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Science News

MAGAZINE OF THE SOCIETY FOR SCIENCE ■ SEPTEMBER 24, 2022

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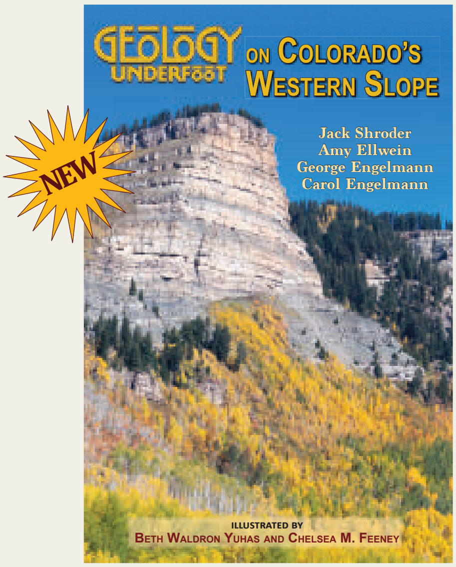

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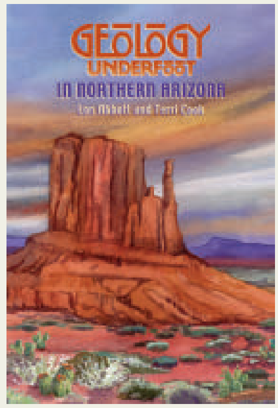

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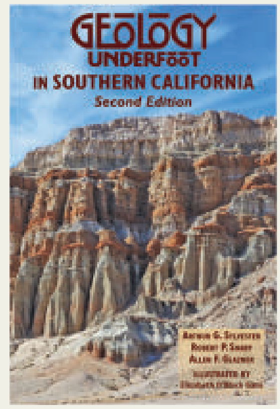

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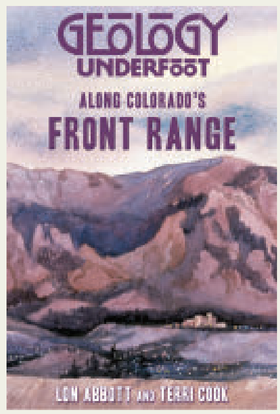

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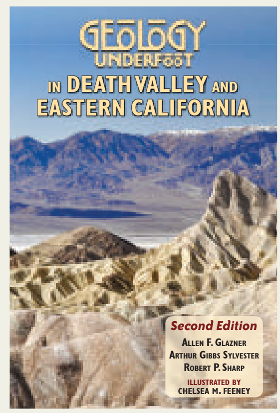

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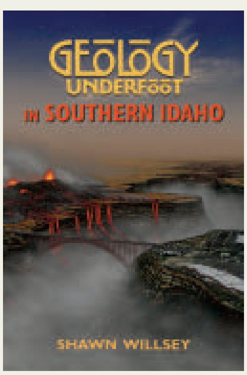

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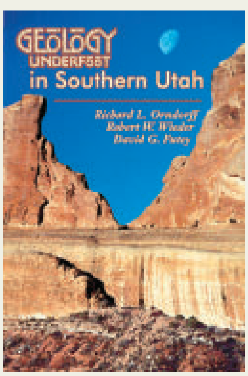

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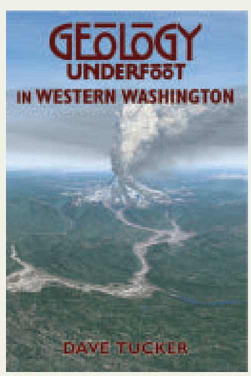

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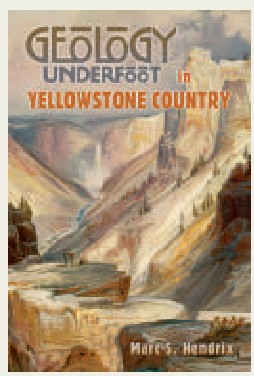

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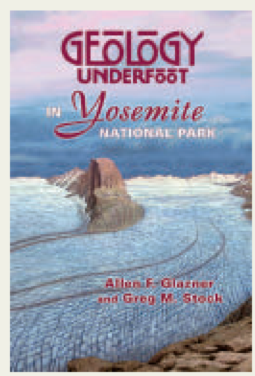

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COVER When it comes to proteins, form helps explain function. There's power in seeing how a protein folds, curls and twists. *DeepMind*

FROM TOP: L. MIELKE; R. GARCÍA-ROA; CAFUEGO/FLICKR (CC BY-SA 2.0)

So much of science is looking and seeing

One of my great joys in life is one of the simplest: looking at the world around me. I often walk along the C&O Canal, a defunct marvel of 19th century transportation engineering that reaches west from Washington, D.C. As I walk, I look. And even though I have strolled the towpath so many times before, I always see something new.

Last Saturday, I saw a native persimmon tree with fruit the size of Ping-Pong balls just starting to turn color. I spied two beaver dams spanning the canal, marvels of rodent engineering. And I saw how the September sunlight was softening into fall, giving everything a glow that an Impressionist painter might envy.

So much of science is looking and seeing. On September 1, the astronomy world went bonkers when news broke that the James Webb Space Telescope had taken its first direct image of a planet outside our solar system. Scientists' Twitter feeds erupted in exclamation points and comments like "thrilled" and "amazing." Taking pictures of very distant planets is exceedingly difficult, but the new megatelescope, which released its first images in July, has made seeing better than any other telescope look easy-peasy (*SN: 8/13/22, p. 30*). Or as associate news editor Christopher Crockett commented wryly in one of our internal Slack channels: "OK JWST, now you're just showing off."

The telescope has also captured the light spectrum of a probable brown dwarf and confirmed the existence of carbon dioxide in the atmosphere of another exoplanet, as astronomy writer Lisa Grossman explains on Page 6. This raises hopes that the telescope might someday spot Earthlike planets capable of sustaining life. That hope may never be fulfilled, but it's clear that if the telescope keeps performing at this level, many extraordinary sights are headed our way.

Serendipitously, this issue of the magazine chronicles another scientific achievement in looking and seeing, using artificial intelligence systems to visualize the 3-D structures of proteins. These molecules are the building blocks of biological life, and their shapes define their purpose. But proteins twist and fold themselves into complex tangles, and scientists' labors to decipher them using electron microscopes and other technologies have been painfully slow.

Enter an AI system called AlphaFold that evaluates already-mapped proteins and uses that information to predict the structures of others. As molecular biology senior writer Tina Hesman Saey reports on Page 16, this should speed up efforts to study life on Earth, whether to develop new medical treatments or learn more about human evolution. Some of AlphaFold's predictions are less accurate than others, as Saey points out, and the AI system so far can't cope with the challenges of decoding how protein structures interact with each other, and with other molecules. That's where a deeper understanding of protein structures will really pay off, scientists say. But even without that capacity, the system is helping scientists skip much of the scut work and move forward to tackling big questions across the life sciences.

These new technologies and the scientists who created and use them let me see things I never imagined possible. And like those happy astronomers, I am thrilled and amazed. *—Nancy Shute, Editor in Chief*

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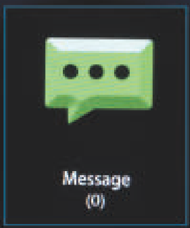

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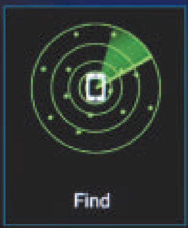

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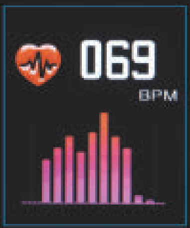

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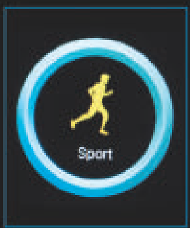
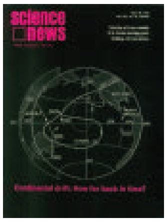


Track steps and calories



Excerpt from the September 30, 1972 issue of *Science News*

50 YEARS AGO

Before Pangaea — what?

The continents as we know them resulted when the protocontinent Pangaea broke apart and its fragments made the long slow journey to their present positions. The process took about 200 million years. But the Earth's crust is an estimated 4.5 billion years old.... [Scientists are exploring] the perplexing problem of what went on during the billions of years before Pangaea went to pieces.

UPDATE: The continents have an on-again, off-again relationship that has existed since well before Pangaea, fossil and rock evidence shows. Most scientists agree that the earliest known supercontinent, called Nuna, formed around 1.5 billion years ago. It broke apart and reunited as the supercontinent Rodinia about 1 billion years ago. A third supercontinent called Pannotia may have formed roughly 600 million years ago near the South Pole, but its existence is debated. Today, scientists are predicting how continents will merge in the future. A supercontinent dubbed Amasia could form 250 million years from now as the continents drift toward the North Pole (*SN: 1/21/17, p. 18*).

Biologist Mark Meekan (shown) took tissue samples from this whale shark near Australia in a bid to uncover what the ocean giant eats.

ANDRE REREKURA/AIMS

RETHINK

Whale sharks may be the world's largest omnivores

As Mark Meekan bobbed among swells in the Indian Ocean, he spotted a giant shadowy figure moving through the water. The tropical fish biologist dove to meet the gentle giant — a whale shark — and took samples of its skin. Though he has swum alongside these aquatic giants before, it's an experience that never gets old, says Meekan, who works at the Australian Institute of Marine Science in Perth.

Averaging around 12 meters long, the whale shark (*Rhincodon typus*) is Earth's largest living fish species and among its most mysterious. The sharks spend most of their lives in the deep ocean where they are hard to observe, so analyzing the chemical makeup of their tissues can help scientists learn more about the animals' biology and behavior, including what they like to eat (SN: 5/9/20 & 5/23/20, *p. 16*).

The skin samples that Meekan and colleagues collected reveal that whale sharks, long thought to be strict meat eaters, also eat and digest algae. The findings, described July 19 in *Ecology*, add to evidence that whale sharks deliberately eat plants, potentially making them the largest omnivores on Earth. The previous record holder, the Kodiak bear (*Ursus arctos middendorffi*), averages about 2.5 meters in length.

Algae has turned up in the stomachs of beached whale sharks before. But because whale sharks feed by swimming mouth open through swarms of zooplankton, "everyone thought it was just accidental ingestion," Meekan says. Carnivores typically can't digest plants, so some scientists suspected that algae passed through whale sharks' guts without being digested.

To find out if that assumption held up, Meekan's team took tissue samples from 17 whale sharks feeding off the coast of Western Australia from 2015 to 2017.

Meekan says most whale sharks don't react when they get jabbed by the sampling spear, which is about as wide as a pinky finger. Some even seem to enjoy the attention, he says. It's as though they think: "This isn't threatening. In fact, I quite like that."

Whale shark skin was rich in an organic molecule called arachidonic acid that is found in brown algae, the analysis showed. Since the sharks can't make this molecule themselves, they probably got it by digesting algae, Meekan says.

The new work supports previous research by a different group that found algae-derived nutrients in the skin of whale sharks near Japan. Together, the findings suggest that digesting greens is common practice for whale sharks.

But that doesn't mean whale sharks are true omnivores, says shark biologist Robert Hueter of Mote Marine Laboratory & Aquarium in Sarasota, Fla. "This is a bit like saying that cows are omnivores because they eat insects while feeding on grass."

Meekan admits that he can't say for certain that whale sharks seek out algae, but the amount they eat isn't incidental. The analysis clearly shows, he says, that algae make up a large part of the sharks' diet. "Their tissues hold a remarkable record of what they've been up to," he says. "We're now learning how to read this library." — *Freda Kreier*

TEASER

How to make mealworms appetizing

A spoonful of sugar may help the mealworms go down.

Adding sugars to powdered, cooked mealworms creates a seasoning with an appetizing meatlike odor, scientists reported August 24 at the American Chemical Society's fall meeting in Chicago.

Some insects can be an environmentally friendly alternative to other animal protein because they require less land and water to raise (SN: 5/11/19 & 5/25/19, *p.* 28). But many people in the United States and other Western countries, where insects aren't eaten widely, generally find the idea of chomping down on bugs unappetizing.

"There aren't a lot of people ready to fry up a whole skillet of crickets and eat them fresh," says Julie Lesnik, a biological anthropologist at Wayne State University in Detroit who wasn't involved in the research. Finding out how to make insect-based foods more appealing could be key to making them more mainstream.

One successful insect-based product could have a snowball effect for similar food, says Brenden Campbell, a cofounder of the insect agriculture company Planet Bugs in San Carlos, Calif., who was not involved in the work.

Previously, chemist In Hee Cho of Wonkwang University in South Korea and colleagues found that roasted and deep-fried mealworms released chemicals similar to those in meat and seafood. In the new research, the team keyed in on what combinations of mealworms, water, sugars and cooking time produced meaty smells and tested the resulting seasonings with volunteers to figure out which smelled the most appealing.

Using insects in seasonings, like Cho's team did, could help people get past their hesitations about eating bugs. "There are plenty of things that are disgusting to us, but we have engineered around it," Lesnik says. *—Anil Oza*

A dead wolf spider stuck with a syringe acts as a claw that grabs other corpses.

HOW BIZARRE

Scientists turned dead spiders into robots

Scientists have reanimated dead spiders to do their bidding.

In a field dubbed "necrobotics," researchers converted the corpses of wolf spiders into grippers that can manipulate objects. All the team had to do was stab a syringe into a dead spider's back and superglue it in place. Pushing fluid in and out of the cadaver made its legs open and shut, the researchers report July 25 in *Advanced Science.*

The idea was born from a simple question, explains mechanical engineer Faye Yap of Rice University in Houston. Why do spiders curl up when they die?

The answer: Spiders are hydraulic machines. They control how much their legs extend by forcing blood into them. A dead spider no longer has that blood pressure, so its legs curl up. "That was so cool," Yap says. "We wanted to leverage it."

Yap and colleagues first tried putting dead wolf spiders in a double boiler, hoping that the heat and humidity would make the spiders expand and push their legs outward. That didn't work. But when the researchers injected fluid into a spider corpse, they could control its grip well enough to pull wires from a circuit board and pick up other dead spiders. Only after hundreds of uses did the necrobots start to dehydrate and show signs of wear, the team says.

In the future, the researchers will coat spiders with a sealant to hold off that decline. But the next big step is to control the spiders' legs individually, Yap says, and in the process, figure out more about how spiders work. Then her team could translate their understanding into better designs for robots.

That would be very interesting, says bioengineer Rashid Bashir of the University of Illinois Urbana-Champaign. A spider corpse robot would probably have problems with consistent performance, Bashir says, and its body will eventually break down over time. But spiders can offer lessons to engineers (SN: 5/11/19 & 5/25/19, *p.* 24). "There's a lot to be learned from biology and nature."

Despite reanimating dead spiders, Yap is no mad scientist. She wonders whether it's OK to play Frankenstein, even with arachnids. "No one really talks about the ethics" of this type of research, she says.

Scientists need to figure that out before the field of necrobotics gets too advanced, Bashir says. "How far do you go?" *—Asa Stahl*

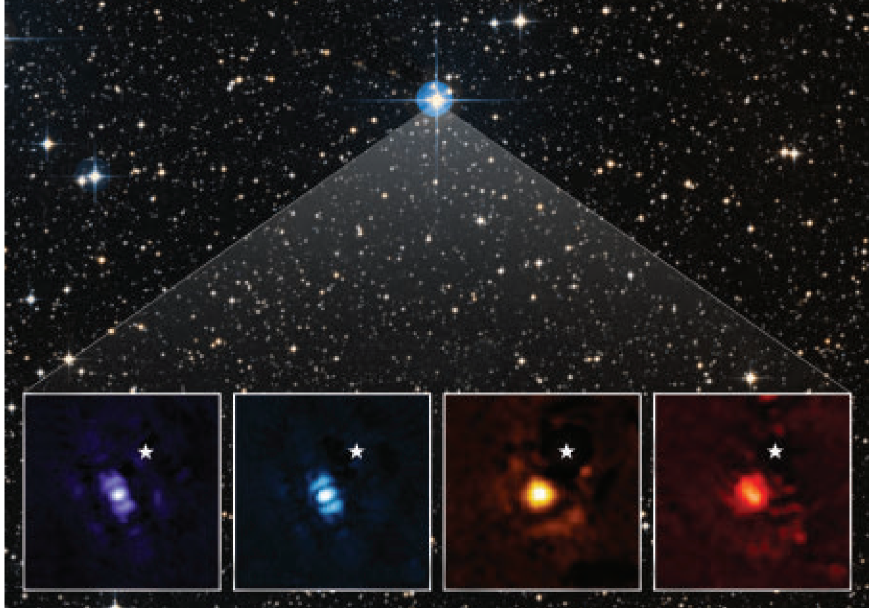
FROM TOP: OLLO/E+/GETTY IMAGES PLUS; T.F. YAP AND COAUTHORS

News

ATOM & COSMOS

Space telescope wows scientists

James Webb snaps its first direct picture of an exoplanet



Exoplanet HIP 65426b shines in four different wavelengths of infrared light (insets) in this image from the James Webb Space Telescope. The star symbol in the insets represents where the parent star is located; to see the planet, the star's light had to be blocked.

BY LISA GROSSMAN

A new era of exoplanet exploration has begun. The James Webb Space Telescope, or JWST, has taken its first direct image of a planet outside the solar system, as well as gotten the first strong sniff of carbon dioxide in the atmosphere of an exoplanet.

"We've demonstrated really how powerful JWST is as an instrument for the direct imaging of exoplanets," says exoplanet astronomer Aarynn Carter of the University of California, Santa Cruz.

Carter and colleagues focused on HIP 65426b, a planet about 300 light-years from Earth that lies more than 100 times farther from its star than Earth sits from the sun. The planet is roughly seven times the mass of Jupiter and young, about 10 million to 20 million years old, compared with the more than 4-billion-year-old Earth, Carter and colleagues report September 1 at arXiv.org.

Its size, distance and youth made HIP 65426b relatively easy to see, and thus a good planet to test JWST's abilities. "We're actually measuring photons from the atmosphere of the planet itself," says coauthor and astronomer Sasha Hinkley of the University of Exeter in England.

Astronomers have found more than 5,000 planets orbiting stars other than the sun. But almost all of those planets were detected indirectly, either by the planets tugging on the stars with their gravity or blocking starlight as they cross between the parent star and a telescope's view. To see a planet directly, astronomers must block out the light from its star and let the planet's own light shine, a tricky process that has been done for only about 20 exoplanets.

In 2017, astronomers discovered HIP 65426b and took a direct image of it with the Very Large Telescope in Chile. Because that telescope is on the ground, it can't see all the light coming from the planet. Earth's atmosphere absorbs a lot of the planet's infrared wavelengths — exactly the wavelengths JWST excels at observing. JWST observed HIP 65426b on July 17 and July 30, capturing its glow in four different infrared wavelengths.

"These are wavelengths of light that we've never ever seen exoplanets in before," Hinkley says. "I've literally been waiting for this day for six years."

Pictures in these wavelengths will help reveal how planets formed and what their atmospheres are made of. "Direct imaging is our future," says MIT astrophysicist Sara Seager, who was not involved in the discovery. "It's amazing to see the Webb performing so well."

The team has not yet studied the planet's atmosphere in detail but did report the first spectrum — a measurement of light in a range of wavelengths — of an object orbiting a different star. The spectrum allows a deeper look into an object's chemistry and atmosphere. Called VHS 1256b, the object is likely something between being a planet and a star, what's known as a brown dwarf, the team reports September 2 at arXiv.org.

Meanwhile, JWST has also recorded indirect yet "incontrovertible" evidence of carbon dioxide in the atmosphere of an exoplanet, says planetary scientist Peter Gao of the Carnegie Institution for Science in Washington, D.C. "There have been hints of carbon dioxide in previous [exoplanet] observations, but never confirmed to such an extent."

The finding, reported by Gao and colleagues August 25 at arXiv.org and accepted for publication in *Nature*, comes from WASP-39b, a giant and puffy planet about 700 light-years from Earth.

For about eight hours in July, JWST observed starlight that filtered through WASP-39b's thick atmosphere as the planet crossed between its star and the telescope. As it did, molecules of CO_2 in the atmosphere absorbed specific wavelengths of that starlight.

The amount of CO_2 in a planet's atmosphere can reveal details about the planet's early formation. If it was bombarded with asteroids, that could have brought in more carbon and enriched the atmosphere with carbon dioxide. If radiation from the star stripped away some of the atmosphere's lighter elements, that could make the atmosphere appear richer in carbon dioxide too.

Eventually, astronomers hope to use JWST to find CO_2 and other molecules in the atmospheres of small rocky planets, like the ones orbiting the star TRAPPIST-1 (SN: 12/23/17 & 1/6/18, *p. 25*). Some of those Earth-sized planets, at just the right distances from their star to sustain liquid water, might be good places to look for signs of life. ■

NASA, ESA, CSA, A. CARTER/UCSC, THE ERS 1386 TEAM, A. PAGAN/STSCI

HUMANS & SOCIETY

Claim made for earliest known hominid

Fossils suggest *Sahelanthropus* walked upright 7 million years ago

BY BRUCE BOWER

In 2001, researchers unearthed a partial fossil leg bone and two forearm bones in Chad in Central Africa. Those fossils come from the earliest known hominid, which lived around 7 million years ago, and reveal that the creature walked upright both on the ground and in the trees, a new study proposes.

But a lively debate surrounds the fossils, concerning whether they actually belong to the hominid, a species known as *Sahelanthropus tchadensis*, or to an ancient ape, and to what extent the individual adopted a two-legged gait. These have become vexing questions as scientists increasingly suspect that ape and hominid species evolved a variety of ways to walk upright, some more efficient than others, around 7 million years ago.

Since the leg bone was discovered — by a team of researchers including paleontologists Guillaume Daver and Franck Guy, both of the University of Poitiers in France — the fossil has also triggered accusations of scientific misconduct and an investigation by the French government research organization CNRS in Paris.

Previously, skull, jaw and tooth finds uncovered at the Chad site in the early 2000s were attributed to *S. tchadensis* and are the only other known fossils of the species (*SN: 4/9/05, p. 227*). But some researchers have suggested that those finds represent an ancient ape instead.

Analyses of the three limb bones show that they belong to *S. tchadensis*, say Daver, Guy and their colleagues. Internal and external features of the leg bone indicate that the individual walked upright, the team reports August 24 in *Nature*. And shapes and structures of the forearm bones suggest that this hominid moved on two legs through trees while grasping branches with its hands.

S. tchadensis' anatomical features "clearly indicate that our oldest known [hominid] representative [walked] on the ground and in the trees," Guy says, but how efficiently or fast the species moved on two legs is hard to tell.

Guy and Daver's team studied 3-D digital models of the fossils derived from CT scans. The group compared the leg bone with fossils of ancient apes and other hominids and with modern apes and humans. Traits including thickening of the leg bone's tough outer layer at key points and the presence of an internal bony projection near the hip joint signal an upright stance, the scientists say.

Fossils from the Chad site, including the three limb bones, suggest that *S. tchadensis* was the earliest known hominid, agrees paleoanthropologist Kristian Carlson of the University of Southern California in Los Angeles. But exactly how it moved while upright remains unknown, he says. The upper leg and forearm bones exhibit a mix of traits that differs from those of living apes and humans, suggesting *S. tchadensis* adopted a novel posture and limb movements while walking.

Whatever stance *S. tchadensis* assumed, it probably resembled that of two other hominids that lived roughly 5 million to 6 million years ago, *Orrorin tugenensis* and *Ardipithecus kadabba*, says paleoanthropologist Yohannes Haile-Selassie of Arizona State University in Tempe. But those hominids' walking abilities also are poorly understood due to limited fossils.

Haile-Selassie regards all three hominids as part of a single genus that evolved from around 7 million to 5 million years ago. That issue is debated, "even between members of our team," Guy says.

Another debate concerns the upper leg's internal bony projection that the team cites as crucial for standing upright. That trait sometimes appears in modern African apes and occasionally is absent in humans, paleoanthropologist Marine Cazenave of the American Museum of Natural History in New York City and colleagues report in the June *Journal of Human Evolution*. The presence of this bony growth does not definitively show that *S. tchadensis* walked upright, Cazenave says.

Other scientists contend that the leg bone comes from an ancient ape that may have sometimes walked upright. Measurements of the bone's shape closely resemble those of modern chimp leg bones, paleoanthropologist Roberto Macchiarelli of the University of Poitiers and colleagues reported in 2020 in the *Journal of Human Evolution*.

Here is where charges of scientific misconduct come into play. That 2020 study was based on measurements of the leg bone taken in 2004 by a University of Poitiers graduate student, who noted that the leg bone appeared to belong to a primate, possibly an ape. Guy and Daver's team initially considered the fossil to be nonprimate, and it was provided to the student for a project.

Macchiarelli confirmed the student's observation and told the university and CNRS of the fossil's identity. The bone was then returned to Guy and Daver's team.

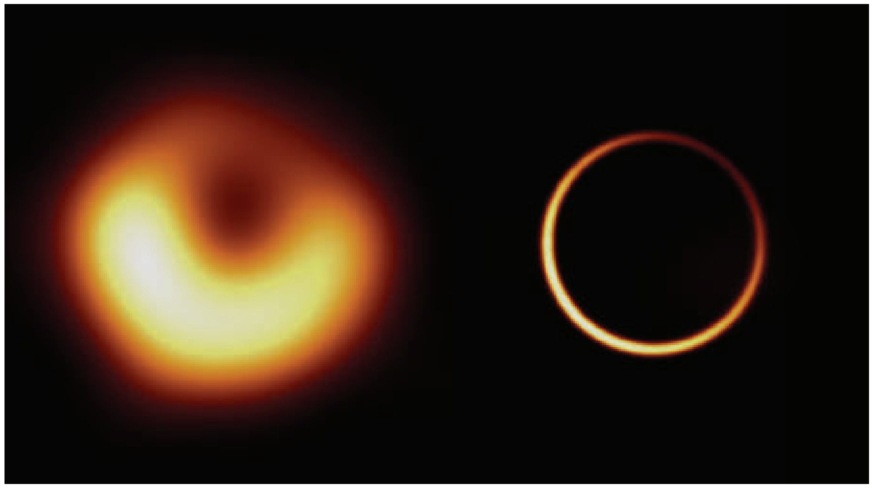
Macchiarelli says he spent the next 16 years complaining to the institutions that the discoverers were violating codes of conduct by withholding information about the bone. Then, CNRS launched an investigation of possible misconduct by Macchiarelli when the 2020 study appeared. As members of the team that discovered the bone, Guy and Daver have the right to publish the first analyses of it. No ruling has been made yet. ■

An analysis of 7-million-year-old fossils — an upper leg bone seen from two angles, far left, and two forearm bones, each also shown from two angles — concludes that they belonged to the earliest known hominid. Other researchers say the bones belonged to an ancient ape.

ATOM & COSMOS

Physicists dispute photon ring claim

Skeptics doubt the detection of a black hole's thin halo



In 2019, the Event Horizon Telescope collaboration unveiled an image of the supermassive black hole in the galaxy M87 (left). Now, scientists claim that they've uncovered a photon ring (right) around the black hole, created by light that orbited the black hole before escaping.

EHT COLLABORATION, A.E. BRODERICK *ET AL*/*ASTROPHYSICAL JOURNAL* 2022

BY EMILY CONOVER

The first image of a black hole may conceal treasure — but physicists disagree about whether the prize has been found.

A team of scientists say they've unearthed a photon ring, a thin halo of light around the supermassive black hole in the galaxy M87. If real, the photon ring would provide a new probe of the black hole's intense gravity. But other scientists dispute the claim. While multiple news headlines suggest the photon ring has been found, many physicists are unconvinced.

Unveiled in 2019 by scientists with the Event Horizon Telescope, or EHT, the first image of a black hole revealed a doughnut-shaped glow from hot matter swirling around the black hole's dark silhouette (SN: 4/27/19, *p.* 6). According to Einstein's general theory of relativity, a thinner ring should be superimposed on that thick doughnut. This ring is produced by photons, or particles of light, that orbit close to the black hole, slung around by the behemoth's gravity before escaping and zinging toward Earth.

Thanks to this circumnavigation, the photons should provide "a fingerprint of gravity," more clearly revealing the black hole's properties, says astrophysicist Avery Broderick of the University of Waterloo and the Perimeter Institute for Theoretical Physics in Canada. In the Aug. 10 *Astrophysical Journal*, he and a subset of other scientists from the EHT collaboration report using a new method to tease out that fingerprint.

Creating images with EHT isn't a simple point-and-shoot affair (SN: 4/27/19, *p.* 7). Researchers stitch together data from EHT's squad of observatories scattered across the globe, using various computational techniques to reconstruct an image. Broderick and colleagues created a new black hole image based on the same data as the original, but assuming the image featured both a diffuse emission and a thin ring. On three out of four days of observations, the data better matched an image with the added thin ring than one without the ring.

But that method has drawn harsh criticism. "The claim of a photon ring detection is preposterous," says physicist Sam Gralla of the University of Arizona in Tucson.

A main point of contention: The photon ring is brighter than expected, emitting about 60 percent of the light in the new image. According to predictions, it should be more like 20 percent. "That's a giant red flag," says physicist Alex Lupsasca of Vanderbilt University in Nashville. More light should come from the black hole's main glowing doughnut than from the thin photon ring.

This unexpected brightness, Broderick and colleagues say, occurs because some of the light from the main glow gets lumped in with the photon ring. So the ring's apparent brightness doesn't depend only on the light from the ring. The team notes that the same effect appeared when testing the method on simulated data.

But that mishmash of purported photon ring light with other light doesn't make for a very convincing detection, critics say. "If you want to claim that you've seen a photon ring, I think you have to do a better job than this," says astrophysicist Dan Marrone of the University of Arizona, a member of the EHT collaboration who was not a coauthor on the new paper.

The new result suggests only that an added thin ring gives a better match to the data, Marrone says, not whether that shape is associated with the photon ring. So it raises the question of whether the researchers are seeing a photon ring at all, or just picking out an unrelated structure in the image.

But Broderick argues that the features of the ring — the fact that its size and location are as expected and are consistent day to day — support the photon ring interpretation.

Meanwhile, in a similar independent analysis, Gralla and physicist Will Lockhart, also of the University of Arizona, found that it wasn't possible to tease the photon ring out of the image, they report in a paper posted August 23 at arXiv.org. Their analysis differed from Broderick and colleagues' in part because it limited how bright the photon ring could be.

To convincingly detect the photon ring, some scientists propose adding telescopes in space to the EHT's crew of observatories (SN: 4/11/20, *p.* 12). The farther apart the telescopes in the network are, the finer details they may be able to pick out — potentially including the photon ring.

"If there were a photon ring detection," Lupsasca says, "that would be the best thing in physics this year, if not for many years." ■

ATOM & COSMOS

Oort cloud comets may spin to death

How these icy objects break up has been a long-standing puzzle

BY LISA GROSSMAN

Comets from the solar system's deep freezer often don't survive their first encounter with the sun. Now one scientist thinks he knows why: Solar warmth makes some of the cosmic snowballs spin so fast, they fall apart.

This suggestion could solve a decades-old mystery about what destroys many "long-period" comets, astronomer David Jewitt reports August 9 at arXiv.org. Long-period comets originate in the Oort cloud, a sphere of icy objects at the solar system's fringe. Those that survive their first trip around the sun tend to swing by our star only once every 200 years at most.

"These things are stable out there in the Oort cloud where nothing ever happens. When they come toward the sun, they heat up, all hell breaks loose and they fall apart," Jewitt says.

The Dutch astronomer Jan Oort first proposed the Oort cloud as a cometary reservoir in 1950. He realized that many of its comets that came near Earth were first-time visitors, not return travelers. Something was taking the comets out, but no one knew what.

One possibility was that the comets die by sublimating all of their water as they near the heat of the sun until there's nothing left. But that didn't fit with observations of comets that seem to physically break up into smaller pieces. Those breakups are hard to watch in real time. "The disintegrations are really hard to observe because they're unpredictable, and they happen quickly," Jewitt says.

He ran into that difficulty when he tried to observe Comet Leonard, a bright comet that put on a spectacular show in winter 2021–2022. Jewitt had applied for time to observe the comet with the Hubble Space Telescope in April and June 2022. But by February, the comet had already disintegrated.

So Jewitt turned to historical observations of long-period comets that have come close to the sun since the year 2000. He selected comets whose water vapor production had been measured to see how quickly the comets were losing mass. He also looked at measurements of how much comets had deviated from their orbits around the sun. Those movements result from water vapor jets pushing the comet around, like a spraying hose flopping around a garden.

That left him with 27 comets, seven of which did not survive their closest approach to the sun.

Jewitt expected that the most active comets would disintegrate the fastest by puffing away all their water. But it turns out that the least active comets with the smallest dirty snowball cores were the most at risk.

It wasn't that the comets were torn apart by the sun's gravity — they didn't get close enough for that. And simply sublimating until they went poof would have been too slow a death to match the observations. The comets are also unlikely to collide with anything else in the vastness of space and break apart that way. And a previous suggestion that pressure makes them explode like a hand grenade doesn't make sense to Jewitt. Comets' upper few centimeters of material would absorb most of the sun's heat, he says, so it would be difficult to heat the center of the comet enough for that to work.

The best remaining explanation, he says, is rotational breakup. As the comet nears the sun and its water heats up enough to sublimate, jets of water vapor form and make the core start to spin like a catherine wheel firework. Smaller cores are easier to push around than a larger one, so they spin more easily.

"It just spins faster and faster, until it doesn't have enough tensile strength to hold together," Jewitt says. That deadly spin speed is actually quite slow. Spinning at about half a meter per second could spell curtains for a kilometer-sized comet, he calculates. "You can walk faster."

Comets are fragile. If you held a fist-sized comet in front of your face, a sneeze would destroy it, says planetary astronomer Nalin Samarasinha of the Planetary Science Institute in Tucson.

Samarasinha thinks Jewitt's proposal is convincing. "Even though the sample size is small, I think it is something really happening." But other things might be destroying these comets too. Samarasinha is holding out for more comet observations, which could come when the Vera C. Rubin Observatory begins surveying the sky in 2023. Jewitt's idea "is something which can be observationally tested in a decade or two." ■

Comet Leonard dazzled earlier this year and then disintegrated after passing by the sun.

LIFE & EVOLUTION

Slow growth doomed 'demon ducks'

Australia's largest birds died off around the time humans arrived

BY JAKE BUEHLER

Giant flightless birds called mihirungs were the biggest birds to ever stride across Australia. The animals, which weighed up to hundreds of kilograms, went extinct about 40,000 years ago. Now researchers might have a better idea why.

The birds may have grown and reproduced too slowly to withstand pressures from humans' arrival on the continent, researchers report August 17 in the *Anatomical Record*.

Mihirungs are sometimes called "demon ducks" because of their massive size and close evolutionary relationship with present-day waterfowl and game birds. The flightless plant-eating birds lived for more than 20 million years.

Over that time, some species evolved into titans. Take Stirton's thunderbird (*Dromornis stirtoni*). It lived during the late Miocene Epoch, which ran from about 10 million to 5 million years ago. It stood 3 meters tall and could weigh more than 500 kilograms, making it the largest-known mihirung and a contender for the largest bird ever.

Little has been known about mihirung biology, such as how long the birds took to grow and mature, says paleobiologist Anusuya Chinsamy-Turan of the University of Cape Town in South Africa.

So Chinsamy-Turan and colleagues at Flinders University in Adelaide, Australia, took samples from 20 fossilized leg bones of *D. stirtoni*, from animals of varying life stages.

"Even after millions of years of fossilization, the microscopic structure of fossil bones generally remains intact" and can be used to decipher clues about extinct animals' biology, Chinsamy-Turan says.

The team examined the thin bone slices under a microscope, detailing the presence or absence of growth marks. These marks provide information on how fast the bone grew while the birds were alive.

D. stirtoni took 15 years or more to reach full size, the team found. It probably became sexually mature a few years before that, based on the timing of a shift from rapidly growing bone to a slower-growing form that's thought to be associated with reaching reproductive age.

This growth pattern differs from what the team had previously learned by studying another mihirung, *Genyornis newtoni*. That species — the last-known mihirung — was less than half as massive as *D. stirtoni*. It was a contemporary of Australia's earliest human inhabitants. *G. newtoni* grew up faster than its giant relative, reaching adult size in one to two years, growing a bit more in the following years and possibly reproducing then.

This difference in development between mihirung species that were separated by millions of years may have been an evolved response to Australia developing a drier, more variable climate over the last few million years, the researchers say. When resources are unpredictable, growing and reproducing quickly can be advantageous.

Even so, that seeming pep in the developmental step of more recent mihirungs was still slower than that of the emus they lived alongside. Emus reach adult size in less than a year and reproduce not long after that, laying large numbers of eggs.

This difference may explain why *G. newtoni* went extinct shortly after hungry humans arrived in Australia, yet emus continue to thrive today, the team says. Even though over millions of years mihirungs as a group seem to have adapted, growing and reproducing more quickly than they once did, it wasn't enough to survive the influx of humans, who probably ate the birds and their eggs, the researchers conclude.

"Slowly growing animals face dire consequences in terms of their reduced ability to recover from threats in their environments," Chinsamy-Turan says.

Other giant flightless birds thought to have met their end thanks to humans — such as the dodos of Mauritius (*Raphus cucullatus*) and the largest of Madagascar's elephant birds (*Vorombe titan*) — also grew relatively slowly, according to previous research by Chinsamy-Turan (*SN: 9/16/17, p. 6*).

"It is very interesting to see this pattern repeating again and again with many large flightless bird groups," says paleoecologist Thomas Cullen of Carleton University in Ottawa, who was not involved with the new study. Modern large flightless birds seem to be the exception in their ability to handle similar pressures, he says. Aside from emus, other such birds that have survived until the present, such as cassowaries and ostriches, also grow and reproduce quickly. ■

One of Australia's extinct giant flightless birds, *Dromornis stirtoni* (illustrated), which weighed about as much as a horse, may have taken around 15 years to reach full size.

PETER TRUSLER

LIFE & EVOLUTION

News stories give spiders a bum rap

Errors may contribute to the animals' undeserved bad reputation

News stories about encounters with spiders, such as this harmless jumping spider, frequently have misinformation or sensationalized language.

BY BETSY MASON

Even spiders, it seems, have fallen victim to misinformation. Media reports about people's encounters with spiders tend to be full of falsehoods with a distinctly negative spin. An analysis of a decade's worth of newspaper stories from dozens of countries finds that nearly half of the reports contain errors, arachnologist Catherine Scott and their colleagues report in the Aug. 22 *Current Biology*.

"The vast majority of the spider content out there is about them being scary and hurting people," says Scott, of McGill University in Montreal. In reality, "spiders almost never bite people."

Of the roughly 50,000 known spider species, vanishingly few are dangerous. Instead, many spiders benefit us by eating insects that are harmful to people. Even with the rare exceptions like black widow spiders, bites are extremely uncommon, Scott says. Some stories about bites blamed spiders that don't occur in the area, and others reported symptoms that don't match symptoms of actual bites. "So many stories about spider bites included no evidence whatsoever that there was any spider involved," Scott says.

Scott and colleagues analyzed over 5,000 online newspaper stories about humans and spiders from 2010 to 2020 across 81 countries. In addition to errors, the team determined that 43 percent of the stories were sensationalized, often using words like *nasty*, *killer*, *agony* and *nightmare*. Stories that included a spider expert were less sensationalistic, though there was no such effect from other experts, including doctors.

If people knew the truth, they could spend less time blaming spiders for bites and killing them with pesticides that are toxic to many other species, Scott says. Spiders also stand to benefit because news helps shape public opinion, which can influence conservation decisions.

"Spiders are kind of unique in that they seem to be really good at capturing people's attention," says arachnologist Lisa Taylor of the University of Florida in Gainesville. "If that attention is paired with real information about how fascinating they are, rather than sensationalistic misinformation, then I think spiders are well-suited to serve as tiny ambassadors for wildlife in general." ■

XBN83/MOMENT/GETTY IMAGES PLUS

BODY & BRAIN

The curious case of the 471-day COVID-19 infection

A patient's lingering illness gave scientists a peek at how the coronavirus evolves

BY MEGHAN ROSEN

As omicron subvariant BA.5 continues to drive the coronavirus' spread in the United States, researchers have been thinking about what could come next. Omicron and its offshoots have been topping the variant charts since last winter. Before that, delta reigned.

Scientists have a few ideas for how new variants emerge. One involves people with persistent infections, people who test positive for the virus over a prolonged period of time. One curious case — of a person infected with SARS-CoV-2 for at least 471 days — shows what can happen when infections roil away uncontrolled.

That lengthy infection first came onto epidemiologist Nathan Grubaugh's radar in the summer of 2021. His team had been analyzing coronavirus strains in patient samples from Yale New Haven Hospital when Grubaugh spotted something he had seen before. Known only as B.1.517, this version of the virus never got a name like delta or omicron, nor rampaged through communities quite like its infamous relatives.

Instead, after springing up somewhere in North America in early 2020, B.1.517 tooled around in a handful of regions around the world, even sparking an outbreak in Australia. But after April 2021, B.1.517 seemed to sputter, one of the who-knows-how-many viral lineages that flare up and then eventually fizzle.

B.1.517 might have been long forgotten, shouldered aside by the latest variant to stake a claim in local communities. "And yet we were still seeing it," Grubaugh says. Even after B.1.517 had petered out across the country, his team noticed it cropping up in patient samples. The same lineage, every few weeks, like clockwork, for months.

One clue was the samples' specimen ID. The code on the B.1.517 samples was always the same, Grubaugh's team noticed. They had all come from a single patient.

That patient, a person in their 60s with a history of cancer, relapsed in November 2020. That was right around when the patient first tested positive for SARS-CoV-2. After seeing B.1.517 show up again and again in their samples, Grubaugh worked with a clinician to get the patient's permission to analyze the data.

Ultimately, the patient has remained infected for more than 471 days, Grubaugh, Yale postdoctoral researcher Chrispin Chaguza and their team reported July 2 in a preliminary study posted at medRxiv.org. Because of deteriorating health and a desire to maintain their anonymity, the patient was not willing to be interviewed, and Grubaugh has no direct contact with them.

But all those samples collected over all those days told an incredible tale of viral evolution. Over about 15 months, at least three genetically distinct versions of the virus had rapidly evolved inside the patient, the team's analyses suggested.

Each version had dozens of mutations and seemed to coexist in the patient's body. "Honestly, if any one of these were to emerge in a population and begin transmitting, we would be calling it a new variant," Grubaugh says.

That scenario is probably rare, he says. After all, lots of prolonged infections have probably occurred during the pandemic, and only a handful of concerning variants have emerged. But the work does suggest that persistent viral infections can provide a playground for speedy evolutionary experimentation — perhaps taking advantage of weakened immune systems.

Grubaugh's work is "probably the most detailed look we've had at a single persistent infection with SARS-CoV-2 so far," says Tom Friedrich, a virologist at the University of Wisconsin–Madison who was not involved with the work.

The study supports an earlier finding about a different immunocompromised patient, one with a persistent omicron infection. In that work, which was posted at medRxiv.org in May, researchers documented the evolution of the virus over 12 weeks and showed that its descendant infected at least five other people.

Together, the studies lay out how such infections could potentially drive the emergence of the next omicron.

"I am pretty well convinced that people with persistent infection are important sources of new variants," Friedrich says.

Who exactly develops these infections remains mysterious. Yes, the virus can pummel people with weakened immune systems, but "not every immunocompromised person develops a persistent infection," says Viviana Simon, a virologist at the Icahn School of Medicine at Mount Sinai in New York City who worked on the omicron infection study.

Some people develop persistent coronavirus infections and continue to test positive for months. Studying those people's infections could help scientists learn how new viral variants emerge.

MAGICBONES/ISTOCK/GETTY IMAGES PLUS

In fact, doctors and scientists have no idea how common these infections are. “We just don’t really have the numbers,” Simon says. That’s a huge gap for researchers, and something Mount Sinai’s Pathogen Surveillance Program is trying to address by analyzing real-time infection data.

Studying patients with prolonged infections could also tell scientists where SARS-CoV-2 evolution is heading, Friedrich says. Just because the virus evolves within a person doesn’t mean it will spread to other people. But if certain viral mutations tend to arise in multiple people with persistent infections, that could hint that the next big variant might evolve in a similar way. Knowing more about these mutation patterns could help researchers forecast what’s to come, an important step in designing future coronavirus vaccine boosters.

Beyond viral forecasting, Grubaugh says identifying people with prolonged infections is important so doctors can provide care. “We need to give them access to vaccines, monoclonal antibodies and antiviral drugs,” he says. Those treatments could help patients clear their infections.

But identifying and treating persistent infections is easier said than done, he points out. Many places in the world aren’t set up to spot these infections and don’t have access to vaccines or treatments. And even when these are available, some patients opt out. The patient in Grubaugh’s study received a monoclonal antibody infusion 90 days into the infection, then refused all other treatments. They have not been vaccinated.

Though the patient remained infectious over the course of the study, their variants never spread to the community as far as Grubaugh knows.

And while untreated chronic infections might spawn new variants, they could emerge in other ways, too, like from animals infected with the virus, from person-to-person transmission in groups of people scientists haven’t been monitoring, or from “something else that maybe none of us has thought of yet,” Grubaugh says. “SARS-CoV-2 has continued to surprise us with its evolution.” ■

EARTH & ENVIRONMENT

Tonga eruption’s towering tsunamis

Blast may have spawned rare, especially fast-moving waves

BY SID PERKINS

The massive Tonga eruption generated a set of tsunamis that may have started out as a single mound of water roughly the height of the Statue of Liberty.

The explosive eruption also triggered an immense atmospheric shock wave that spawned a second set of especially fast-moving tsunamis, a rare phenomenon that can complicate early warnings for these oft-destructive waves, researchers report in the Oct. 1 *Ocean Engineering*.

As the Hunga Tonga–Hunga Ha’apai undersea volcano erupted in the South Pacific in January, it displaced a large volume of water upward, says Mohammad Heidarzadeh, a civil engineer at the University of Bath in England. The water in that mound later “ran downhill,” as fluids tend to do, to generate the initial tsunamis.

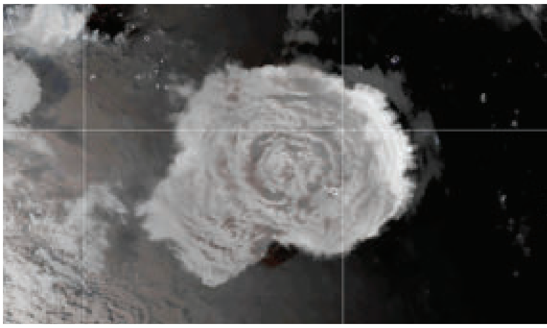
To estimate the original size of the mound, Heidarzadeh and his team used computer simulations, plus data from deep-ocean instruments and coastal tide gauges within about 1,500 kilometers of the eruption, many in or near New Zealand. Wave arrival times and sizes at those locations were key pieces of data.

The team analyzed nine possibilities for the initial wave, each of which was shaped like a baseball pitcher’s mound and had a distinct height and diameter. The best fit to the real-world data came from a mound 90 meters tall and 12 kilometers wide. That initial wave would have had an estimated 6.6 cubic kilometers of water.

Despite starting out about nine times as tall as the tsunami that devastated the Tohoku region of Japan in 2011, the Tonga tsunamis killed only five people and caused about $90 million in damage, largely because of their remote source.

Another unusual aspect of the eruption was another set of tsunamis generated by a strong atmospheric pressure wave.

That pressure pulse resulted from a steam explosion that occurred when a large volume of seawater infiltrated the hot magma chamber beneath the erupting volcano. As the pressure wave raced across the sea surface at speeds exceeding 300 meters per second, it pushed water ahead of it, creating tsunamis, Heidarzadeh says.



On January 15, 2022, the undersea volcano Hunga Tonga-Hunga Ha’apai erupted, as seen by satellite, and generated tsunamis.

NASA EARTH OBSERVATORY IMAGE BY JOSHUA STEVENS USING GOES IMAGERY COURTESY OF NOAA AND NESDIS

Along many coastlines, including some in the Indian Ocean and Mediterranean Sea, these pressure wave–generated tsunamis arrived hours ahead of the gravity-driven waves spreading from the 90-meter-tall mound of water. Gravity-driven tsunamis typically travel across deep parts of the ocean, far from continents, at speeds between 100 and 220 m/s. When the waves reach shallow water near shore, they slow and water stacks up and then the waves strike shore.

Pressure wave–generated tsunamis have been reported for only one other volcanic eruption: the 1883 eruption of Krakatau in Indonesia.

Those quicker-than-expected arrival times — plus the fact that the pressure wave tsunamis for the Tonga eruption were comparable in size with the gravity-driven ones — could complicate early warnings for these tsunamis.

One way to address the issue would be to install instruments that measure atmospheric pressure with the deep-sea equipment already in place to detect tsunamis, says Hermann Fritz, a tsunami scientist at Georgia Tech in Atlanta. With that setup, scientists would be able to discern if a passing tsunami is associated with a pressure pulse, thus providing a real-time clue about how fast the wave might be traveling. ■

BODY & BRAIN

Scientists aim to restore sense of smell

COVID-19 pandemic boosts interest in old and new treatments

BY LAURA SANDERS

It was the juice that tipped him off. At lunch, Ícaro de A.T. Pires found the flavor of his grape juice muted, flattened into just water with sugar. There was no grape goodness. "I stopped eating lunch and went to the bathroom to try to smell the toothpaste and shampoo," says Pires, an ear, nose and throat specialist at Hospital IPO in Curitiba, Brazil. "I realized then that I couldn't smell anything."

Pires was three days into COVID-19 symptoms when his sense of smell vanished, an absence that left a mark on his days. On a trip to the beach two months later, he couldn't smell the sea. "This was always a smell that brought me good memories and sensations," Pires says. "The fact that I didn't feel it made me realize how many things in my day weren't as fun as before. Smell can connect to our emotions like no other sense can."

As SARS-CoV-2, the virus responsible for COVID-19, has ripped across the globe, it has stolen the sense of smell away from millions of people, leaving them with a condition called anosmia. Early in the pandemic, when Pires' juice turned to water, that olfactory theft became one of the quickest ways to signal a COVID-19 infection. With time, most people with smell loss recover the sense. Pires, for one, has slowly regained a large part of his sense of smell. But that's not the case for everyone.

About 5 percent of people with post–COVID-19 smell loss or the closely related taste loss are still not able to smell or taste normally six months later, a recent analysis of 18 studies suggests. The number, reported in the July 30 *BMJ*, seems small. But when considering the estimated 600 million cases and counting of COVID-19 around the world, it adds up.

Scientists are searching for ways to hasten olfactory healing. Three years into the COVID-19 pandemic, researchers have a better idea of how many people are affected and how long it seems to last. Yet when it comes to ways to rewire the sense of smell, the state of the science isn't coming up roses.

A method called olfactory training, or smell training, has shown promise, but big questions remain about how it works and for whom. The technique has been around for a while; the coronavirus isn't the first ailment to snatch away smell. But with newfound pressure from people affected by COVID-19, olfactory training and a host of other newer treatments are now getting a lot more attention.

"If we have to provide a silver lining, COVID is pushing the science at a speed that's never happened before," says Valentina Parma, an olfactory researcher and assistant director of the Monell Chemical Senses Center in Philadelphia. "But," she cautions, "we are really far from a solution."

Nasal attack

Compared with sight or hearing, the sense of smell can seem like an afterthought. But losing it can affect people deeply. "Your world really changes if you lose the sense of smell, in ways that are usually worse," Parma says. The smell of a baby's head, a buttery curry or the sharp salty sea can all add emotional meaning to experiences. Smells can also warn of danger, such as the rotten egg stench that signals a natural gas leak.

As an ear, nose and throat doctor, Pires recalls a deaf patient who lost her sense of smell after COVID-19 and enrolled in a clinical trial on smell training that he and colleagues conducted. The patient worked in a perfumery company — her sense of smell was crucial to her job and her life. "At the first appointment, she said, with tears in her eyes, that it felt like she wasn't living," Pires recalls.

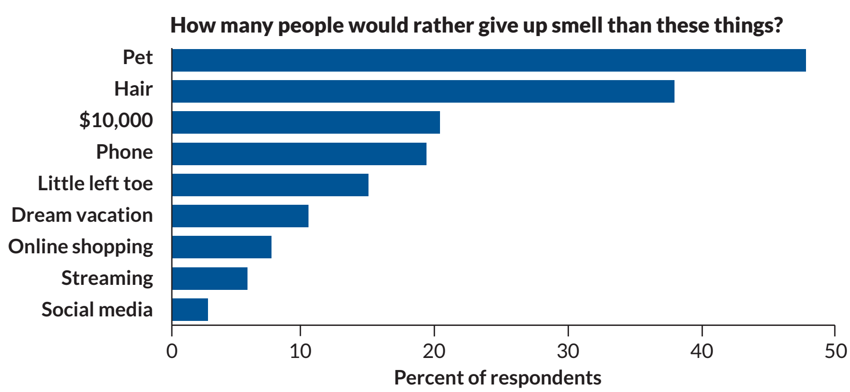
Unlike the cells that detect light or sound, the cells that sense smell can replenish themselves. Stem cells in the nose are constantly pumping out new smell-sensing cells. Called olfactory sensory neurons, these cells are dotted with molecular nets that snag specific odor molecules that waft into the nose. Once activated, these cells send messages to the brain.

Because of their nasal neighborhood, olfactory sensory neurons are exposed to the hazards of the environment. "They may be covered with a little layer of mucus, but they're sitting out there being constantly bombarded with bacteria and viruses and pollutants and who knows what else," says Steven Munger, a chemosensory neuroscientist at the University of Florida College of Medicine in Gainesville.

Exactly how SARS-CoV-2 damages the smell system isn't clear. But recent studies suggest the virus's assault is indirect. The virus can infect and kill nose support cells called sustentacular cells, which are thought to help keep olfactory neurons happy and fed by delivering glucose and

Sacrificing smell In a recent survey of about 400 people, some participants rated the ability to smell as less important than various creature comforts, hair and even the little left toe.

SOURCE: R.S. HERZ AND M.R. BAJEC/*BRAIN SCIENCES* 2022



T. TIBBITTS

maintaining the right salt balance. That attack can inflame the olfactory epithelium, the layers of cells that line parts of the nasal cavity.

Once this tissue is riled up, the olfactory sensory neurons get wonky, even though the cells themselves haven't been attacked. After an infection and ensuing inflammation, these neurons slow down the production of their odor-catching nets, a decrease that could blind them to odor molecules, scientists reported in the March 17 *Cell*.

With time, the inflammation settles down, and the olfactory sensory neurons can get back to their usual jobs, scientists suspect. "We do think that for postviral smell disorders, the most common way to recover function is going to be spontaneous recovery," Munger says. But in some people, this process doesn't happen quickly, if ever.

That's where smell training comes in.

A nose workout

One of the only therapies that exists, smell training is quite simple — a good old-fashioned nose workout. It generally involves deeply smelling four scents (usually rose, lemon, eucalyptus and cloves) for 30 seconds apiece, twice a day for months.

In one study, 40 people who had smell disorders came away from the training with improved smelling abilities, on average, compared with 16 people who didn't do the training, olfactory researcher Thomas Hummel and his colleagues reported in 2009 in *Laryngoscope*.

Since then, the bulk of studies has shown that the method helps between 30 and 60 percent of the people who try it, says Hummel, of Technische Universität Dresden in Germany. His view is that the method can help some people, "but it does not work in everybody."

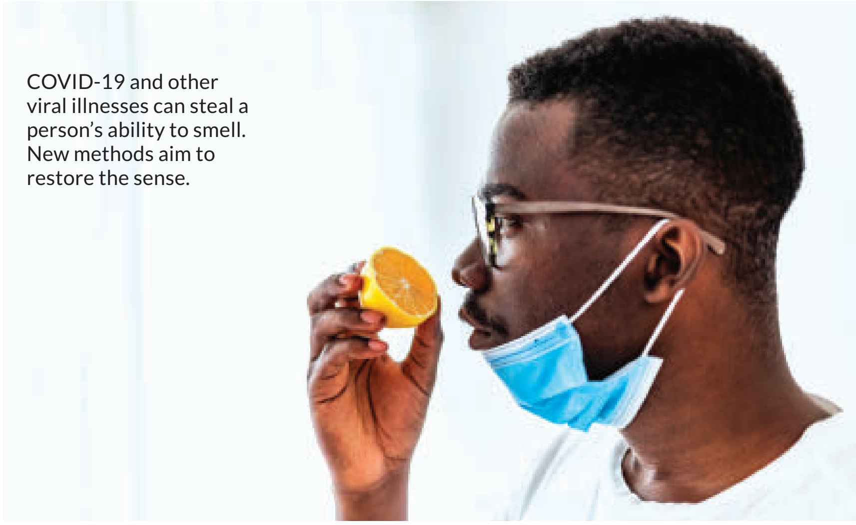
One of the nice things is that there are no harmful side effects, Hummel says. But to do the training correctly takes discipline and stamina. "If you don't do it regularly, and you give up after 14 days, this is futile," he says.

Pires in his recent trial had hoped to speed up the process, which usually takes three months, by adding four more odors to the regimen. For four weeks, 80 participants received either four or eight smells. Overall, both groups improved, but there was no difference between the two groups, the team reported July 21 in the *American Journal of Rhinology & Allergy*.

It's not known how the technique works in the people it seems to help. It could be that it focuses people's attention on smells; it could be stimulating the growth of replacement cells; it could be strengthening some pathways in the brain. Data from other animals suggest that such training can increase the number of olfactory sensory neurons, Hummel says.

Though this nose boot camp may be a possible approach for people to try, it's not a sure bet, Munger says. "In my view, it's very important to be up-front with patients about the very real possibility this therapy may not lead to a restoration of smell, even if they and their doctor feel it is worth trying," he says. "I am not trying to discourage people here, but I also think we need to be very careful not to give unwarranted promises."

Smell training doesn't come with harmful biological side effects, but it can cause consternation if it doesn't work, Parma says. In her practice, "I have been talking to a lot of people who say, 'I did it every day for six months, twice a day for 10 minutes. I met in groups with other people, so we kept each other accountable .... And it didn't work for me.'" She adds, "I would want to address the frustration that this induces in patients."



COVID-19 and other viral illnesses can steal a person's ability to smell. New methods aim to restore the sense.

LJUBAPHOTO/E+/GETTY IMAGES PLUS

Beyond training

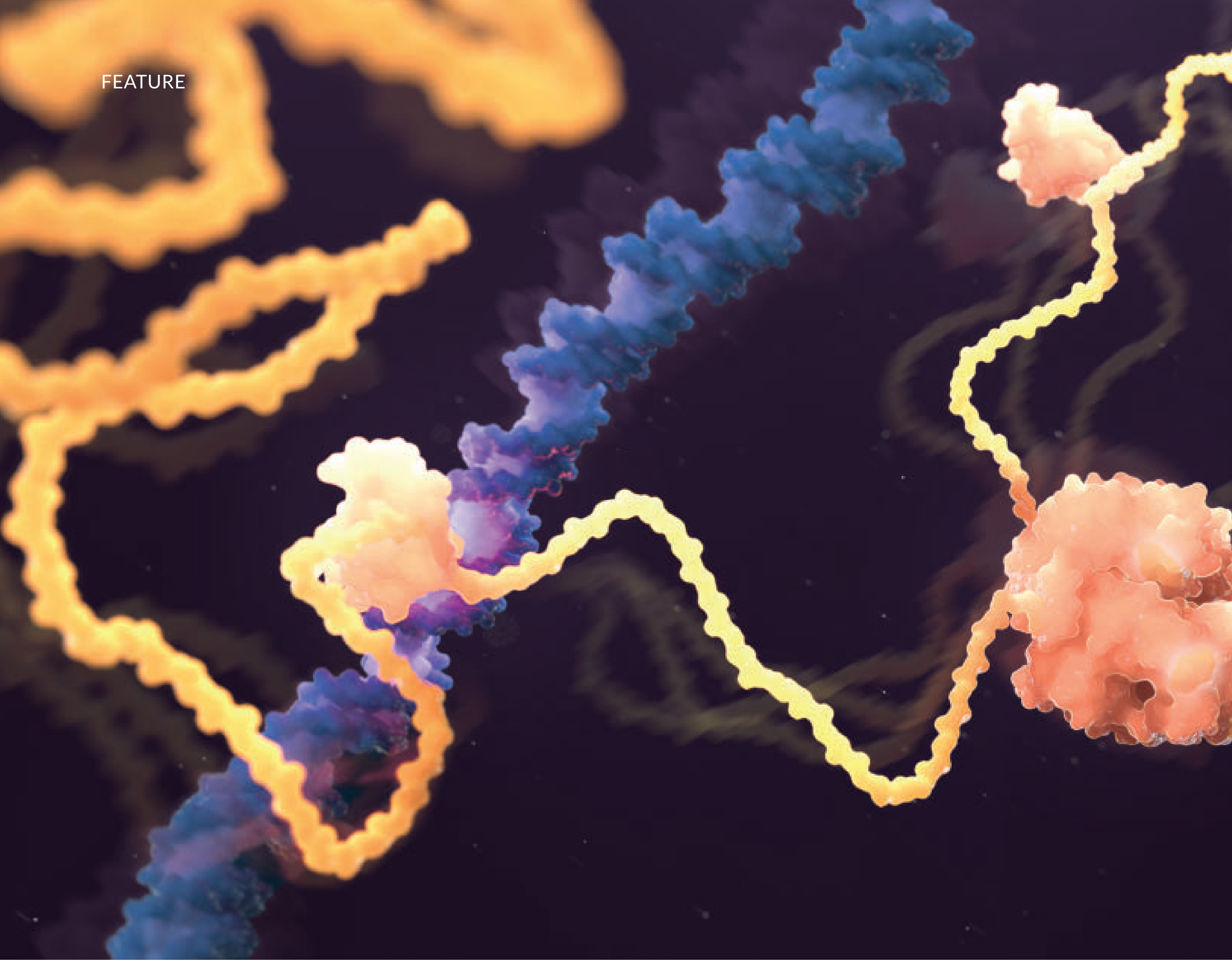
Other potential treatments are coming under scrutiny, such as steroids, omega-3 supplements, growth factors and vitamins A and E, all of which might encourage the recovery of the nasal epithelium.

More futuristic remedies are also in early stages of research. These include epithelial transplants designed to boost olfactory stem cells, treatments with platelet-rich plasma to curb inflammation and promote healing, and even an "electronic nose" that would detect odor molecules and stimulate the brain directly. This cyborg smelling system takes inspiration from cochlear implants for hearing and retinal implants for vision.

For many people, the sense of smell is appreciated only after it's gone, Parma says, an apathy that's illustrated in stark terms by a recent survey of about 400 people. The vast majority of respondents — nearly 85 percent — would rather give up their sense of smell than sight or hearing. About 19 percent of respondents said they would prefer to give up their sense of smell than their phone.

The survey results "dramatically illustrate the negligible value people place on their sense of smell," researchers wrote in the March *Brain Sciences*.

Even as a doctor who treats people with smell loss, Pires has a newfound fondness for a good whiff. "Having lost it for a while made me appreciate it even more." ■



Protein Origami

An AI called AlphaFold has predicted millions of structures, some better than others **By Tina Hesman Saey**

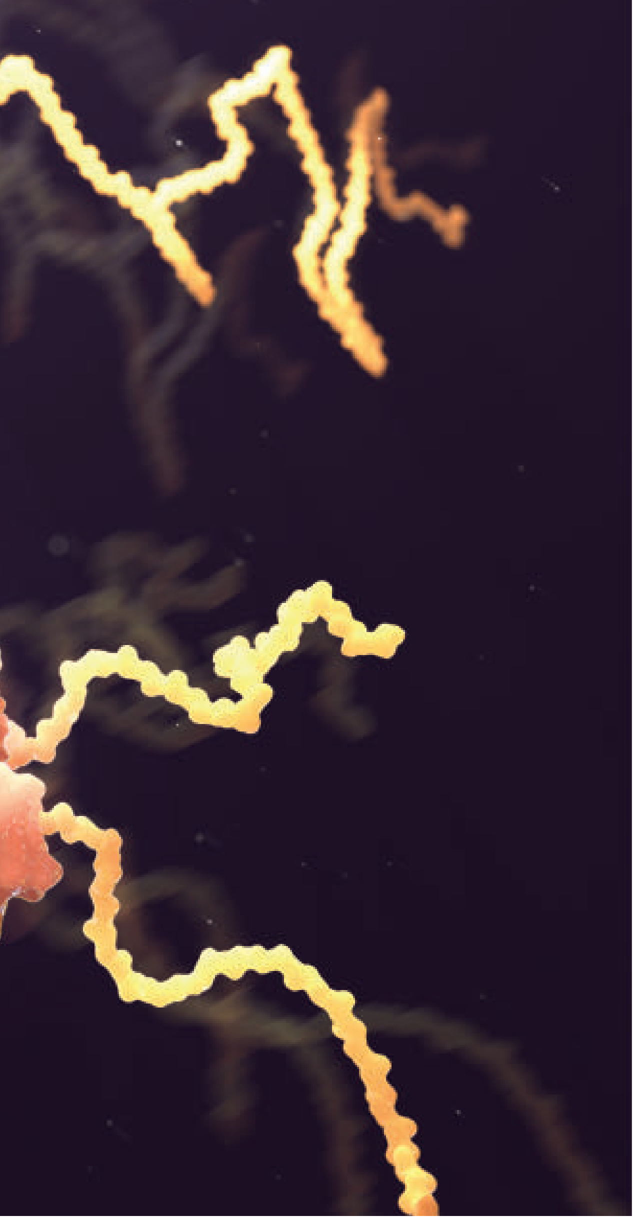
AlphaFold, a deep-learning artificial intelligence system, predicted the structure of the estrogen receptor protein, seen in this illustration binding to DNA (purple). The predicted protein has some parts folded into precise structures (pink) and other areas that resemble free-flowing spaghetti (yellow).

As people around the world marveled in July at the most detailed pictures of the cosmos snapped by the James Webb Space Telescope, biologists got their first glimpses of a different set of images — ones that could help revolutionize life sciences research.

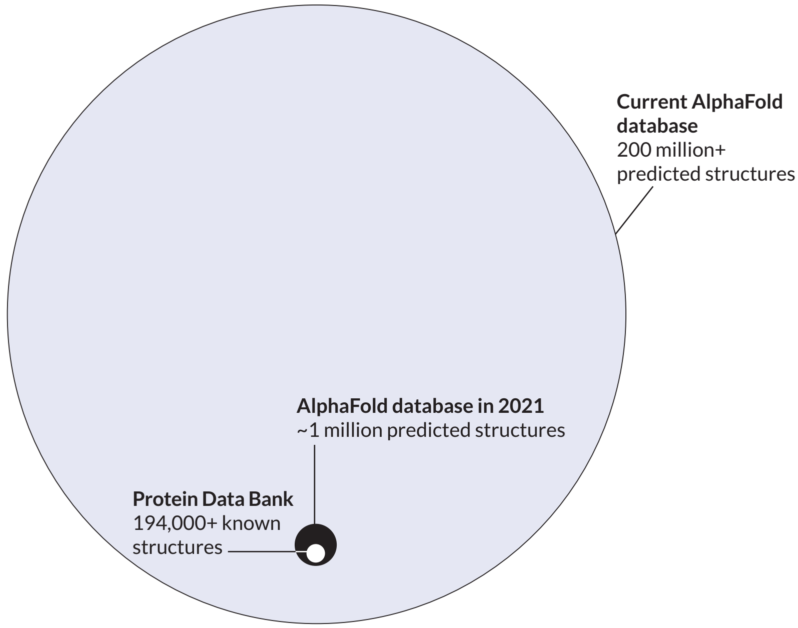
The images are the predicted 3-D shapes of more than 200 million proteins, rendered by an artificial intelligence system called AlphaFold. "You can think of it as covering the entire protein universe," said Demis Hassabis at a July 26 news briefing. Hassabis is cofounder and CEO of DeepMind, the London-based company that created the system. Combining several deep-learning techniques, the computer program is trained to predict protein shapes by recognizing patterns in structures that have already been solved through decades of experimental work using electron microscopes and other methods.

The AI's first splash came in 2021, with predictions for 350,000 protein structures — including almost all known human proteins. DeepMind partnered with the European Bioinformatics Institute of the

VERONICA FALCONIERI HAYS



Total number of protein structures identified and predicted



Expanding the protein universe Decades of slow-going experiments have revealed the structure of more than 194,000 proteins, all housed in the Protein Data Bank. In 2021, the AlphaFold project released predicted structures for about 1 million proteins, including almost all known human proteins. This year, the AlphaFold database exploded with predicted structures for more than 200 million proteins.

European Molecular Biology Laboratory to make the structures available in a public database.

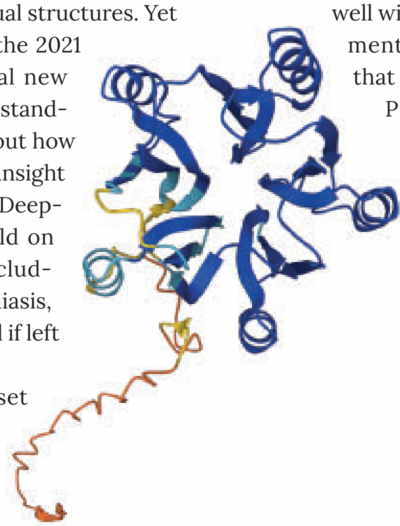
July's massive new release expanded the library to "almost every organism on the planet that has had its genome sequenced," Hassabis said. "You can look up a 3-D structure of a protein almost as easily as doing a key word Google search."

These are predictions, not actual structures. Yet researchers have used some of the 2021 predictions to develop potential new malaria vaccines, improve understanding of Parkinson's disease, work out how to protect honeybee health, gain insight into human evolution and more. DeepMind has also focused AlphaFold on neglected tropical diseases, including Chagas disease and leishmaniasis, which can be debilitating or lethal if left untreated.

The release of the vast dataset was greeted with excitement by many scientists. But others worry that researchers will take the predicted structures as the true shapes of proteins. There are still things AlphaFold can't do — and wasn't designed to do — that need to be tackled before the protein cosmos completely comes into focus.

Having the new catalog open to everyone is "a huge benefit," says Julie Forman-Kay, a protein biophysicist at the Hospital for Sick Children and the University of Toronto. In many cases, AlphaFold and RoseTTAFold, another AI researchers are excited about, predict shapes that match up well with protein profiles from experiments. But, she cautions, "it's not that way across the board."

Predictions are more accurate



The confidence level of AlphaFold's predictions vary within each protein. Dark blue and light blue regions on a predicted structure mean the algorithm is relatively sure. Less certain predictions are colored yellow and orange.

Model confidence

- Very high
- Confident
- Low
- Very low

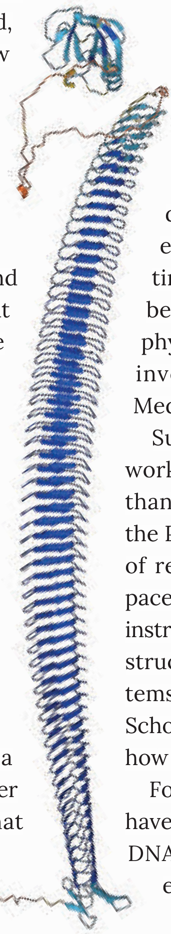
F20H23.2

SOURCE ORGANISM: Thale cress (*Arabidopsis thaliana*)

IMPORTANCE: This plant protein is a kinase, which tacks phosphates onto other molecules, potentially changing their functions.

FROM TOP: T. TIBBITTS; DEEPMIND

for some proteins than for others. Erroneous predictions could leave some scientists thinking they understand how a protein works when really, they don't. Painstaking experiments remain crucial to understanding how proteins fold, Forman-Kay says. "There's this sense now that people don't have to do experimental structure determination, which is not true."



Ice nucleation protein

SOURCE ORGANISM:
Pseudomonas bacteria (*Pseudomonas syringae*)

IMPORTANCE: Leads to frost damage on plants by triggering ice crystals at relatively high temperatures. It might be used for seeding clouds and food preservation.

Plodding progress

Proteins start out as long chains of amino acids and fold into a host of curlicues and other 3-D shapes. Some resemble the tight corkscrew ringlets of a 1980s perm or the pleats of an accordion. Others could be mistaken for a child's spiraling scribbles.

A protein's architecture is more than just aesthetics; it can determine how that protein functions. For instance, proteins called enzymes need a pocket where they can capture small molecules and carry out chemical reactions. And proteins that work in a protein complex, two or more proteins interacting like parts of a machine, need the right shapes to snap into formation with their partners.

Knowing the folds, coils and loops of a protein's shape may help scientists decipher how, for example, a mutation alters that shape to cause disease. That knowledge could also help researchers make better vaccines and drugs.

For years, scientists have bombarded protein crystals with X-rays, flash frozen cells and examined them under high-powered electron microscopes, and used other methods to discover the secrets of protein shapes. Such experimental methods take "a lot of personnel time, a lot of effort and a lot of money. So it's been slow," says Tamir Gonen, a membrane biophysicist and Howard Hughes Medical Institute investigator at the David Geffen School of Medicine at UCLA.

Such meticulous and expensive experimental work has uncovered the 3-D structures of more than 194,000 proteins, their data files stored in the Protein Data Bank, supported by a consortium of research organizations. But the accelerating pace at which geneticists are deciphering the DNA instructions for making proteins has far outstripped structural biologists' ability to keep up, says systems biologist Nazim Bouatta of Harvard Medical School. "The question for structural biologists was, how do we close the gap?" he says.

For many researchers, the dream has been to have computer programs that could examine the DNA of a gene and predict how the protein it encodes would fold into a 3-D shape.

Here comes AlphaFold

Over many decades, scientists made progress toward that AI goal. But "until two years ago, we were really a long way from anything like a good solution," says John Moult, a computational biologist at the University of Maryland's Rockville campus.

Moult is one of the organizers of a competition: the Critical Assessment of protein Structure Prediction, or CASP. Organizers give competitors a set of proteins for their algorithms to fold and compare the machines' predictions against experimentally determined structures. Most AIs failed to get close to the actual shapes of the proteins.

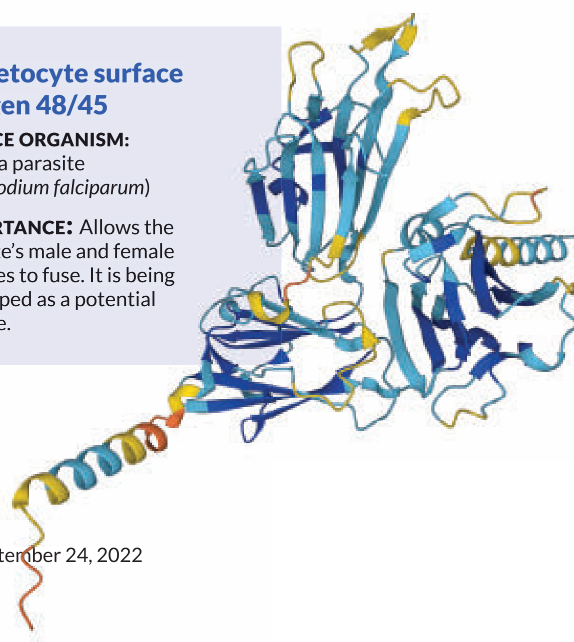
Then in 2020, AlphaFold showed up in a big way, predicting the structures of 90 percent of test proteins with high accuracy, including two-thirds with accuracy rivaling experimental methods.

Deciphering the structure of single proteins had been the core of the CASP competition since its

Gametocyte surface antigen 48/45

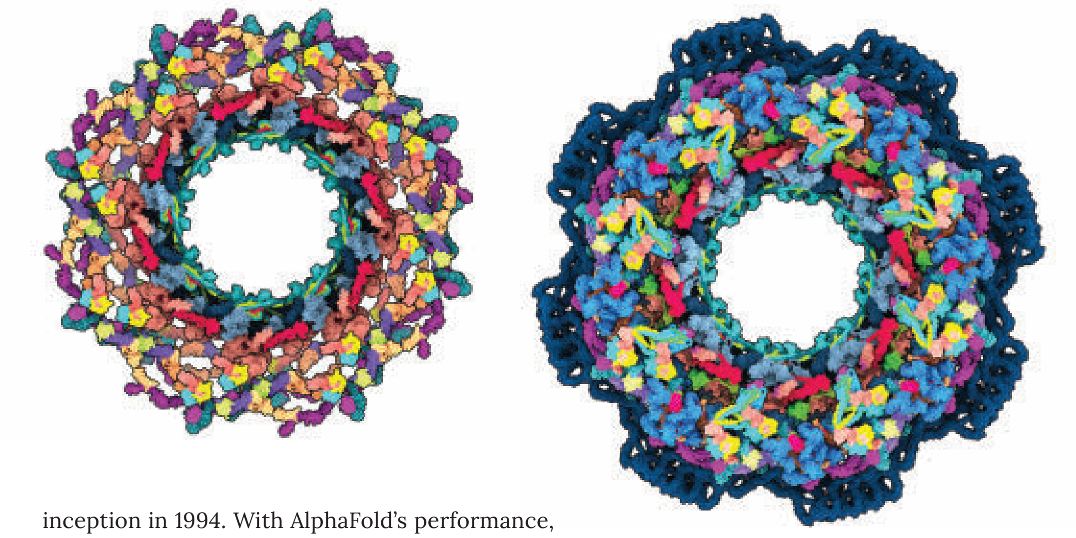
SOURCE ORGANISM:
Malaria parasite (*Plasmodium falciparum*)

IMPORTANCE: Allows the parasite's male and female gametes to fuse. It is being developed as a potential vaccine.



BOTH: DEEPMIND

Previous model **Current model**



The nuclear pore

Researchers previously solved about 30 percent of the 1,000-piece puzzle that is the nuclear pore complex (left). AlphaFold helped make sense of experimental data to complete close to 60 percent of the structure (right).

inception in 1994. With AlphaFold's performance, "suddenly, that was essentially done," Moult says.

Since AlphaFold's 2021 release, more than half a million scientists have accessed its database, Hassabis said in the news briefing. Some researchers, for example, have used AlphaFold's predictions to help them get closer to completing a massive biological puzzle: the nuclear pore complex. Nuclear pores are key portals that allow molecules in and out of cell nuclei. Without the pores, cells wouldn't work properly. Each pore is huge, relatively speaking, composed of about 1,000 pieces of 30 or so different proteins. Researchers had previously managed to place about 30 percent of the pieces in the puzzle.

Now that puzzle is almost 60 percent complete, after combining AlphaFold predictions with experimental techniques to understand how the pieces fit together, researchers reported in the June 10 *Science*.

Now that AlphaFold has pretty much solved how to fold single proteins, this year CASP organizers are asking teams to work on the next challenges: Predict the structures of RNA molecules and model how proteins interact with each other and with other molecules.

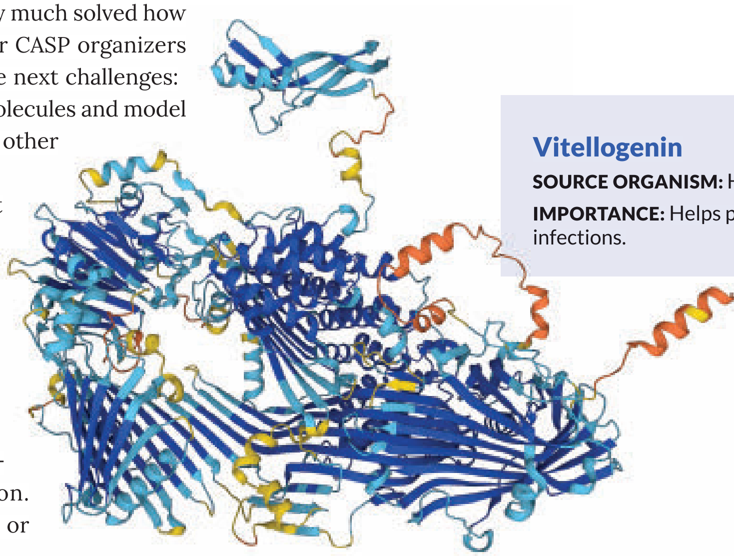
For those sorts of tasks, Moult says, deep-learning AI methods "look promising but have not yet delivered the goods."

Where AI falls short

Being able to model protein interactions would be a big advantage because most proteins don't operate in isolation. They work with other proteins or other molecules in cells. But AlphaFold's accuracy at predicting how the shapes of two proteins might change when the proteins interact are "nowhere near" that of its spot-on projections for a slew of single proteins, says Forman-Kay, the University of Toronto protein biophysicist. That's something AlphaFold's creators acknowledge too.

The AI trained to fold proteins by examining the contours of known structures. And many fewer multiprotein complexes than single proteins have been solved experimentally.

Forman-Kay studies proteins that refuse to be confined to any particular shape. These intrinsically disordered proteins are typically as floppy as wet noodles (SN: 2/9/13, p. 26). Some will fold into defined forms when they interact with other proteins or molecules. And they can fold into new shapes when paired with different proteins or



Vitellogenin

SOURCE ORGANISM: Honeybee (*Apis mellifera*)

IMPORTANCE: Helps protect against bacterial infections.

FROM TOP: S. MOSALAGANTI *ET AL*/*SCIENCE* 2022; DEEPMIND molecules to do various jobs.

AlphaFold's predicted shapes reach a high confidence level for about 60 percent of wiggly proteins that Forman-Kay and colleagues examined, the team reported in a preliminary study posted in February at bioRxiv.org. Often the program depicts the shapeshifters as long corkscrews called alpha helices.

Forman-Kay's group compared AlphaFold's predictions for three disordered proteins with experimental data. The structure that the AI assigned to a protein called alpha-synuclein resembles the shape that the protein takes when it interacts with lipids, the team found. But that's not the way the protein looks all the time.

For another protein, AlphaFold predicted a mishmash of the protein's two shapes when working with two different partners. That Frankenstein structure, which doesn't exist in actual organisms, could mislead researchers about how the protein works, Forman-Kay and colleagues say.

> A static "structure doesn't tell you everything about how a protein works."
>
> **JANE DYSON**

AlphaFold may also be a little too rigid in its predictions. A static "structure doesn't tell you everything about how a protein works," says Jane Dyson, a structural biologist at the Scripps Research Institute in La Jolla, Calif. Even single proteins with generally well-defined structures aren't frozen in space. Enzymes, for example, undergo small shape changes when shepherding chemical reactions.

If you ask AlphaFold to predict the structure of an enzyme, it will show a fixed image that may closely resemble what scientists have determined by X-ray crystallography, Dyson says. "But [it will] not show you any of the subtleties that are changing as the different partners" interact with the enzyme.

"The dynamics are what Mr. AlphaFold can't give you," Dyson says.

A revolution in the making

The computer renderings do give biologists a head start on solving problems such as how a drug might interact with a protein. But scientists should remember one thing: "These are models," not experimentally deciphered structures, says Gonen, at UCLA.

He uses AlphaFold's protein predictions to help make sense of experimental data, but he worries that researchers will accept the AI's predictions as gospel. If that happens, "the risk is that it will become harder and harder and harder to justify why you need to solve an experimental structure." That could lead to reduced funding, talent and other resources for the types of experiments needed to check the computer's work and forge new ground, he says.

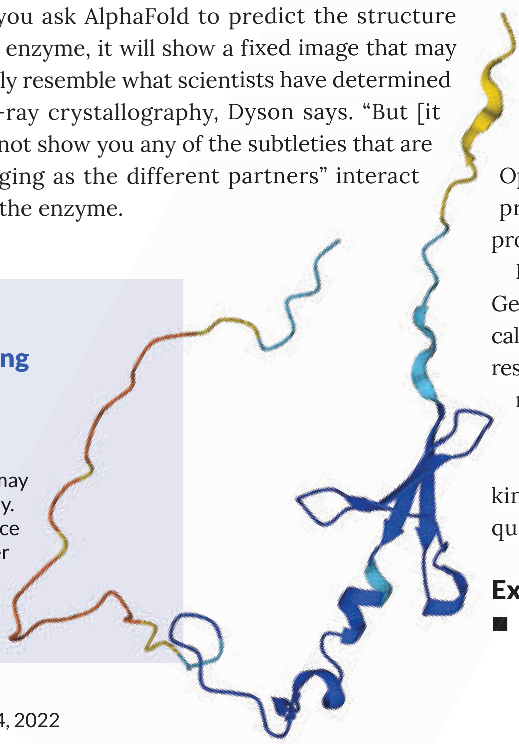
Harvard Medical School's Bouatta is more optimistic. He thinks that researchers probably don't need to invest experimental resources in the types of proteins that AlphaFold does a good job of predicting, which should help structural biologists triage where to put their time and money.

"There are proteins for which AlphaFold is still struggling," Bouatta agrees. Researchers should spend their capital there, he says. "Maybe if we generate more [experimental] data for those challenging proteins, we could use them for retraining another AI system" that could make even better predictions.

He and colleagues have already reverse engineered AlphaFold to make a version called OpenFold that researchers can train to solve other problems, such as those gnarly but important protein complexes.

Massive amounts of DNA generated by the Human Genome Project have made a wide range of biological discoveries possible and opened up new fields of research (SN: 2/12/22, p. 22). Having structural information on 200 million proteins could be similarly revolutionary, Bouatta says.

In the future, thanks to AlphaFold and its AI kin, he says, "we don't even know what sorts of questions we might be asking." ■



Eukaryotic translation initiation factor 4E-binding protein 2

SOURCE ORGANISM: Human

IMPORTANCE: Helps control production of other proteins and may be involved in learning and memory. Despite AlphaFold's high confidence (blue) in its predictions of the lower coiled area and the ribbon structure just above it, the two would never appear at the same time.

DEEPMIND

Explore more

- AlphaFold Protein Structure Database: alphafold.ebi.ac.uk/

Island Lessons

Saba, a tiny spot in the Caribbean, is trying to preserve its beloved species

By Anna Gibbs

The Caribbean island of Saba has one volcano, one major road and a wealth of biodiversity. Some of its hallmark species are declining, and scientists are enlisting residents to help keep an eye on them.

FRANS LEMMENS/CORBIS DOCUMENTARY/GETTY IMAGES PLUS

The coral reef, once bustling with more than 5,000 long-spined sea urchins, became a ghost town in a matter of days. White skeletons with dangling spines dotted the reef near the Dutch Caribbean island of Saba, the water cloudy from the disintegrating corpses. In just a week last April, half of the urchins, *Diadema antillarum*, in a section of reef called "Diadema City" had died. In June, only 100 remained.

The mysterious die-off started sweeping across the Caribbean in February. It's eerily similar to a mass mortality event in 1983 that wiped out as much as 99 percent of the Caribbean *Diadema* population — a huge blow to not only the urchins, which have not fully recovered four decades later, but also the reefs. Without urchins grazing, algae can overwhelm a reef, damaging adult coral and leaving nowhere for new coral to settle.

Before the die-off, Saba's coral cover — the part of a reef that consists of live hard coral rather than sponges, algae or other organisms — hovered around 50 percent. Today, that number is down to 3 percent.

"It's just downhill, downhill, downhill," says Alwin Hylkema, a marine ecologist at Van Hall Larenstein University of Applied Sciences and Wageningen University in the Netherlands who is based in Saba (pronounced "say-bah").

I learned about Saba's sea urchin problem only shortly after I learned that the island existed. Saba is a blip in the Caribbean; at 13 square kilometers,

it's about a quarter the size of Manhattan, with the towering Mount Scenery volcano at its center. Its reefs attract scuba divers, but a lack of beaches shields it from regular Caribbean tourist traffic — hence its nickname, "the unspoiled queen." What the island lacks in size and sand it makes up for with its great variety of species, its biodiversity. Steep cliffs support several microclimates. In just a few hours, a visitor can hike from volcanic rock to grassy field to misty cloud forest.

This diversity makes Saba the perfect spot for Sea & Learn, an annual educational program that brings scientists from around the world to the island. Former dive shop owner Lynn Costenaro launched the program in 2003 to encourage more divers to visit Saba during the off-season. But the event has grown to play an important role in educating the island's 2,000 residents about their home's unique wildlife and ecosystems.

Throughout October, the scientists present their research on everything from biology and geology to astronomy at restaurants and in plazas. Several researchers also host public research trips underwater and on shore, so attendees can see the lobsters, or rock formations or stars for themselves.

This kind of local engagement with the environment comes at a time when many species are at risk, and not just on Saba, says Severin Irl, an island ecologist at Goethe University Frankfurt in Germany. Although islands cover only about 7 percent of the world's landmass, they are home to an estimated 20 percent of all species — and 75 percent of all documented extinctions.

Some island species occupy only one island; others are spread out in small populations across several islands. Species within small populations can develop a very narrow, island-specific set of adaptations, which spells trouble when humans and invasive species arrive. Today, any given plant or animal on an island is 12 times as likely to go extinct as species on the mainland, Irl and an international group of researchers reported in the November 2021 *Global Ecology and Conservation*. And the decline is speeding up at an unprecedented rate. As biodiversity decreases, islands lose the complexity that helps keep the ecosystem stable and less vulnerable to disruptions, such as climate change.

"We're in the midst of a biodiversity crisis … and islands are really bearing the brunt of that global change," says arachnologist Lauren Esposito of the California Academy of Sciences, who has presented research on spiders and scorpions at Sea & Learn.

About a quarter of the world's population of a red-billed tropicbird subspecies (a parent and chick shown) lives on Saba. New generations are threatened by feral cats that roam the island cliffs.

L. MIELKE

Tiny orchids called *Brassavola cucullata* (left) are found on Saba's rock ledges and high in trees. Mike Bechtold (right, in white cap) shows students at the 2021 Sea & Learn how to measure the plant's leaves.

FROM LEFT: M. BOEKEN; JOE SNYDER

The features that put island inhabitants at risk — their small size and isolation — also make them wonderful laboratories. Like the famous Galápagos Islands that turned Charles Darwin on to natural selection, islands present opportunities to study individual species as well as ecosystem dynamics, in a relatively small microcosm. In 2021, the California Academy of Sciences launched Islands 2030, co-led by Esposito, in five tropical archipelagos, including the Lesser Antilles where Saba is located. The aim is to conduct biodiversity research as well as train local communities to become guardians of their environments. The program took its inaugural trip to Saba's Sea & Learn last October.

I attended that Sea & Learn and tagged along on field trips to see what progress and pitfalls researchers had experienced while working on Saba to protect a tiny orchid, a bright-billed bird and those dying urchins.

Counting orchids

On my first night, I joined locals and tourists at the Brigadoon restaurant to hear Mike Bechtold talk about Saba's orchids. Bechtold, a retired nuclear arms expert from Virginia who fell in love with orchids while serving in Korea, first traveled to the island in 2003 to study the flowers. He's since presented several times at Sea & Learn. This was his first time back in seven years.

After defining an orchid as a flowering plant with three petals and a laundry list of unusual attributes, Bechtold described the disorganized history of orchid research on Saba, including a series of miscommunications that has resulted in count discrepancies. A recently published book identifies 22 species, while Bechtold counts 32.

"To know what we have to preserve, well, we at least have to know what is there," says Michiel Boeken, a former secondary school teacher from the Netherlands who studied orchids on Saba during his 2010 to 2012 tenure as principal of the island's only secondary school.

The morning after his presentation, Bechtold led a hike to Spring Bay to look for orchids. We walked along the island's only major road — aptly named The Road. At the trailhead, we descended into a swath of trees laden with mosses and other plants. We'd only walked for about 10 minutes when Bechtold pointed out an *Epidendrum ciliare*, the most common orchid on Saba, perched on a tree.

Stepping carefully over hermit crabs, we looked for the pile of rocks that marked where to leave the trail to find another species, *Brassavola cucullata*. Bechtold, Boeken and colleagues had surveyed the Spring Bay population from 2011 to 2014 to see if Saba's numbers were declining. As we lowered ourselves down the steep hillside, we eventually spied the tiny white and yellow flowers of *B. cucullata* atop a tall tree with a metal tag glued beneath it; it was #582 of 834 *B. cucullata* plants that Bechtold helped tag a decade earlier.

We counted the plant's leaves and measured them. Bechtold's team had found that larger plants with more leaves had a better chance of survival than smaller plants, as did plants that were higher off the ground, like #582. Plants close to the ground were often munched on by wild goats.

The orchid is found from Mexico to northern South America. But here, the *B. cucullata* population was indeed declining, with small plants dying and not many new plants starting to grow, the researchers reported in 2020 in the *International Journal of Plant Sciences*. Without counting flowers for many more years, if not decades, it will be hard to know if the decline reflects natural population dynamics or if it's a troublesome trend.

Regardless of cause, the population's small size makes the island's *B. cucullata* vulnerable. A recent hurricane knocked over several trumpet trees hosting large orchid plants. Some of the plants were crushed; others, lowered to the ground when their tree toppled, faced death by goat chomping.

Tracking red-billed tropicbirds

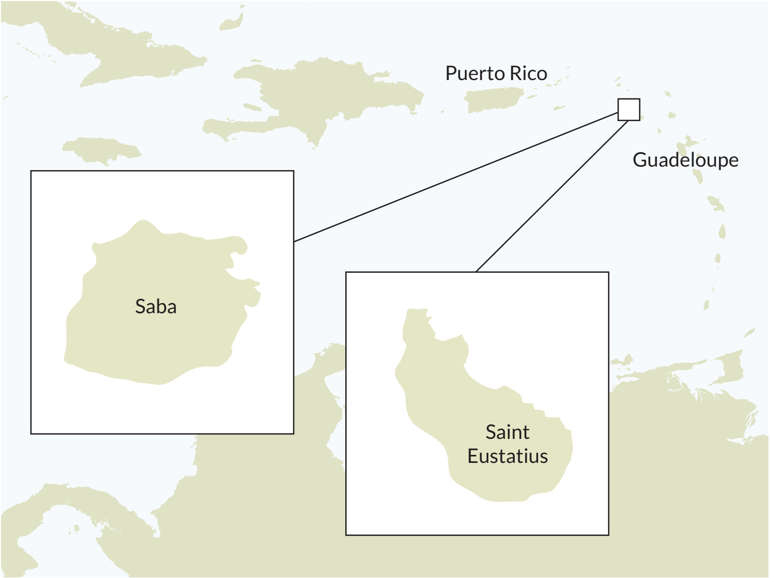
A week after the orchid hike, I found myself perched on a boulder high up on a cliff at Tent Bay on the island's southern coast, looking for nests tucked into narrow rock crevices. German ecologist Lara Mielke, another volunteer and I started out at dawn to beat the heat, climbing hand over foot up the exposed hill. Overhead, red-billed tropicbirds, with long white tails and bright crimson beaks, swooped out across the sea.

About 1,500 breeding pairs of *Phaethon aethereus mesonauta*, one of the three subspecies of red-billed tropicbirds, breed on Saba, as much as a quarter of the subspecies's global population. Tropicbirds spend most of their lives at sea, only coming to land for a few months each year to breed and raise a single chick. Their cliffside nesting spot makes the birds hard to study even when they're on land. Fortunately, on Saba and the neighboring island Saint Eustatius, or "Statia," the terrain is tough but not impossible to scale.

While climbing, I was startled by an abrasive squawk coming from a deep crevice hiding a nest. But the birds are more squawk than bite, and Mielke was able to reach her arm into the small opening and extract the bird to wrap a band around its leg.

Tameness, helpful when it comes to banding, makes these birds vulnerable to invasive predators. Tropicbird chicks are often eaten by feral cats that roam the island's cliffs. Over the years, the Saba Conservation Foundation has set up cat eradication programs with mixed success.

After banding the bird, Mielke handed me a warm egg she'd pulled from the nest. I held it in my palm as she filled a plastic bin with water. An egg's buoyancy indicates how far along it is. We knew, though, that once the chick hatched, it probably wouldn't



Small neighbors The Dutch islands of Saba and Saint Eustatius are in the Lesser Antilles archipelago, southeast of Puerto Rico. Red-billed tropicbirds fare differently on each island.

With help from volunteers, ecologist Lara Mielke (right) has scaled cliffs to band tropicbirds and monitor their eggs. She has also attached GPS trackers to the birds' tails to study their foraging patterns.

FROM TOP: C. CHANG; LONNEKE SCHUT

live long. In past years, researchers have observed the disappearance of every chick at Tent Bay, presumably snatched by the feral cats.

Chicks have much better odds on the other side of the island. In 2011 and 2012, Boeken — involved in several conservation efforts on Saba — found that 62 of 83 hatchlings, or 75 percent, at Old Booby Hill near Spring Bay to the north survived to fledge the nest. And on Statia, which has no cat problem, as many as 90 percent of chicks survive after they've hatched. Though, for reasons still unknown, their colonies produce much fewer chicks because many eggs simply never hatch.

Tropicbirds are faithful to both their mate and nest site, sometimes even returning to the same rock cavity each year, says ecologist Hannah Madden of the Caribbean Netherlands Science Institute, who moved from the Netherlands to Statia in 2006 and has spearheaded Statia and Saba's tropicbird research. But the birds may be loyal to a fault. If a nest is repeatedly robbed or eggs fail to hatch, the chances of successfully raising chicks may be increased by relocating or finding a new mate.

Madden and Mielke, working as an independent researcher, are now analyzing GPS data of the subspecies's foraging patterns. The last Caribbean-wide assessment of seabirds happened over two decades ago, so Madden has been hosting webinars to teach people on other islands how to collect such data during next year's nesting season.

"In 2023, we want people from as many islands as possible in the Caribbean to get out there and monitor the seabirds on their islands," she says.

Hitting home

Peter Johnson, an 11th-generation Saba resident, teaches math and physics at the secondary school. Sometimes after class he sits outside the school and listens to the red-billed tropicbirds flying overhead.

"Their birdcall is so unique," he says. "They're certainly something that reminds me of home."

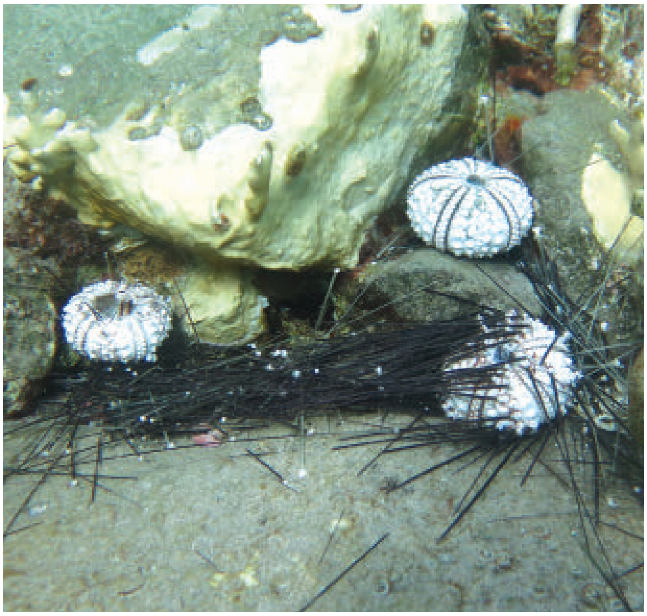
Johnson was a kid when Sea & Learn started in 2003. He still remembers when, in the fifth grade, scientists came to his classroom and let him try on a spelunking helmet used for cave exploration. Years later, he returned to Saba after earning degrees in engineering in Virginia. "You're more inclined to be proud of where you're from, the more you know about it," he says.

Esposito, of the Islands 2030 initiative, recalls being impressed by the fluency of Saban youth when talking about nature. Sea & Learn scientists visit Saba's schools to teach about the island's unique species. When Esposito asks students if they've seen the island's local snake — its only snake, the red-bellied racer — they usually say yes. She doesn't get the same answer on Statia or neighboring islands.

"I have seen the direct effect of Sea & Learn," she says. "There is this connection between the people coming to do research and the local population and communities that doesn't exist in most other places."

Sea & Learn coordinator Emily Malsack hopes the program encourages locals to stay on Saba to work in conservation. It's already having an impact. Johnson is now the president of the Saba Conservation Foundation. Saban native Dahlia Hassell-Knijff got

Healthy *Diadema* sea urchins (left) were once a major presence among coral reefs off of Saba and throughout the Caribbean. But their return since a 1980s die-off has been slow. In April, thousands in the Diadema City colony died, leaving only their spines and white skeletons behind (right).



FROM LEFT: STACEY WILLIAMS; A. HYLKEMA

to the island, where she oversees projects at the regional Dutch Caribbean Nature Alliance. She also grew up attending Sea & Learn.

"It was a very tiny organization [at the time], but it didn't seem tiny to me," Hassell-Knijff says. "It was like a dream come true for a little kid."

Hassell-Knijff's story is "an indication of progress that's to come," Esposito says. Islands 2030 plans to recruit early-career scientists from five archipelagoes to attend the California Academy of Sciences in San Francisco, where they can work toward an advanced degree and become part of a network of scientists from their archipelago. The hope is that this next generation will return to their home islands to become leaders in biodiversity science and conservation.

There's a need for this support. Many researchers who study island biology travel from abroad, spend some time and leave, causing research to sputter and disrupting long-term studies that are crucial to understanding population trends of, say, orchids and tropicbirds. Mielke recently ended her six months on Saba to return to Germany, and after 16 years on Statia, Madden moved back to the Netherlands this summer.

"It's just tough," Madden says. "At this point, I don't know who will take over the projects that I'm working on." Bechtold, too, worries about who will track the orchids after he and Boeken retire from research and can no longer travel to Saba.

Saving the urchins

The night that marine ecologist Alwin Hylkema presented his research about *Diadema*, the plaza was packed with over 100 adults and children. Hylkema has become something of a local celebrity. At first, he conducted his urchin research from the Netherlands, visiting Saba twice a year, until he realized it made more sense to do his studies on site. He moved his family to Saba in 2019.

Since then, Hylkema has worked on restoring *Diadema* to the reefs around Saba. But it's a challenge: After urchin larvae settle onto a reef, they are easily eaten by queen triggerfish and spiny lobsters. To help more of the animals survive to adulthood, Hylkema's team has been collecting the youngsters, known as settlers, and growing them in a lab on Saba. Once the animals are a few centimeters wide and less likely to become a meal, the team returns them to the reefs.

In October 2021, things were starting to look up for the animals. That same week, Hylkema's team bred *Diadema* in captivity for the first time in Caribbean history.

JOE SNYDER

A crowd gathered on a Saba plaza last October to hear researcher Alwin Hylkema talk about sea urchins. He has been restoring *Diadema* to the reefs since 2017.

The lab-grown urchin success came just in time. Hylkema anticipates producing 1,000 to 2,000 juveniles by the end of this year, which he hopes to use for restocking the devastated population at Diadema City. But that will have to wait until whatever is causing the die-off dissipates. Researchers at Cornell University are analyzing *Diadema* tissue sent by Hylkema and others to try to determine the cause, likely a pathogen.

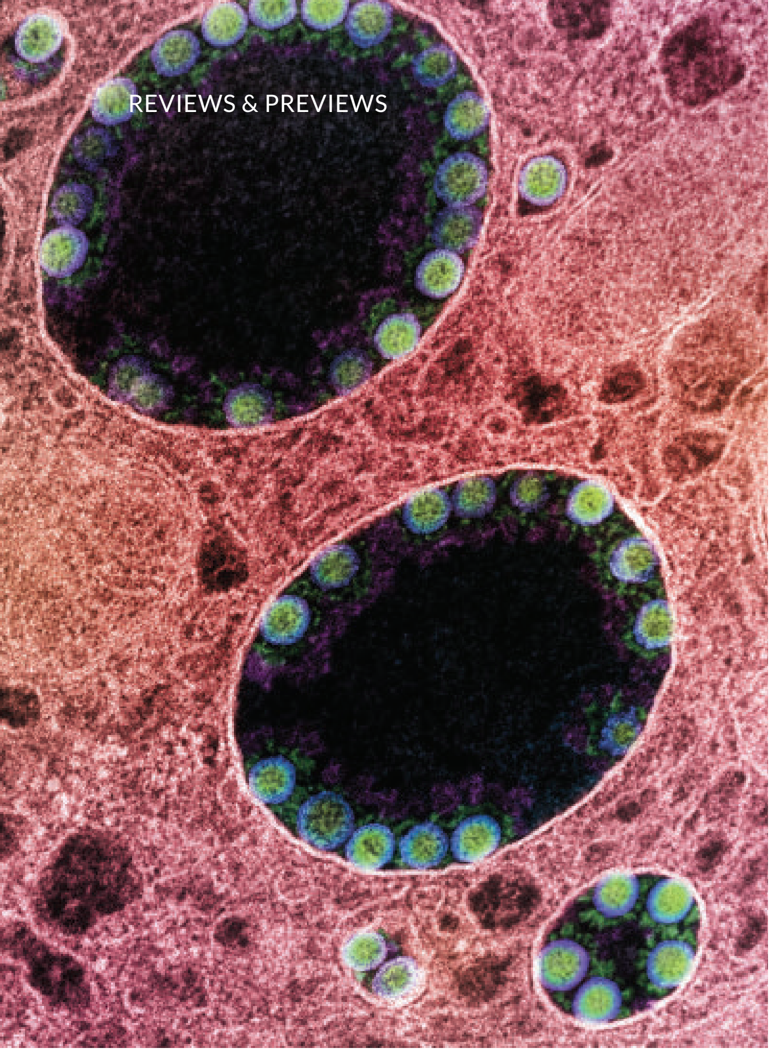
One afternoon, I hitchhiked south from the town of Windwardside in the middle of the island to the harbor in Fort Bay, where Hylkema's lab is located. I wanted to see the captive-bred *Diadema*. The crates in the lab were organized by urchin size: The youngest ones looked like inch-long pom-poms; older urchins resembled plums covered in long, black sewing needles.

In an air-conditioned storage container out back, specks of urchin larvae swirled in glass jars on a vibrating metal plate. After 50 or so days, the larvae will settle and eventually be transferred to the crates. If all goes well, the animals will grow in the lab until they're big enough to be taken out to the reefs, where they'll begin the next generation of *Diadema*. ■

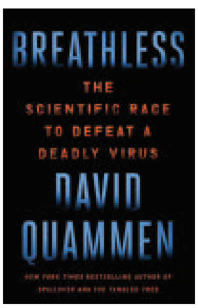
Explore more

- José María Fernández-Palacios *et al*. "Scientists' warning — The outstanding biodiversity of islands is in peril." *Global Ecology and Conservation*. November 2021.

Anna Gibbs, a former Science News *intern, is a freelance science writer based in New York City.*



A new book about the pandemic focuses on the science of SARS-CoV-2 (green in this false-color image of an infected olfactory epithelial cell).



Breathless
David Quammen
SIMON & SCHUSTER, $29.99

BOOKSHELF

The origin story of the coronavirus

When COVID-19 burst onto the global stage in 2020, it was deadly and disruptive. In the first weeks of January, researchers identified the cause: A coronavirus was to blame, a relative of the virus that caused the 2003 SARS outbreak. Echoes of what had happened nearly 20 years earlier — thousands were infected and at least 774 people died before the SARS outbreak was brought under control — sent ripples of anxiety throughout the virology world.

Scientists of all backgrounds rushed to understand the new scourge, dubbed SARS-CoV-2. Hospitals around the world were soon overwhelmed, and daily life for billions of people was thrown into disarray. Quarantine, isolation, N95 masks and social distancing entered our collective lexicon. *Breathless*, by science writer David Quammen, takes readers along on the ensuing two-year scientific roller coaster.

The book is a portrait of the virus — SARS-CoV-2's early days in China, how decades of science helped researchers craft effective vaccines within a year, the arrival of highly mutated variants. It's not about the societal upheaval or the public health failures (and successes). While Quammen acknowledges the importance of those aspects of the pandemic, he chooses to focus on the "firehose" of scientific studies — both good and bad — that drove our understanding of COVID-19.

He dives deep into one of the pandemic's most controversial questions: Where did SARS-CoV-2 come from? Nature or the lab? Quammen describes the saga in elaborate detail. First there were worries that some of the virus's features appeared engineered. Those concerns were quickly dispelled when researchers found those features in viruses from wild bats and pangolins. Then there was the thought that workers in a lab studying bat viruses could have become accidentally infected and unknowingly spread the virus to others.

Rather than dismiss that accidental lab leak hypothesis, Quammen takes readers step by step through the genetic and epidemiological data. That includes recent evidence supporting the scenario that the virus emerged — perhaps in two separate jumps — from an unknown animal at the Huanan Seafood Wholesale Market in Wuhan, China. Through his conversations with experts in virus ecology and evolution, readers learn the nuances of how virologists do research and the controversies of gain-of-function studies that test what happens when viruses acquire new traits. Quammen's conclusion: An accidental lab leak is not impossible. "But it seems unlikely."

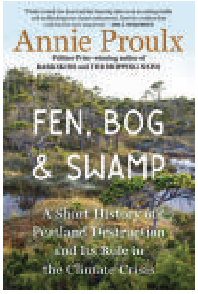
To understand the pandemic, Quammen draws on lessons learned from our previous run-ins with coronaviruses, including the SARS outbreak and the 2012 MERS outbreak in the Middle East (SN: 12/28/13, p. 23). Part of his 2012 book *Spillover* focused on the bat origin of the SARS outbreak (SN: 10/20/12, p. 30). That tome is unnervingly prescient. If the original SARS coronavirus had been most contagious before symptoms began, Quammen wrote in *Spillover*, officials would have had a much harder time ending the outbreak. "It would be a much darker story," he wrote. But that's exactly what happened with SARS-CoV-2. People can pass the virus to others before knowing they are sick, a trait that helped COVID-19 spiral out of control.

As a science journalist who has followed SARS-CoV-2 since its discovery, I found *Breathless* to be surprisingly cathartic. My memories of the last few years have blurred together. *Breathless* presents the sweeping scientific story of the pandemic, connecting puzzle pieces that at the time had felt so out of place.

Some readers may feel it's too soon to scrutinize a pandemic that isn't even over. But SARS-CoV-2 certainly won't be the last harmful virus to emerge. Quammen puts the pandemic in the context of the coronavirus scares that came before to highlight how science builds on itself. And one thing is certain: There will be another. "There are many more fearsome viruses where SARS-CoV-2 came from," he writes, "wherever that was." — *Erin Garcia de Jesús*

BOOKSHELF

Why imperiled peatlands deserve more respect



Fen, Bog & Swamp
Annie Proulx
SIMON & SCHUSTER, $26.99

A recent TV ad features three guys lost in the woods, debating whether they should've taken a turn at a pond, which one guy argues is a marsh. "Let's not pretend you know what a marsh is," the other snaps. "Could be a bog," offers the third.

It's an exchange that probably wouldn't surprise novelist Annie Proulx. While the various types of peatlands — wetlands rich in partially decayed material called peat — do blend together, I can't help but think, after reading her latest book, that a historical distaste and underappreciation of wetlands in Western society has led to the average person's confusion over basic peatland vocabulary.

In *Fen, Bog & Swamp: A Short History of Peatland Destruction and Its Role in the Climate Crisis*, Proulx seeks to fill the gaps. She details three types of peatland: fens, which are fed by streams and rivers; bogs, fed by rainwater; and swamps, distinguishable by their trees and shrubs. While all three ecosystems are found around most of the world, Proulx focuses primarily on northwestern Europe and North America, where the last few centuries of modern agriculture led to a huge demand for dry land. Wet, muddy and smelly, wetlands were a nightmare for farmers and would-be developers. Since the 1600s, U.S. settlers have drained more than half of the country's wetlands; just 1 percent of British fens remains today.

Only recently have the consequences of these losses become clear. "We are now in the embarrassing position of having to relearn the importance of these strange places," Proulx writes. For one, peatlands have great ecological value, supporting a variety of wildlife. They also sequester huge amounts of carbon dioxide, and some peatlands prevent shoreline erosion, while buffering land from storm surges (*SN: 3/17/18, p. 20*). But the book doesn't spend too much time on nitty-gritty ecology. Instead, Proulx investigates these environments in the context of their relationship with people.

Known for her fiction, Proulx, who penned *The Shipping News* and "Brokeback Mountain," draws on historical accounts, literature and archaeological digs to imagine places lost to time. She challenges the notion that wetlands are purely unpleasant or disturbing — think Shrek's swamp, where only an ogre would want to live, or the Swamps of Sadness in *The Neverending Story* that swallow up Atreyu's horse.

Proulx jumps back as far as 20,000 years ago to the bottom of the North Sea, which at the time was a hilly swath called Doggerland. When sea levels rose in the seventh century B.C., people there learned to thrive on the region's developing fens, hunting for fish and eels. In Ireland, "bog bodies" — many thought to be human sacrifices — have been preserved in the peat for thousands of years; Proulx imagines torchlit ceremonies where people were offered to the mud, a connection to the natural world that is hard for many people to comprehend today. These spaces were integrated into the local cultures, from Renaissance paintings of wetlands to British lingo such as *didder* (the way a bog quivers when stepped on). Proulx also reflects on her own childhood memories — wandering through wetlands in Connecticut, a swamp in Vermont — and describes how she, like writer Henry David Thoreau, finds beauty in these places. "It is … possible to love a swamp," she says.

Fens, bogs and swamps are technically distinct, but they're also fluid; one wetland may transition into another depending on its water source. This same fluidity is reflected in the book, where Proulx flits from one wetland to another, from one part of the world to another, from one millennium to another.

At times didactic and meandering, Proulx will veer off to discuss humankind's destructive tendency not just in wetlands, but nature in general, broadly rehashing aspects of the climate crisis that most readers interested in the environment are probably already familiar with. I was most enthralled — and heartbroken — by the stories I had never heard before: of "Yde Girl," a redheaded teenager sacrificed to a bog; the zombie fires in Arctic peatlands that burn underground; and the ivory-billed woodpecker, a bird missing from southern U.S. swamps for almost a century. — *Anna Gibbs*

Trees and shrubs distinguish swamps from other types of peatlands.

KAREN FOX/IMAGE SOURCE/GETTY IMAGES PLUS

SOCIETY UPDATE

Society for Science, the nonprofit organization that publishes *Science News,* is thrilled to share our Annual Report, highlighting the Society's centennial year. The report showcases the excellent work we accomplished in 2021 and takes a step back in time to 1921, when our story began.

Read about all we achieved, from hosting three virtual STEM competitions to providing educators across the nation with STEM equipment, like Arduino starter kits for their classrooms. Watch videos about the amazing young people who won top prizes in our science competitions. Take a moment to read interviews between Maya Ajmera, President & CEO of the Society and Publisher of *Science News*, and some of our competitions' amazing alumni. Walk through science history by visiting Century of Science, where the *Science News* team shows how topics such as climate change, computing and epidemics have evolved in the last 100 years.

NASA, ESA, THE HUBBLE HERITAGE TEAM/STSCI AND AURA

View the 2021 Annual Report at societyforscience.org/annual-report-2021

SOCIETY FOR SCIENCE

AUGUST 13, 2022

SOCIAL MEDIA

Out of this world

The James Webb Space Telescope's first mind-blowing images, including one of the "Cosmic Cliffs" (shown below), thrilled many readers. On Facebook, reader **Jeff Reynolds** marveled at the great achievement: "A magic day when super science mingles with the bright stuff of dreams."

NASA, ESA, CSA, STSCI

Space palettes

The stunning first pictures from the James Webb Space Telescope provide the deepest and clearest look yet into outer space, ***Lisa Grossman*** *reported in "Postcards from a new space telescope"* (SN: 8/13/22, p. 30). JWST observes space using infrared, a form of light not visible to the human eye. To visualize the images, scientists colorize them. Reader **John Dohrmann** wondered how that colorizing is done.

JWST's images are colorized by senior data imaging developer Joseph DePasquale and science visuals developer Alyssa Pagan, both of the Space Telescope Science Institute in Baltimore, **Grossman** says. Their basic rule of thumb is to paint the pictures using wavelengths of light as a guide. The light emitted in the longest wavelength in an image is assigned the color red, and the shortest blue, she says. Wavelengths in between are assigned a spectrum of greens and yellows (SN: 3/17/18, p. 4). But there are also other considerations, such as data on the chemical compositions of stuff in the image. How to colorize those elements can be more of an art than a science, **Grossman** says. "There's a subjective artistry to it too."

Reader **Stu Kantor** asked why some stars in the JWST images appear to have eight spikes — six large ones and two smaller ones (see "Out of this world," left).

Those are called diffraction spikes, **Grossman** says, and they're an artifact of the telescope's optical setup. JWST has two mirrors: a primary hexagonal mirror and a smaller secondary mirror that sits in front of the primary mirror and is held up by three support beams. When it hits the telescope, light bends at the two edges of each of the secondary mirror's supports, producing six diffraction spikes. The six edges of the primary mirror also create six spikes. Scientists designed the telescope so that four of the spikes from the secondary supports overlap with four of the primary mirror's spikes, **Grossman** says, so though there are 12 spikes, we see only eight.

Diffraction spikes are not unique to JWST. "Images from the Hubble Space Telescope have these too, but they only have four," **Grossman** says. "The eight points are a distinctive feature of JWST, like an artist's signature."

On the nose

Scientists discovered a neural link in the dog brain that connects the olfactory system to vision, which may help explain why humankind's best friend is such a good sniffer, ***Laura Sanders*** *reported in "New nose-to-brain link ID'd in dogs"* (SN: 8/13/22, p. 9). The story inspired several readers to reflect on the behavior of their own furry friends.

"I now know why my German shepherd could not play the simplest version of the shell game," **Ed Hughes** wrote. "Using a small piece of dog food and two Dixie cups... one shift in the location of the cup hiding the dog food completely confused her. I could watch her eyes follow the cup, but she never picked the cup with the dog food. She had prelocated it with her nose, and anything her eyes detected was completely ignored."

Reader **Roy R. Ferguson** shared his fascination with dogs' sniffing abilities, having worked with the animals in search and rescue efforts for the last 20 years with his wife.

"We have learned to allow the K-9s to do their work with as little supervision as possible," **Ferguson** wrote. "They constantly make decisions that seem unusual at the time but make sense once the full story is known."

"Our K-9s have located drops of blood in light rain and human decomposition in various vehicles. Live finds include one man who wandered over 10 miles after a head wound and a 6-year-old who had been out all night .... The child find was notable due to the large amount of scent contamination in the area," **Ferguson** added.

"We have no idea how these amazing creatures do such marvelous feats. They work their hearts out for nothing more than praise and a toy reward," **Ferguson** wrote. "It has occurred to [us] that we are there to provide them support, drive and work the radio. In return, they make us look as though we know what we're doing."

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Attack of a zombie fungus

Sometimes a photo is a matter of life, death — and zombies.

This haunting image, winner of the 2022 *BMC Ecology and Evolution* photography competition, captures the fruiting bodies of a parasitic fungus emerging from the lifeless body of an infected fly in the Peruvian rainforest. The fungus belongs to the genus *Ophiocordyceps*, a diverse group of parasitic fungi known as "zombie fungi" due to their ability to infect insects and control their minds (SN: 8/17/19, *p.* 5).

Roberto García-Roa, a conservation photographer and evolutionary biologist at the University of Valencia in Spain, took the photo while visiting the Tambopata National Reserve, a protected habitat in the Amazon.

"There is still much to unravel about the diversity of these fungi as it is likely that each insect species infected succumbs to its own specialized fungus," says parasitic fungi expert Charissa de Bekker of Utrecht University in the Netherlands.

For this ill-fated fly, the manipulative endgame began when fungal spores landed on its body. The spores infiltrated the fly's exoskeleton before infecting the body and hijacking its brain. Once in control of the fly's movements, the fungus used its new powers of locomotion to relocate to a microclimate more suitable to its own growth — somewhere with the right temperature, light and moisture.

The fungus then bided its time until the fly died and became food for the fungus. Fruiting bodies worked their way out of the fly, filled with spores that then released into the air to continue the macabre cycle in a new unsuspecting host. It is a "conquest shaped by thousands of years of evolution," García-Roa said in an August 19 statement announcing the winning photo. — *Richard Kemeny*

R. GARCÍA-ROA

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