journal of Psychiatry*. Doctors observed, for instance, that men who were depressed often didn’t present with classic symptoms, such as sadness, but instead presented as hostile, impulsive and aggressive.

Rutz suspected that this gender disparity in diagnosis and treatment might underpin why, at the time, men in Sweden were being diagnosed with depression half as often as women but dying by suicide five times as often. Without obvious signs of depression, Rutz noted, to the outside observer, many male suicides occurred seemingly without warning.

“The criteria of depression that are taught in psychiatric textbooks and diagnostic manuals today and which also have been used in the Gotland project seem insufficient in detecting the typical masculine way of being depressive,” Rutz wrote.

Rutz went on to develop a screening tool for male depression, which paved the way for more recent male-specific tools. They include the Male Depression Risk Scale, developed by Simon Rice, a clinical psychologist at Orygen, an Australian nonprofit

research, clinical and advocacy institute focused on youth mental health.

The scale focuses on emotion suppression, anger and aggression; drug and alcohol use; somatic symptoms, such as concerns about sleep and sex; and risk-taking. Participants rate various statements, such as how often they bottle up negative feelings, have difficulty managing anger or use drugs for temporary relief. None of the questions ask about sadness or hopelessness.

Research shows that some men meet the criteria for depression on the Male Depression Risk Scale but not on more traditional scales. In a recent study of 1,000 Canadian men, Rice and his team found that 80 respondents, or 8 percent, met the criteria for depression only on a traditional scale that includes a question about how often the respondent has felt “down, depressed or hopeless.” In addition, 120 respondents, or 12 percent, met the criteria on both scales. But 110 respondents, or 11 percent, met the criteria for depression only on the men’s scale, the team reported in 2020 in the *Journal of Mental Health*.

The results suggest that had the CDC’s Youth Risk Behavior Survey included a male-specific question about depression, there might still have been a gender gap but perhaps a smaller one.

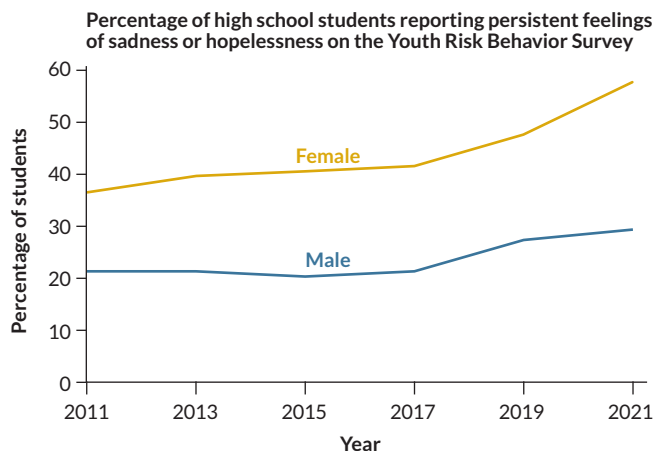
Too many boys and men are suffering in silence, says Rice, who is also a principal research fellow at the University of Melbourne. Ten or 11 percent of missed cases “might sound like a small percentage,” he says, “but at the population level, that is huge.”

Depression or something else?

The idea that acting out and aggression could, on occasion, constitute symptoms of depression remains controversial.

The CDC, Ethier says, has relied on extensive research in formulating its survey’s depression-related question, which reads: “During the past 12 months, did you ever feel so sad or hopeless almost every day for two weeks or more in a row that

Depths of despair Over the last decade, a national survey of U.S. high school students has consistently found higher levels of persistent feelings of sadness or hopelessness in teen girls compared with teen boys. But some experts say the survey may not offer a complete picture of boys’ mental health. SOURCE: CDC



you stopped doing some usual activities?”

“That item is actually quite good at predicting who has depressive symptoms,” Ethier says, adding that such accuracy holds true for both girls and boys.

That’s not to say that boys aren’t struggling, Ethier says. Anecdotally, for instance, teachers are reporting a spike in behavioral problems in their classrooms, particularly among boys. But rather than indicating depression, Ethier says, such behavior is emblematic of the broader mental health crisis among teens.

That might sound like splitting hairs. If boys are distressed, why not label them as depressed? Providing the proper diagnosis matters for appropriate treatment and future health outcomes, Ethier says. “We know that depressive symptoms in adolescence have long-term implications for health and mental health. I don’t know that the research is as conclusive about that for behavioral issues in the classroom.”

For McDermott, who studies the difficulties of measuring depression, such behavioral problems could indicate other disorders, chiefly attention-deficit/hyperactivity disorder. But he has no doubt that some of those boys are depressed. “It is hard to say with 100 percent certainty that all boys who are acting out are experiencing depression, but it is a good bet that many of them are,” he says.

The core symptoms of depression, whether internal or

external in nature, are the same in men and women, McDermott says. But on a depression scale focusing on internalizing symptoms such as sadness or hopelessness, a depressed man would, on average, score lower than an equally depressed woman.

Why those baselines vary by gender isn’t entirely clear, McDermott says. But when it comes to hopelessness, evidence suggests that boys might sometimes suppress those feelings in adherence to male norms that discourage vulnerability. Consider the results of a review of 74 studies with a total sample size of more than 19,000 mostly U.S. participants published in 2017 in the *Journal of Counseling Psychology*. High scores on a scale measuring conformity to Western masculine norms, such as emotional control, self-reliance and power over women, were linked with poorer mental health, including depression, and a reduced likelihood of seeking help.

Gender norms become entrenched during the teen years, says Leslie Adams, a behavioral researcher at Johns Hopkins University. That’s when boys are really absorbing messages around masculinity from friends, family and social media. “Endorsing feelings of sadness and hopelessness kind of goes against these learned, general scripts,” Adams says.

Those male scripts are poorly understood, say Adams and others studying male mental health, because most gender research focuses on girls and women.

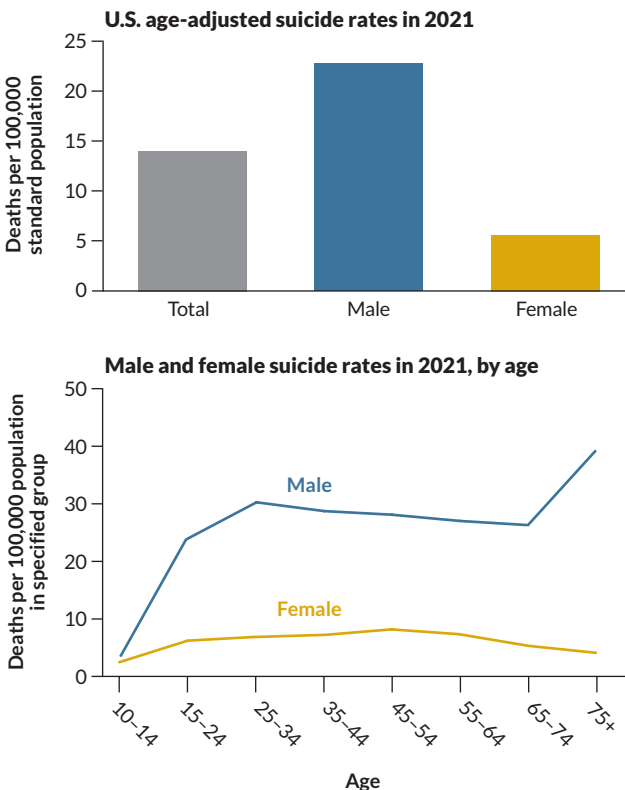
For instance, take research into social media use. Ethier points to the popularity of male social media personalities espousing harmful attitudes toward women, such as TikToker Andrew Tate, who was recently arrested in Romania on suspicion of human trafficking. Anecdotally, Tate and influencers like him are one way boys come to understand the world, but data on the influence of social media on boys are sparse, Ethier says.

“We focus a lot on the ways that social media might be impacting girls in terms of body image,” she says. “I don’t think we focus enough of the conversation on what is being portrayed to boys.”

The resulting knowledge gap about boys’ lives affects all of society. “It is difficult to see that we can effectively address the health of boys and young men, achieve gender equity for girls and young women, or achieve rights for lesbian, gay, bisexual and transgender youth, without tackling the masculine identities adopted by boys in adolescence,” a group of pediatric health experts wrote in a commentary in 2018 in the *Journal of Adolescent Health*.

Suicide stats The latest data in the United States show that the overall suicide rate for males is much higher than for females (top graph). That gap holds across most age groups (bottom graph), even though teen girls report higher levels of suicidal thinking and planning than boys.

SOURCE: NATIONAL CENTER FOR HEALTH STATISTICS



Thorny issues

Just as Rutz observed on the island of Gotland, missing depression in boys and men can come with high stakes.

“Depression can manifest in many ways... beyond sadness and hopelessness,” Adams says. “When we don’t assess the other ways that depression can manifest, there are implications. One is suicide.”

Adams suspects that the same tendency to frame depression as an internal emotion also influences how researchers ask about suicide. For instance, asking about who has considered suicide or made a plan, as the CDC does in its youth survey, reflects the belief that the respondent is both ruminating and

thinking ahead. “For boys, [suicide] may not have that linear path,” Adams says. “We’re missing... impulsivity.”

That could help explain why, in the CDC survey, teen girls reported higher levels of suicidal thinking, planning and attempts than boys, despite the fact that boys die by suicide at higher rates. Provisional federal data show that, in 2021, roughly 6 of every 100,000 girls ages 15 to 24 died by suicide. That’s compared with roughly 24 of every 100,000 boys of the same age. From 2020 to 2021, the rate of suicide in that age group increased 5 percent in girls compared with 8 percent in boys.

Access to guns might factor in here. For every 10 percent increase in household gun ownership in a state, the youth suicide rate increases by about 27 percent, researchers reported in 2019 in the *American Journal of Preventive Medicine*. And boys are seven times as likely to kill themselves with a gun than girls are, according to a 2022 report by Everytown for Gun Safety, a gun violence prevention organization.

Missed depression in boys could help explain a long-standing research question, Adams and others say: Why do more women get diagnosed with depression, the most common precursor to suicide, when more men die by suicide?

One path forward is to look beyond sadness and hopelessness as proxies for depression, Adams says. What about impulsivity, conflict with others or social withdrawal? Perhaps those symptoms serve as better proxies for depression — and suicidal thinking — in men, she says.

Understanding other proxies could protect not just depressed individuals from harm but also broader society, another line of research suggests. Seena Fazel, a forensic psychiatrist at the University of Oxford, and colleagues began examining data from Swedish patient registries to investigate if depression links to violent behavior. Their participant pool included about 47,000 adults diagnosed with depression from 2001 to 2009 and nearly 900,000 people without such a diagnosis.

People with depression were three times as likely to commit a violent crime, such as assault, arson or a sexual offense, as individuals without depression, the team reported in 2015 in *Lancet Psychiatry*.

To attempt to rule out genetic or environmental differences, the team looked at siblings. A person with depression was twice as likely to commit a violent crime as their sibling without depression. Fazel and another team reported a similar link between depression and violence among teens and young adults in 2017 in the *Journal of the American Academy of Child & Adolescent Psychiatry*.

The link between violence and depression has been found for both men and women. But since men commit most violent crimes, missing depression in men is a concern, Fazel says.

But he stresses the importance of keeping such findings in perspective. His earlier work, for instance, found that over a 13-year period in Sweden, there were 450 violent crimes committed per 10,000 people. Of those, 24 were committed by people with severe mental illness. “With guns and mental illness,” Fazel says, “you are much more likely to kill yourself than kill somebody else.”

Better screening Depression may manifest differently in men and women, so some researchers have developed male-specific diagnostic tools. The Male Depression Risk Scale asks individuals to rate how often over the last month various statements (some shown below) apply to them. These statements address emotion suppression, anger and other topics that are not often included in traditional screening tools. SOURCE: S. RICE ET AL/HARVARD REVIEW OF PSYCHIATRY 2022

Items from the Male Depression Risk Scale

I bottled up my negative feelings.

I had unexplained aches and pains.

I needed alcohol to help me unwind.

I overreacted to situations with aggressive behavior.

I stopped caring about the consequences of my actions.

It was difficult to manage my anger.

Using drugs provided temporary relief.

Shifting views

The idea that depression may look different in men and women — not to mention differences based on other demographic factors (SN: 2/11/23, p. 18) — is gaining traction.

For instance, a 2022 revision to the *Diagnostic and Statistical Manual of Mental Disorders*, or DSM, the American Psychiatric Association’s reference book, acknowledges the gender differences in depression. The revision’s authors note that, compared with depressed women, depressed men tend to report “greater frequencies and intensities of maladaptive self-coping and problem-solving strategies, including alcohol or other drug misuse, risk-taking and poor impulse control.”

Even before the revision, the DSM included “irritable mood” as a feature of depression in youngsters. So teenagers’ age and gender both potentially influence how they express depression.

Even if the idea that depression looks different in boys and girls gains wider acceptance, changing the Youth Risk Behavior Survey will take time. If enough experts express concerns about how questions related to mental health are posed, then the earliest the CDC could amend the survey would be for the 2025 round of data collection, a CDC spokesperson told *Science News*.

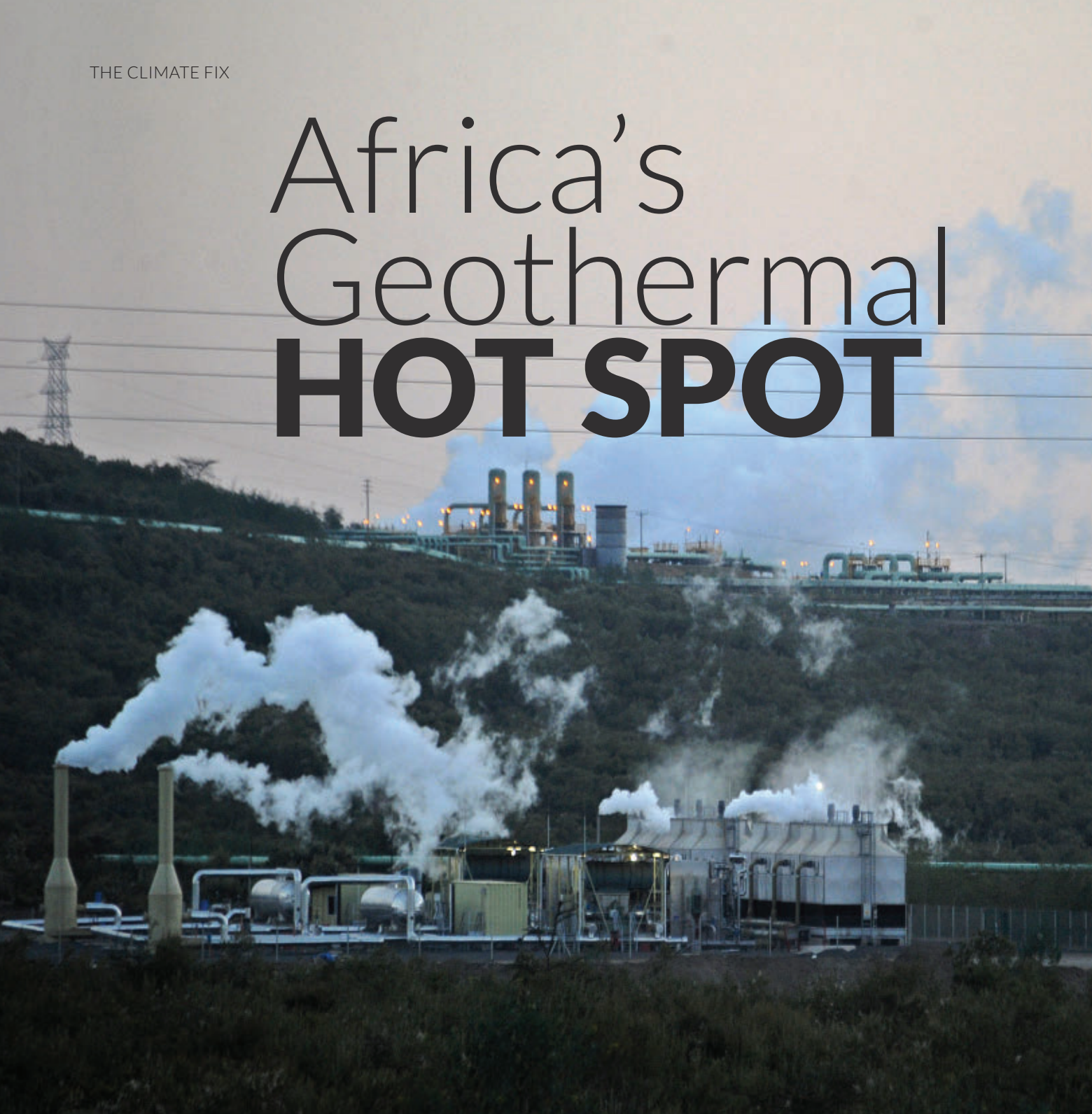
But the experts I spoke with are hopeful that such changes will trickle into other mainstream research. Even adding a single word to questions, such as asking about irritability in addition to sadness and hopelessness, could identify a huge number of depressed boys who might otherwise appear fine, these researchers argue.

Tweaks of this nature, Rice says, “could be a game changer at identifying depression in boys [and] young men.” ■

Explore more

- Read the CDC’s report on the Youth Risk Behavior Survey at bit.ly/Youth_Risk_Behavior_Survey
- Ian T. Zajac et al. “Suicide risk, psychological distress and treatment preferences in men presenting with prototypical, externalising and mixed depressive symptomology.” *Journal of Mental Health*. May 13, 2020.

Africa's Geothermal **HOT SPOT**



Kenya is helping its neighbors tap into
Earth's heat to generate renewable energy

By Geoffrey Kamadi



Geothermal energy accounts for almost half of Kenya's total energy production. The majority of that energy is produced at the Olkaria power project (shown).

THE CLIMATE FIX

This article is part of a series of stories on climate change solutions and how people around the world are tackling the biggest challenge of our time.

plummeting valleys and undulating hills — a rugged landscape that inspired the backdrop of Disney's *The Lion King*.

Those forces have also made Naivasha the frontier of Kenya's geothermal power industry.

The country's first geothermal well was drilled there in the 1950s. By 1981, Kenya had its first geothermal power plant, harnessing a renewable resource that taps into heat generated deep within the Earth. Today, Naivasha's Olkaria geothermal power project plus a small facility at another site are capable of generating 963 megawatts of electricity when running at full power. At the end of last year, Kenya ranked seventh on the list of top geothermal energy countries in the world. Geothermal accounts for 47 percent of the country's total energy production — a percentage that's growing. The only other geothermal energy producer in Africa, Ethiopia, started production in 1998 and has an installed capacity of just 7.5 megawatts.

But regional interest is growing, especially as Africa works toward universal energy access by 2030, in accordance with the United Nations' Sustainable Development Goals. Roughly 43 percent of the continent's population, equaling about 600 million people, lacks access to electricity. A 2021 analysis by the Dalberg consulting firm in partnership with the U.N. showed that there's enough renewable energy potential to power Africa's energy needs well into the future, though the up-front costs would be higher than if fossil fuels were used to meet those energy demands.

If African countries pursue renewable energy to meet their electricity goals, the up-front cost would be \$1.5 trillion, about 50 percent more than the \$1 trillion that fossil fuels would require, says James Mwangi, formerly of Dalberg and founder of the group Climate Action Platform for Africa. But thanks to lower operating and maintenance costs, renewables eventually pay off. In one scenario in the Dalberg analysis, a renewable-heavy future would take 13 years or so to break even with one where fossil fuels are still heavily used.

With the renewables route, Mwangi says, "Africa could reach universal energy access much faster and ultimately have the lowest energy costs in the

The dusty town of Naivasha sits within the Great Rift Valley, where the African continent is being divided into two. About 90 kilometers northwest of Kenya's capital city of Nairobi, Naivasha welcomes gaggles of tourists each year trekking to Hell's Gate National Park. The forces that are splitting apart the African tectonic plate have sculpted the area's steep cliffs,

The total worldwide installed capacity for generating electricity from geothermal energy is 16,000 megawatts. In 2022, Kenya ranked seventh on the list of top geothermal countries.

SOURCE: THINKGEOENERGY RESEARCH 2023

Top 10 geothermal countries (megawatts of installed capacity)

United States: 3,794
Indonesia: 2,356
Philippines: 1,935
Turkey: 1,682
New Zealand: 1,037
Mexico: 963
Kenya: 944*
Italy: 944
Iceland: 754
Japan: 621

*ThinkGeoEnergy's tally of Kenya's installed capacity, as of January 2023, differs slightly from KenGen's.

world.” The localized nature of renewable sources, compared with often-imported fossil fuels, could also enhance energy security and independence.

In East Africa, geothermal energy is an attractive option. It's abundant thanks to the East African Rift System, which brings heat toward the surface. Like other renewable energies such as wind and solar, geothermal doesn't emit carbon dioxide. And it comes with extra benefits. “Geothermal power is reliable,” says Anna Mwangi, senior geophysicist at the Kenya Electricity Generating Company, or KenGen, the government entity that operates Olkaria (and no relation to James Mwangi). Geothermal sources are available night and day, and don't depend on the sun, wind or rain. So geothermal energy may be more resilient to climate change than some other renewables.

But setting up geothermal power plants requires more money and specialized expertise than other renewable energies. And like any development project, it can come with social costs, such as displacing people from their land.

Given its long-standing experience, Kenya is now assisting its neighbors. “We are offering technical support to the countries in the region, as a way to help them develop their geothermal potential,”



“Geothermal power is reliable,” says geophysicist Anna Mwangi.

says Anna Mwangi. KenGen has already drilled multiple geothermal wells in Ethiopia and Djibouti.

A reliable resource

Globally, geothermal resources are often found along the boundaries of tectonic plates, such as around the Pacific Ocean's Ring of Fire. In Africa, a bounty of geothermal resources exist where a new boundary is forming: the East African Rift System. The exact start of the system is not clearly defined; it originates on the Arabian Peninsula before running

south along the Red Sea and into Djibouti. As it runs southward in Africa, the rift zone branches into two arms: The eastern arm ends at the border between Kenya and Tanzania while the western arm goes farther south, running 6,400 kilometers through more than 10 countries before ending in Mozambique.

For millions of years, the African Plate has been pulled in opposite directions, at a rate of a few centimeters per year. Eventually, this stretching will split Africa into two separate continents and create two tectonic plates, the Nubian Plate to the west and the Somalian Plate to the east.

The stretching also causes magma to dome up in various points along the rift system. One such place is Olkaria in Naivasha. Beneath the surface, the molten rock heats groundwater. Wells bring that hot water and steam to the surface. When harnessed at high pressure and used to turn turbines, the steam generates electricity. The hot water is then injected back into the ground to recharge the subterranean water supply.

There's no comprehensive estimate for how much total energy East Africa could harvest from geothermal sources. But experts estimate that Kenya and Ethiopia could each generate 10,000 megawatts. That's roughly triple Kenya's total installed electricity capacity and double Ethiopia's.

For now, it's mostly Kenya — one of the world's fastest-growing geothermal power players — that has plumbed this deep heat. In addition to Olkaria, there's a small site at the nearby Eburru geothermal field that can generate 2.4 megawatts of electricity. Farther to the north, a 35-megawatt power plant is expected to open this year at the Menengai geothermal field, with another one in development.

A push toward geothermal energy in recent years has come as droughts have dwindled some of Kenya's hydropower sources. With rainfall and temperatures



Geothermal energy doesn't just generate electricity. It can also be used as a direct source of heating, like at this spa next to the Olkaria geothermal power project.

Geothermal energy potential versus installed capacity in select East African countries

Country	Estimated potential (megawatts)	Installed capacity (megawatts)
Kenya	10,000	963
Ethiopia	10,000	7.5
Tanzania	5,000	0
Uganda	1,500	0
Djibouti	1,000	0
Comoros	30–50	0

Deep-seated power Comprehensive estimates of geothermal energy potential are not available for all East African countries. But the estimates that do exist suggest there's room for growth. SOURCES: KENGEN, THINKGEOENERGY

projected to become more erratic and extreme with climate change, geothermal energy may be the more dependable option, Anna Mwangi says.

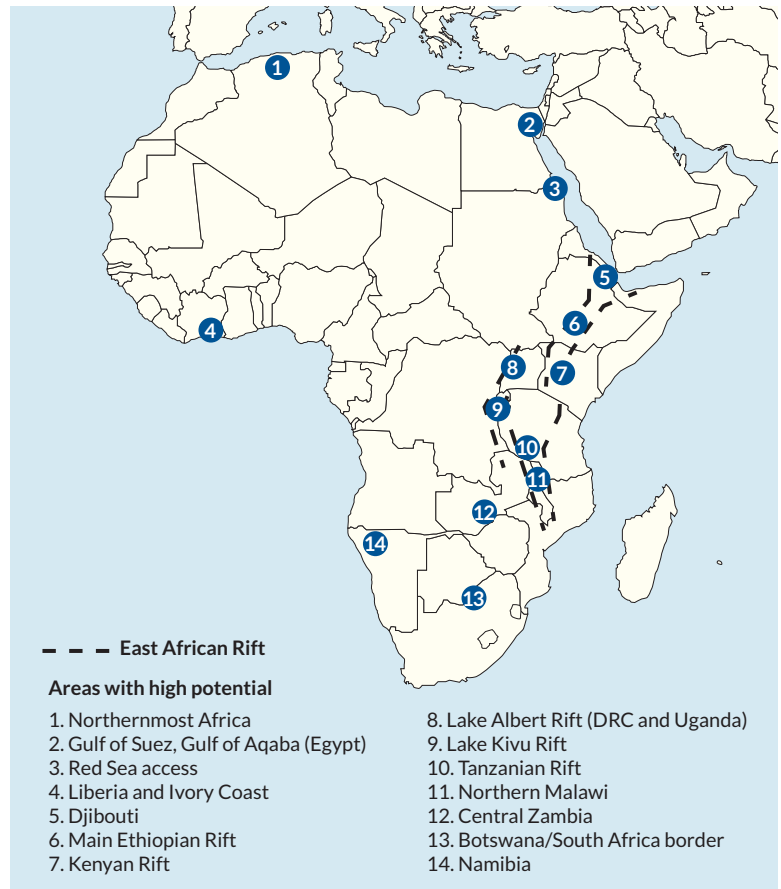
Geothermal power plants can run at maximum power output up to 90 percent of the time, when taking downtime due to maintenance into account, says François Le Scornet, president and senior market intelligence consultant at Carbonex Consulting in France. That's comparable to a nuclear power plant and about twice as reliable as a fossil fuel plant or wind farm (and four times as good as solar). Indeed, with the rise of geothermal energy, Kenya's power outages have declined, according to a report released in February by the International Renewable Energy Agency and the International Geothermal Association.

The scalding-hot water and steam that flow up a geothermal well can do more than generate electricity; they can also be a direct source of heating. The Oserian flower farm near Naivasha, for instance, pipes the water in to warm a greenhouse at night. The warmth dries out the air to prevent fungus from spoiling the roses, carnations and other flowers destined for bouquets around the world. At Olkaria, tourists in need of relaxation after a long day of exploring Hell's Gate can soak in the geothermal spa near the power plant.

Finding the heat

It takes a team of specialists to determine a site's suitability for geothermal resource exploration.

Locations in Africa with high potential for geothermal energy



Good prospects A recent analysis pinpointed 14 areas in Africa with high potential for developing geothermal energy. Most of these locations are within the East African Rift System.

SOURCE: S. ELBARBARY ET AL/GEOTHERMAL ENERGY 2022

At minimum, what's needed are the presence of groundwater, high temperatures — often around or above 150° Celsius — and permeable rock that will enable heated water and steam to flow into production wells, says Mohamed Abdel Zaher, a geophysicist at the National Research Institute of Astronomy and Geophysics in Cairo.

Certain visual characteristics on the surface may give an initial hint. Hot springs, hot mud puddles, geysers and even steam rising from the ground are signs of geothermal activity. Another clue is the presence of certain rocks, such as travertine, or mineral veins like quartz that indicate rock has been altered during interactions with hot water.

At Olkaria, a tip-off was the fact that the surrounding area is ring-shaped like a caldera, a collapsed volcano. A series of younger volcanic domes appear to have intruded into the caldera.

If the surface characteristics look promising,



Journalists stand next to a geothermal well while on a tour of Olkaria.

geochemists will step in to analyze fluid and gas samples to estimate how deep and hot the heat source might be and where the fluids flow. Seismometers might be deployed to infer the brittleness of the subsurface rock. It's important that rock be permeable, but it needs to be strong enough to withstand the interaction of cool water being heated from the magma below.

If all those data look promising, exploration drilling will commence and if all goes well, a production well and eventually a full-blown power plant will follow.

Zaher and his colleagues recently completed a project that might help experts across the continent zero in on potential geothermal targets before starting costly on-the-ground exploration. "It is quite difficult to predict the precise power or electricity that can be produced for all of Africa," he says. But his group incorporated a range of geologic, seismic and other geophysical data into a geographic information system to predict the most promising spots for geothermal exploration. The resulting map identifies 14 areas that have high geothermal potential, the team reported last year in *Geothermal Energy*.

Not surprisingly, many of these locations are within the East African Rift System, though high potential also exists in northern Africa in Morocco, Algeria and Tunisia, as well as in Liberia, Namibia,

Zambia and South Africa. In many of those countries, the tectonics are such that using geothermal energy for direct heating—as is done at the Oserian flower farm and could be applied in a variety of settings, including industrial processing—may be more feasible than for electricity generation, Zaher says.

Beyond Kenya

KenGen has led on-the-ground geothermal exploration in a number of nearby countries. In addition to the drilling done in Ethiopia and Djibouti, surface studies to identify potential geothermal resources have been done in Sudan, Uganda, Rwanda, Tanzania, Zambia and the Comoros islands off the coast of Mozambique, Anna Mwangi says.

In addition, KenGen—in collaboration with the Icelandic-based GRÓ Geothermal Training Programme and Kenya's Geothermal Development Company—has been training university students, energy professionals and government officials within East Africa on geothermal resource exploration and development, as well as power plant financing and management. With help from the World Bank, Kenya is also setting up the Geothermal Centre of Excellence, which will train professionals in the region once it opens in a couple years, Mwangi says.

Even with the right technical knowledge, though, it can take several years to go from exploration to geothermal energy production. In fact, even once

a well has been drilled, it could still take up to a decade or more before a power plant is up and running. Funding constraints can be one barrier.

This is what Kenyan engineers were faced with in 2012, Mwangi says. Wells had already been drilled, yet funding for putting up power plants to generate electricity at full capacity was still unavailable.

This opened an avenue for experimentation. Typically, a power plant is supplied with water and steam from multiple wells at varying distances away. But a new wellhead approach, which hadn't been implemented anywhere in the world, allowed for the generation of power directly and quickly from a single well, at low cost, in the meantime.

Once a permanent power plant is ready to be built, the wellhead installation can be disassembled and taken to another well for the same purpose. About 85 megawatts of power have been produced this way in Kenya. "Such well-based power plants give us the early generation benefit, and generate revenue in the meantime," Mwangi says. "Otherwise, these production wells would have remained capped awaiting construction and commissioning of a new power plant."

The costs of geothermal

Even as interest and expertise in geothermal energy grow in East Africa, financial constraints remain an impediment. In Kenya, a single geothermal well can cost about \$6 million to drill, and it can be another \$300 million to build a roughly 165-megawatt plant.

"Up-front capital cost is high in geothermal, but running costs are limited," says Le Scornet, the energy consultant.

The worldwide levelized cost of electricity, or LCOE, for a new geothermal installation in 2021 averaged \$0.068 per kilowatt-hour, according to the International Renewable Energy Agency. The LCOE is the lowest price at which electricity can be sold for an energy project to break even. The figure takes into account lifetime costs, from building a plant to operating and maintaining it.

Geothermal's LCOE is about 40 percent higher than a new hydropower project or solar photovoltaic array, which have an LCOE of \$0.048 per kilowatt-hour. An onshore wind farm is about half as expensive, at \$0.033 per kilowatt-hour, but geothermal energy is slightly less costly than an offshore wind farm's \$0.075 per kilowatt-hour. (For context, Kenya's per capita energy consumption in 2019 was about 168 kilowatt-hours, according to the U.N.)

Le Scornet says that stable financing mechanisms are needed to provide stability and reduce actual and perceived project risks. To tackle



Zebras gather near a tube carrying water that will be injected back into geothermal wells near Olkaria.

this challenge, the Geothermal Risk Mitigation Facility, funded by the European Union and the African Union, was set up in 2012 to cofinance surface studies and drilling programs.

"Support from project partners like the EU, for instance, and the African Development Bank can be instrumental, especially in countries with high debt levels and where competition with alternative projects presents obvious challenges for the development of new geothermal projects," Le Scornet says.

But not all costs are purely financial. Kenya's Olkaria project demonstrates one of the social costs. In developing and expanding the project over time, some members of the local Maasai community, a seminomadic pastoralist group, have been removed from their land, says Ben Ole Koissaba, lead consultant for Rarin Consulting Services, which champions for the land rights of Indigenous communities. Relocated people "have been cut off from the rest of the community," says Koissaba, who is a member of the Maasai. And some of the housing built for them has not been culturally appropriate, he says.

While some of the Maasai consider the displacement an outstanding issue, Kenya's geothermal exploration isn't slowing down. By 2025, the country aims to more than double its current production capacity to 2,500 megawatts. ■

Explore more

- Samah Elbarbary *et al.* "Geothermal renewable energy prospects of the African continent using GIS." *Geothermal Energy*. May 30, 2022.

Geoffrey Kamadi is an award-winning freelance science journalist based in Nairobi, Kenya.



Fires in the Dark
 Kay Redfield Jamison
 KNOFF, \$30

BOOKSHELF

How great healers ease mental anguish

Mentally and spiritually devastated after surviving World War I's combat horrors, British poet Siegfried Sassoon was treated for emotional wounds at a military hospital. He wrote a poem for his psychotherapist that included these lines: Fires in the dark you build; tall quivering flames / In the huge midnight forest of the unknown.

Kay Redfield Jamison takes the title of her new book, *Fires in the Dark*, from Sassoon's vivid image of how medical psychologist, physician and anthropologist W.H.R. Rivers tended to his psychological war wounds. Jamison uses writings by both men to explore Sassoon's therapeutic relationship with Rivers. Their story forms part of a deeper probe into how psychological pain can be healed and what it takes to be a great healer. Jamison writes movingly about topics ranging from the workings of ancient Greek healing temples to the tribulations of World War I nurses facing the limits of healing soldiers' ravaged bodies and minds.

Jamison, a psychiatrist herself, has previously written about her personal experience with bipolar disorder, which informs this literary journey into healing (SN: 4/8/00, p. 232).

Since the dawn of humankind, certain individuals — who combine compelling personalities, a stout character and superior people skills — have stood out as healers of what Jamison has previously described as “unquiet minds.”

Effective healers accompany sufferers on a journey toward wellness, she writes. Healing tools include the deft use of suggestion, confession, memory, ritual and medicines. Healers find ways to provide consolation and hope, enabling their wounded charges to engage with meaningful work and find purpose in life.

That theme reverberates in Jamison's account of how Rivers treated Sassoon, whose war reactions might today be diagnosed as post-traumatic stress disorder. As an anthropologist, Rivers had learned about and witnessed healing rituals and supernatural beliefs of different cultures. He had written that “psycho-therapeutics would seem to be the oldest branch of medicine.”

Rivers struck colleagues and those he treated as forceful but caring, demanding but sympathetic. Sassoon wrote that he liked and trusted Rivers within minutes of meeting him. After listening to Sassoon relate his traumatic war experiences, Rivers focused on the soldier's memory and imagination as key healing elements.

Rivers encouraged Sassoon to use

poetry to memorialize friends and soldiers he had commanded but who had not survived. As verses of remembrance and grief accumulated, Sassoon achieved a measure of control over the war's terror and futility. Feeling a sense of guilt and responsibility for soldiers still fighting, Sassoon returned to the war.

Psychotherapy as practiced by Rivers had roots in the powers of suggestion wielded millennia earlier by priests and sorcerers, Jamison writes. Ancient Egyptians and Greeks, for example, called on priest-physicians who performed early types of surgery, chanted against disease-causing spirits and used magic spells to amplify patients' responses to medicinal potions.

Jamison includes a fascinating description of ancient Greek healing temples run by followers of Asclepius, the god of medicine. In settings designed to be peaceful refuges, individuals with mental maladies received a special herbal ointment made from imported ingredients. Sufferers were encouraged to enter meditative or hypnotic states and to tell their dreams to temple healers. Dream content guided treatment recommendations.

Therapists today practice a range of purely secular techniques, though they still hark back to the days of Asclepius, Jamison says. Scientifically supported approaches rest on a time-tested need for therapists to gain clients' trust and nurture self-understanding and hope for improvement (SN: 11/5/05, p. 299). That's truer than ever in an era characterized by the well-funded promotion of medications and brain technologies over mere “talk” as keys to vanquishing mental problems.

As recently as the 20th century, Jamison writes, mental health clinicians emphasized general features of psychotherapy that promote healing. Psychiatrist and psychologist Jerome Frank, for instance, influentially argued in a 1961 book that any successful form of psychotherapy counteracts the demoralization of those who experience the world as chaotic.

Jamison also delves into examples of the healing powers of music, art, drama and public rituals of remembrance. She includes the poignant story of how, thanks to an Anglican

army chaplain, remains of the Unknown Warrior came to be buried at Westminster Abbey in 1920 in a ceremony that lessened the post-war grief of people across Britain.

Healers often find it difficult to untangle why their efforts sometimes light fires in the dark and other times fizzle out. Jamison's stories of healing outline a process that's still emerging from Sassoon's huge midnight forest of the unknown.

— Bruce Bower

During World War I, psychologist W.H.R. Rivers (left) treated psychic scars of the poet Siegfried Sassoon (right).





Congratulations to the winners of **REGENERON ISEF 2023**

The Regeneron International Science and Engineering Fair, a program of Society for Science, is the world's largest global pre-college science and engineering competition. In May, 1,638 young scientists from 64 countries, regions and territories participated in Dallas, winning nearly \$9 million in awards and scholarships. Regeneron ISEF provides a global stage for young scientists and engineers around the world.

Kaitlyn Wang (above, second from right), 17, of San Jose, Calif., won the George D. Yancopoulos Innovator Award of \$75,000.

Saathvik Kannan (above, far right), 17, of Columbia, Mo., received one of two Regeneron Young Scientist Awards of \$50,000.

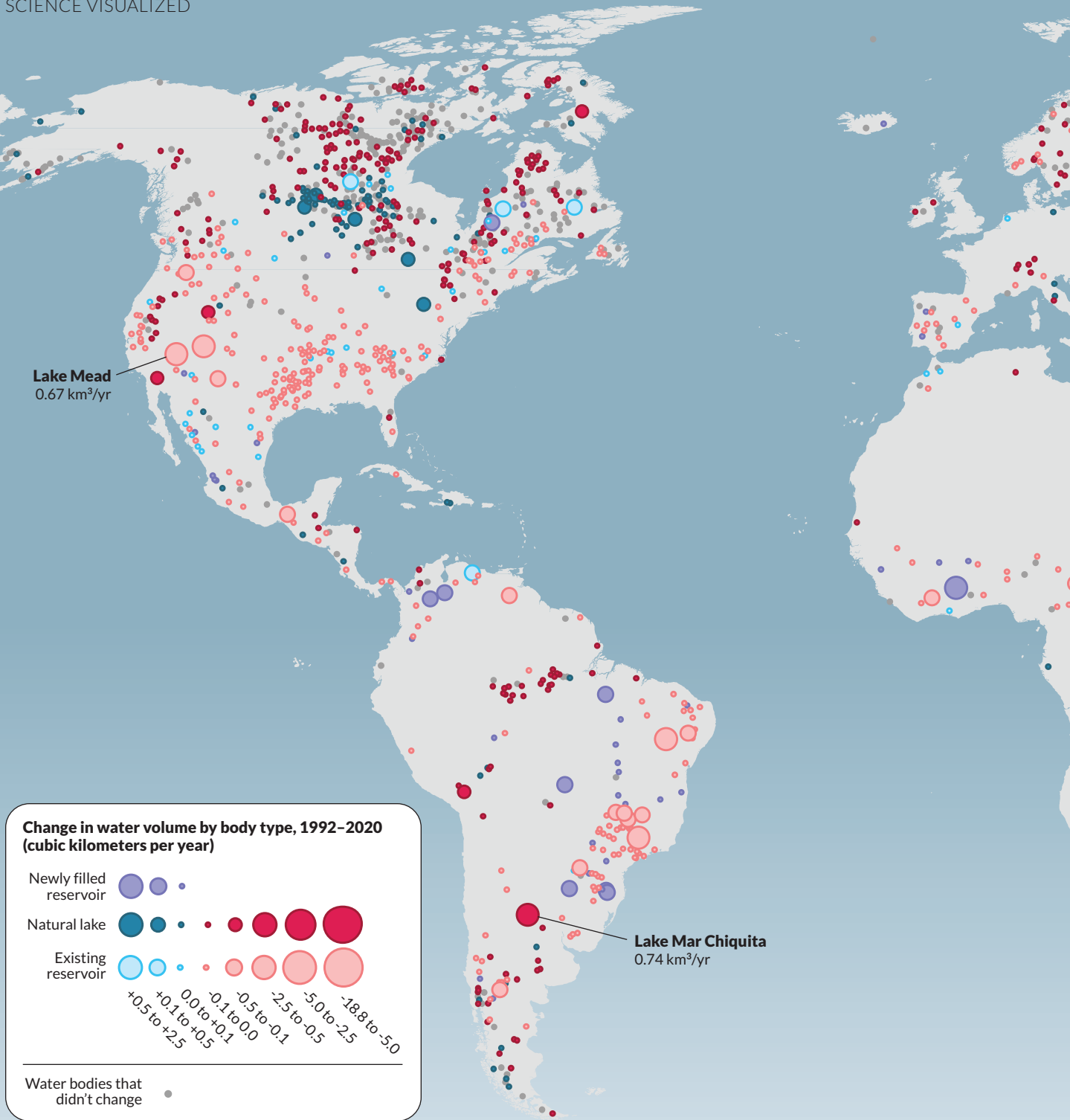
Teepakorn Keawumdee (above, far left), 17; **Pannathorn Siri** (above, middle), 16; and **Poon Traultangmun** (above, second from left), 18, of Bangkok shared the second Regeneron Young Scientist Award of \$50,000.

Natasha Kulviwat, 16, of Jericho, N.Y., received the Gordon E. Moore Award for Positive Outcomes for Future Generations of \$50,000.

Yuyang Wang, 16, of Shanghai received the Craig R. Barrett Award for Innovation of \$10,000.

Rishabh Ranjan, 17, and **Gopalaniruddh Tadinada**, 17, of Louisville, Ky., shared the H. Robert Horvitz Prize for Fundamental Research of \$10,000.

Eugene Chen, 16, of Shanghai received the Peggy Scripps Award for Science Communication of \$10,000.



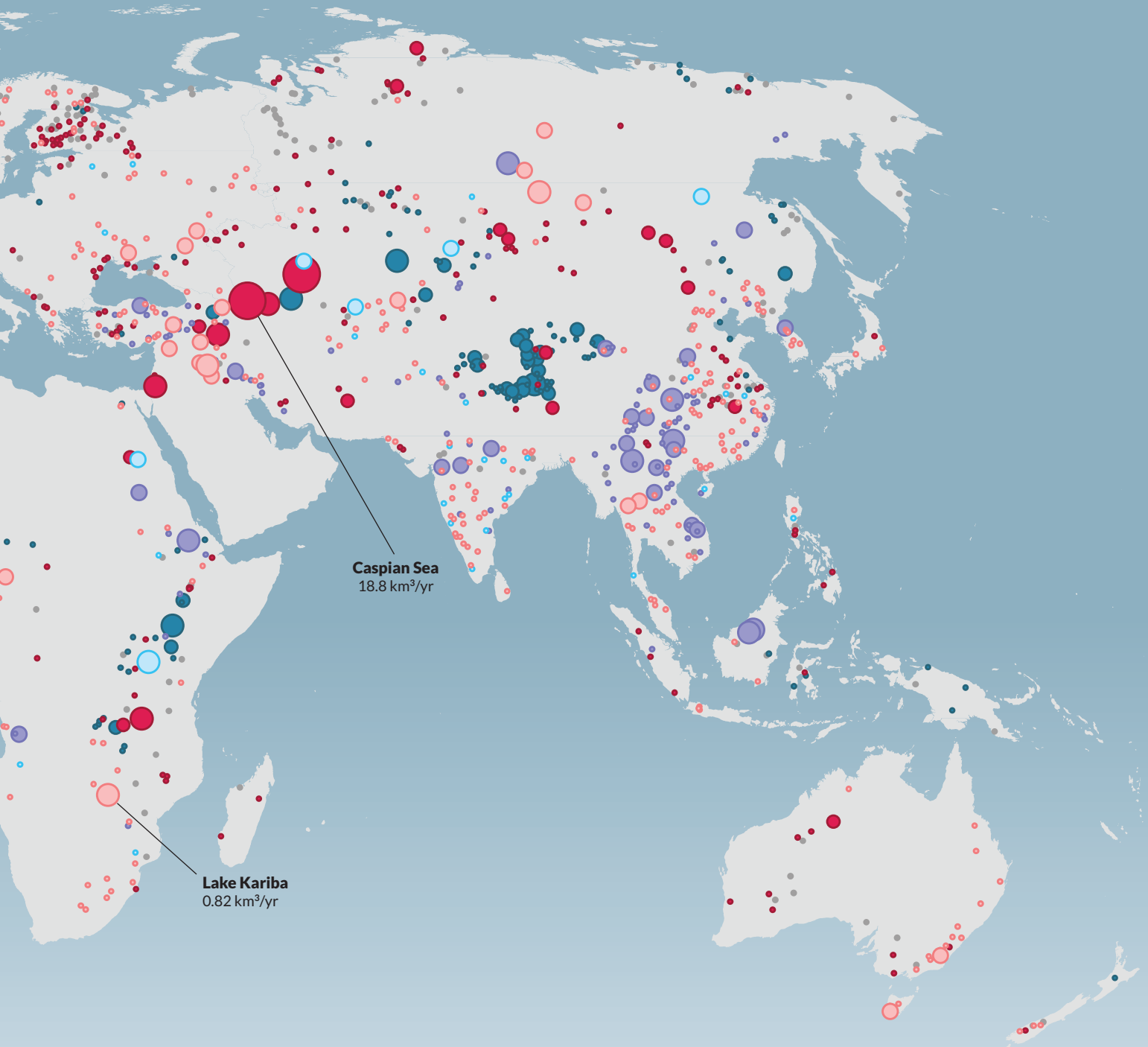
How nearly 2,000 lakes and reservoirs changed over 3 decades

More than half of the largest lakes and reservoirs shrank over the last three decades, researchers report in the May 19 *Science*.

That’s a big problem for people who depend on those lakes for drinking water and irrigation. “About one-quarter of the Earth’s population lives in these basins with lake water losses,”

says surface hydrologist Fangfang Yao of the University of Virginia in Charlottesville. Drying lakes also threaten the survival of local ecosystems and migrating birds, and can even lead to dust storms that harm human health (SN: 6/3/23, p. 18).

Using satellite data from 1992 to 2020, Yao and colleagues



tracked the volume of water in nearly 2,000 of the largest reservoirs and natural lakes, all pinpointed in the map shown above. These bodies account for 96 percent of Earth's lake water and 83 percent of all reservoir water. Four bodies with some of the largest loss rates are highlighted.

In that time span, about 53 percent of the observed lakes shrunk (dark red), while only 22 percent made gains (dark blue), the team found. That's a net loss of roughly 600 cubic kilometers of water, or about 17 times the maximum capacity

of Lake Mead, the largest reservoir in the United States.

Nearly two-thirds of existing reservoirs lost water (light red), while 8 percent gained (light blue). The filling of new reservoirs (purple) contributed to a slight overall increase in global reservoir storage of nearly 140 cubic kilometers.

Using hydrologic and climate simulations, the researchers concluded that climate change and human consumption are the main causes of the decline in natural lakes. In reservoirs, sediment buildup is the primary driver of loss. — *Nikk Ogasa*



MAY 6, 2023 & MAY 20, 2023

SOCIAL MEDIA

Marvels of the sea

Octopuses (one shown below) and squid masterfully edit RNA while leaving DNA intact. Such modifications could explain the creatures' intelligence and behavioral flexibility, **Tina Hesman Saey** reported in "Kraken the code" (SN: 5/6/23 & 5/20/23, p. 34). "Octopuses never fail to amaze us with their intelligence and adaptability," marveled Twitter user **@NanacySharma**. "It's incredible how they navigate the world with their unique abilities. Let's continue to appreciate and protect these fascinating creatures."



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Icy hot

*Ice particles from Saturn's rings are falling into the planet's atmosphere. In part because the particles vaporize, energy is released, heating up and making the sky glow at ultraviolet wavelengths, **Ken Crosswell** reported in "Saturn's icy rings may bring the heat" (SN: 5/6/23 & 5/20/23, p. 18).* Some readers asked how energy could be released given that energy is typically consumed during vaporization.

Vaporizing water does require energy, **Crosswell** says, but other processes are at play. Collisions between falling ice particles and atmospheric gas deposit heat energy into the air from friction. Ultraviolet radiation from the sun also breaks up water molecules, creating free-range "hot" hydrogen atoms that raise the atmosphere's temperature. Together, all of these processes result in a net influx of energy into Saturn's atmosphere, **Crosswell** says.

See-through muscles

*Microscopic banded structures in the muscles of ghost catfish separate light passing through the fish's body into different wavelengths, giving the creature its iridescence, **McKenzie Prillaman** reported in "How a transparent fish turns rainbow" (SN: 5/6/23 & 5/20/23, p. 48).*

Reader **Jeffrey Goodis** asked how the muscles can be transparent.

How transparent a material is depends on two factors, says physicist **Qibin Zhao** of the Shanghai Jiao Tong University. The material's molecular structure determines how much light bends when passing through. And the way that light interacts with the surrounding environment helps determine the level of transparency.

Like many other kinds of fish, the ghost catfish has muscles with a molecular structure that is orderly but loosely packed, which readily lets light through. But ghost catfish muscles are so thin that light bends very little when it goes from water to muscle and back to water. The muscles of other fish would also be transparent if they were as thin as those of the ghost catfish, **Zhao** says.

Bear necessities

*Low levels of a clotting protein called HSP47, which is typically found in platelets and cells that make up connective tissues, may keep hibernating bears free of blood clots. The finding could make way for new anticlotting treatments that balance preventing clots and causing too much bleeding, **Erin Garcia de Jesús** reported in "Hibernating bears avoid blood clots" (SN: 5/6/23 & 5/20/23, p. 16).*

Reader **Jeffery Lowers** wondered what the potential downsides of medicines that target HSP47 might be.

Stopping HSP47 from doing its job would affect the ability of platelets in the blood to quickly stop bleeding in the event of a cut or an injury. Such a risk would probably not be a top concern for hibernating animals or people who are in a coma. But it does mean that future medicines that target this protein may not work for every patient.

Take a person with a bone fracture, says **Marjory Brooks**, a veterinarian and comparative hematologist at Cornell University. For such a patient, platelet function is crucial because platelets help repair broken bones by stifling any bleeds and healing wounds, **Brooks** says.

Correction

"Jupiter's lightning is a lot like Earth's" incorrectly stated that a lightning bolt lurches forward at an average of hundreds of thousands of meters per second (SN: 6/17/23, p. 14). It lurches at an average of tens of thousands of meters per second.



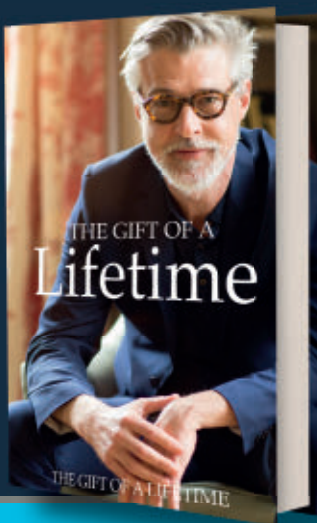
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