A Nearby Supernova's Fate | The Tale of Apes' Missing Tails

ScienceNews

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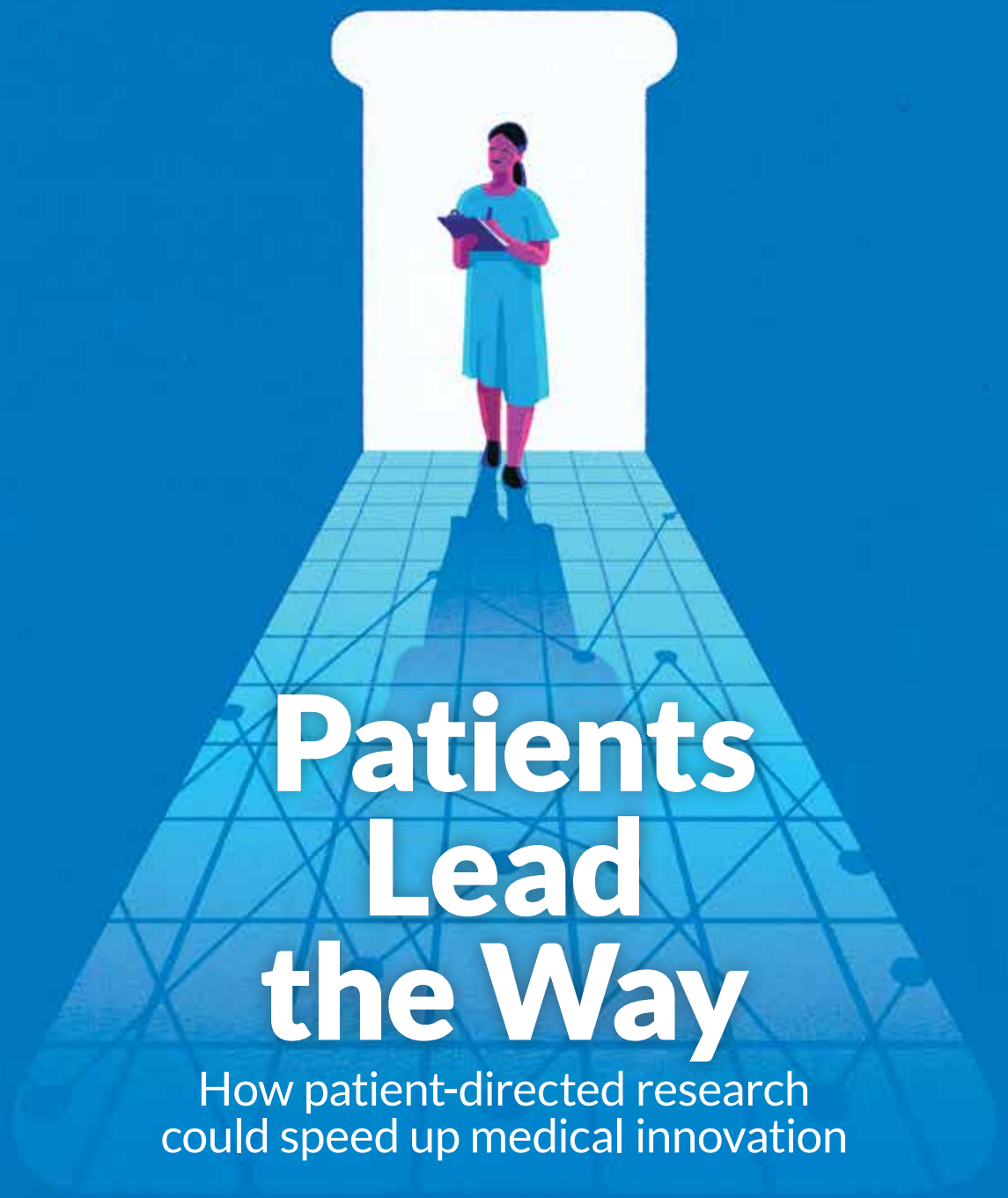

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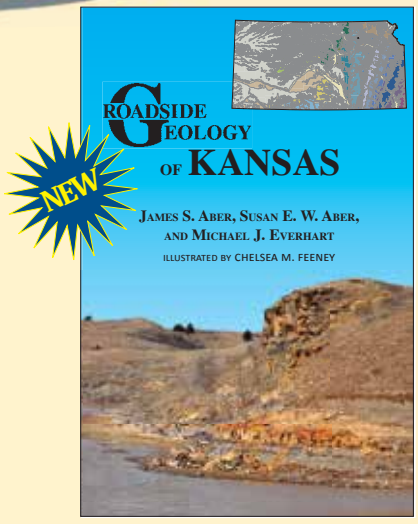

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JAMES S. ABER, SUSAN E. W. ABER, AND MICHAEL J. EVERHART
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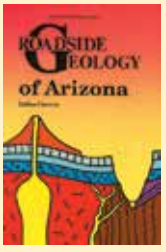

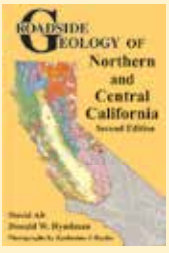

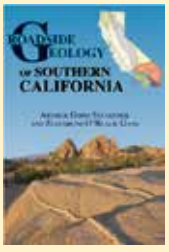

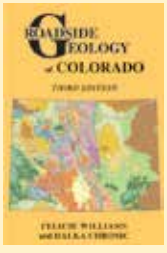

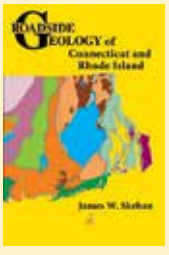

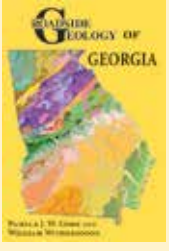

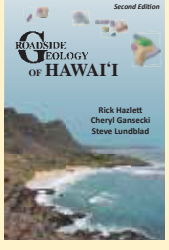

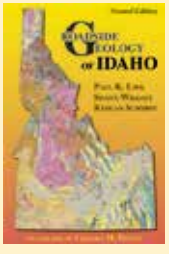

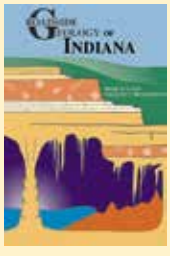

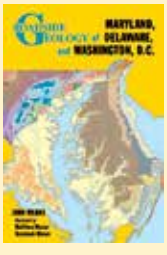

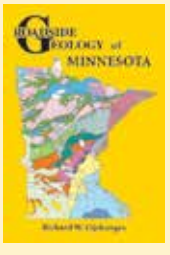

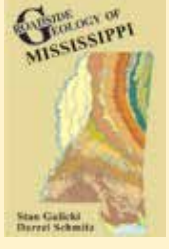

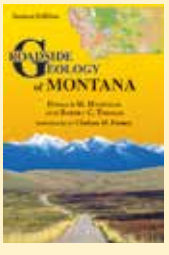

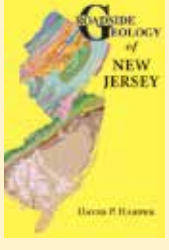

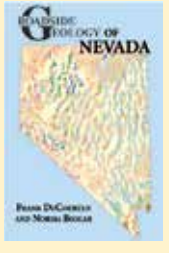

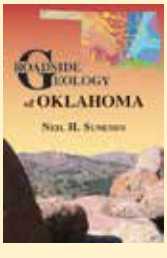

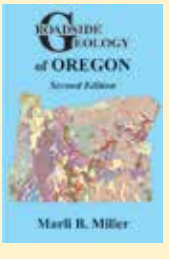

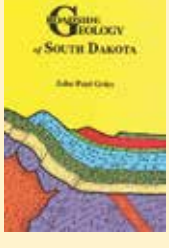

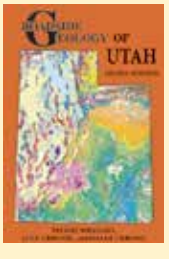

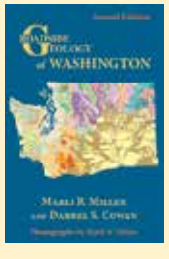

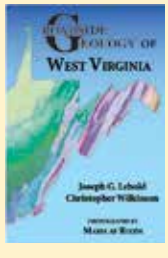

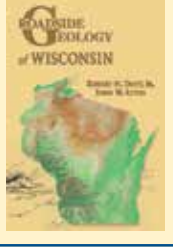

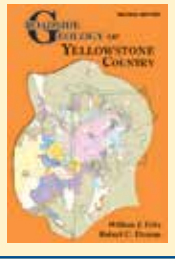

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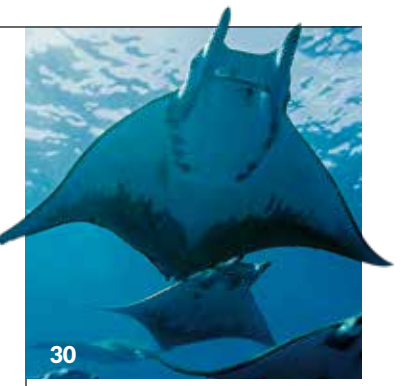
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Departments

COVER Advocates hope patient-led research becomes a routine part of conventional medical studies. *Pete Ryan*

FROM TOP: NSF; GERARD SOURY/THE IMAGE BANK/GETTY IMAGES; NASA, ESA, CSA, STSCI

How patient-led research is advancing science

About 6 in 10 adults in the United States are chronically ill with conditions including heart disease, diabetes or chronic lung disease. These are not diagnoses that anyone wants to get, but decades of research have provided a wealth of information on disease mechanisms, treatments and prevention.

But for the nearly 7 percent of U.S. adults who are currently experiencing long COVID, trying to figure out what's causing their debilitating symptoms and what treatments might help is a struggle. Long COVID was first identified in 2020 during the early months of the COVID-19 pandemic. Four years on, researchers have made progress in understanding that it's a complex syndrome. But treatments remain elusive. And some people whose lives have been derailed by long COVID have no patience for waiting on the lumbering pace of biomedical research.

It's a situation all too familiar to people with myalgic encephalomyelitis/chronic fatigue syndrome, or ME/CFS, a condition first identified decades ago. Like long COVID, ME/CFS is a complex syndrome with debilitating symptoms. And as with long COVID, treatments are lacking.

In this issue, we explore how people with long COVID or ME/CFS are advancing patient-centered medicine (Page 22). Freelance science journalist Betsy Ladyzhets introduces us to patients with these diseases who have banded together to collect data on whether taking certain supplements and antibiotics affects their symptoms. Members of the project, called Remission Biome, are advised by scientists and check in with their own doctors but work independently. These patients are focused on what's most important to them: improving their quality of life.

There's a rich history of patients pushing for scientists to speed up disease research. Perhaps the most famous example is ACT UP, founded in 1987 by members of the LGBT community enraged by the U.S. government's glacial response to HIV/AIDS, a disease that was devastating their ranks. One poster at a protest at the National Institutes of Health in 1990 read: "Red Tape Kills Us." Activist pressure changed not only the trajectory of HIV/AIDS research, but all biomedical research. Patients and patient advocates are now included in NIH advisory committees. And patients, including those with long COVID, testify in Congress on the need for more research funding and patient support.

Today, we may be at another turning point. Social media has transformed people's ability to connect with others with the same disease. The founders of Remission Biome met on Twitter (now called X). The network of people participating in Remission Biome reaches across borders and accommodates people whose debilitating symptoms would make it impossible for them to take part in a standard clinical trial.

Patient-led research isn't a panacea; the work typically doesn't include control groups and the same safety protocols that are standard in institutional research. But scientists are increasingly realizing the value in not just listening to patients, but learning from them. And patients are learning that even while in the midst of a disabling disease, they have power. —*Nancy Shute, Editor in Chief*

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Excerpt from the March 30, 1974 issue of *Science News*

50 YEARS AGO

A rock from the moon's early days

Taking its last shot at the prize, the Apollo program came through. A major goal of the scientists examining samples brought back from the lunar surface was to find a rock virtually as old as the moon itself, a relic more than 4.5 billion years old.... After five visits to the moon, the last-ditch effort, Apollo 17, finally paid off.

UPDATE: Apollo-era lunar rocks are still revealing secrets of the moon's youth. For instance, the moon's magnetic field — if it existed — lasted for the satellite's first 500 million years or so, a recent analysis suggested (*SN: 8/28/21, p. 7*). Another sample of moon rocks, collected in 2020 by China's Chang'e-5 mission, is providing new tidbits from later time periods. Those rocks suggest the moon was volcanically active for longer than previously thought, with lava flowing as recently as 2 billion years ago (*SN: 11/6/21, p. 6*). China's Chang'e-6 mission, slated to launch in May, might deliver the first rocks from the moon's farside. That material could explain why the near and far sides appear to be geologically distinct.

Bull sharks (one shown), tiger sharks and great white sharks were responsible for the 14 fatal shark bites in 2023.

SCIENCE STATS

Sharks bit fewer than 100 people in 2023

Despite the sensationalized portrayal of sharks in movies like *Jaws*, the ocean's apex predators have far more to fear from people than vice versa.

Even though millions of people around the world swim in the ocean each year, just 91 people were bitten by sharks in 2023 and only 14 of those bites were fatal, according to a new report from the Florida Museum of Natural History in Gainesville. Out of all bites, 69 were unprovoked while 22 were provoked, defined as a human-initiated interaction such as trying to touch or feed a shark. Those numbers are consistent with the five-year global average.

The fact that so few bites occur each year is "a pretty strong indication that sharks are trying to avoid us," says marine ecologist Joe Miguez of the University of Florida. If sharks thought humans were prey, there might be "thousands of shark attacks each day," he says.

In 2023, more than half of unprovoked shark bites happened in the

THE -EST

A wee frog nabs title of smallest known vertebrate

A Brazilian flea toad's head is too tiny to bear its many crowns.

Scientists have bestowed the frog — which is native to Brazil but is neither a flea nor a toad — with two titles: the world's smallest known amphibian and smallest known vertebrate overall. From snout to rump, one particularly pint-sized *Brachycephalus pulex* measured just under 6.5 millimeters, herpetologist Mirco Solé of the Universidade Estadual de Santa Cruz in Ilhéus, Brazil, and colleagues report February 7 in *Zoologica Scripta*. That's small enough to sit comfortably on a pinkie fingernail.

Brazilian flea toads are so small that one can comfortably sit on a Brazilian real coin.

The team measured this minuscule male as well as 45 *B. pulex* adults. On average, males measure 7 millimeters long and females measure 8 millimeters. The previous record holder, the male *Paedophryne amauensis* frog, averages 8 millimeters long.

Even tinier vertebrates may turn up. Anything smaller than 6 millimeters "would really challenge morphology and physics," Solé says. "But who knows."

— *Erin Garcia de Jesús*

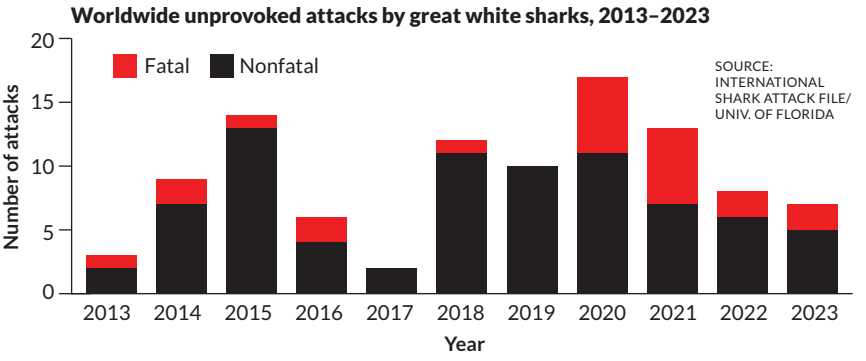
FROM TOP: STEVE HINCZYNSKI/ISTOCK/GETTY IMAGES PLUS; W.H. BOLAÑOS *ET AL/ZOOLOGICA SCRIPTA* 2024

United States, a total of 36. That's down from 41 in 2022. Following long-term trends, nearly one-quarter of all unprovoked bites globally occurred in Florida. Ample coastline, abundant prey fish and year-round human swimmers explain why the state is a shark bite hot spot.

One uptick in 2023 was unprovoked fatal attacks, at 10 — double the amount in 2022. But put in historical perspective, shark bite fatalities are actually decreasing, on average, as people respond more quickly and effectively to treat bite wounds, says shark biologist Neil Hammerschlag of Atlantic Shark Expeditions in Boutiliers Point, Canada.

"These fatalities usually aren't a result of a shark eating someone. It's a result of blood loss," Hammerschlag says. Sharks use their teeth much like humans use their hands, he says, as sensory structures to test the environment.

Of the nearly 550 known shark species, three caused fatalities in 2023: great white sharks (*Carcharodon carcharias*), bull sharks (*Carcharhinus leucas*) and tiger sharks (*Galeocerdo cuvier*).



A bite of data Unprovoked attacks on humans by great white sharks are rare and tend to be nonfatal (black). An uptick in fatal attacks (red) in recent years probably resulted from great white shark populations increasing in coastal areas where tourism is also on the rise.

Great whites were responsible for four of the 14 fatalities last year. This is probably because white shark populations are growing in areas where seals, a main food source, are becoming more abundant, says Gavin Naylor, program director of the University of Florida's International Shark Attack File.

> The intent of compiling shark bite data is to protect people from sharks and to help these keystone predators thrive.

Seal colonies are often found near surf breaks, which also attract surfers. "It's likely that these bites from white sharks might be a little bit more commonplace" as more people surf and shark populations continue to grow, Naylor says.

The intent of compiling shark bite data is to protect people from sharks and to help these keystone predators thrive, he says. Populations of oceanic sharks have plummeted by more than 70 percent globally over the last half century primarily due to increased fishing, which has depleted their food sources.

The odds of being bitten by a shark are incredibly slim. Still, Naylor offers simple advice for avoiding bites: "Don't swim alone. Don't swim too far from shore. Don't swim at dawn or dusk."

— Brianna Randall

TEASER

New rice hybrid packs cow protein

Foodies of the future may dine on beefed-up rice.

A new lab-grown meat product merges rice grains with cow cells, scientists report February 14 in *Matter*. The rice acts as a scaffold that supports the growth of fat or muscle cells. Together, the ingredients form a rice-meat hybrid that steams up to a pinkish-brown mash.

It tasted delicious, "nutty and a little sweet," says Sohyeon Park, a chemical engineer at Yonsei University in Seoul, South Korea. Lab-made beefy rice isn't ready for the dinner table yet, she says, but it could one day offer a more sustainable way to eat meat.

Current methods for producing beef include farming cattle, which requires vast expanses of pastureland and emits over 100 million metric tons of the potent greenhouse gas methane into the atmosphere each year. Finding ways to eschew the moo may be better for the environment, scientists suggest. Some potential alternatives include farming crickets and eating fungi instead (SN: 6/18/22, p. 5).

Lab-grown meat is another way to cut the cow (mostly) out of the equation. In the lab, Park and colleagues coated rice grains with fish gelatin and enzymes and then added cow cells to each grain. The fishy coating helped the cells stick to and grow inside the grains. And rice offers a 3-D structure for cells to cling to, like vines climbing a trellis. That structure gives the cultured cells a more meatlike heft, Park says. On their own, the cells typically grow in thin, flat layers.

Nutritionally, the hybrid rice is more sizzle than steak. It has about 3.9 grams of protein per 100 grams of rice. Conventional rice has 3.6 grams. Park hopes to boost that number by packing more cow cells into each grain. Besides working well as a scaffold, she says, rice is inexpensive, nutritious and popular — a grade-A ingredient.

— Meghan Rosen

It may look like a bowl of chopped brains, but this pinkish product is actually a rice-meat hybrid.

FROM TOP: ADAPTED BY C. CHANG; YONSEI UNIV.

ASTRONOMY

Telescope spies on supernova's heart

Famous explosion left behind a neutron star, infrared data hint

BY ADAM MANN

Within the dusty cloud left behind by supernova 1987A, the most famous stellar explosion in modern history, astronomers have found compelling evidence for a long-sought neutron star.

NASA's James Webb Space Telescope has spied indirect hints of a powerful source of light—probably a type of neutron star—coming from the core of the supernova remnant, researchers report in the Feb. 23 *Science*. The finding could provide insights into how a neutron star behaves mere decades after its birth.

"Supernova 1987A is truly a unique laboratory to study supernovas," astrophysicist Patrick Kavanagh of Maynooth University in Ireland said February 17 in a news conference in Denver at a meeting of the American Association for the Advancement of Science. It's "the gift that keeps on giving, with new observations continually yielding new discoveries."

On February 23, 1987, telescopes around the world got a front-row seat to a spectacular supernova in the Large Magellanic Cloud, a companion galaxy to the Milky Way (SN: 2/18/17, p. 20). Such explosions occur when a star at least eight times the mass of the sun dies. Located just 160,000 light-years from Earth, supernova 1987A, as it came to be known, was visible with the naked eye for months afterward. The explosion generated tremendous amounts of neutrinos, a handful of which ended up hitting detectors on Earth. It was the first time the ghostly particles had been seen coming from beyond the solar system.

Since the discovery of 1987A, scientists have wondered what happened to the iron core of the blue supergiant star that exploded. Did it collapse into an ultradense neutron star or a black hole? The fact that neutrinos escaped the event favors the neutron star possibility, but whatever was left behind has yet to be directly spotted. That's partly because the original star's outer layers, now traveling away from the explosion at 10,000 kilometers per second, have created a thick haze of dust that obscures the area.

In this composite false-color image, rings of gas and dust surround the remnant of supernova 1987A. The blue region is where the James Webb Space Telescope detected ions around a purported neutron star.

Infrared light travels through dust more easily than other wavelengths, so the infrared eyes of the James Webb Space Telescope, or JWST, are well suited to peering into the cloud surrounding 1987A. With JWST, Kavanagh and colleagues detected photons, or particles of light, in the dusty central region that indicate the presence of argon and sulfur. Tellingly, these elements had been ionized, meaning that some of their electrons had been stripped away.

"You need a source of high-energy photons in order to create these ions," says coauthor Claes Fransson, an astronomer at Stockholm University. "The question is: What is giving rise to this ionization?"

The team suggests two possibilities. Supernova 1987A could have left behind a pulsar, a highly magnetized neutron star that generates powerful beams of radiation. Alternatively, the photons could come from an ordinary neutron star whose surface blazes at a million degrees Celsius.

"This is some of the strongest indirect evidence suggesting the presence of a neutron star," says Aravind Pazhayath Ravi, an astrophysicist at the University of California, Davis. Taken together with data gathered by other instruments including the Atacama Large Millimeter/submillimeter Array in Chile, the new observations make the possibility of a black hole even more unlikely.

Directly detecting the young neutron star would enable researchers to compare it with older ones elsewhere in the cosmos, providing more insight into the interior structure of such exotic objects. But first, the clouds surrounding 1987A's remnant will have to thin out more, which is expected in roughly the next decade, Ravi says. When that happens, "we'll have the photograph of the youngest ever observed neutron star." ■

HUBBLE SPACE TELESCOPE, NIRSPEC/JAMES WEBB SPACE TELESCOPE, JOSEFIN LARSSON

ASTRONOMY

Early galaxies may be deceptively light

Conventional physics can explain odd observations, scientists say

BY ADAM MANN

Reports that the James Webb Space Telescope broke the universe may have been exaggerated.

In its first images, JWST captured what appeared to be gargantuan galaxies in the early universe — ones too big to be explained by current cosmological theories (*SN: 3/25/23, p. 14*). But a new analysis of data from the Hubble Space Telescope suggests that the alleged behemoths may have more prosaic explanations that fit with the standard understanding of the universe, a team led by cosmologist Julian Muñoz of the University of Texas at Austin reports in the Feb. 9 *Physical Review Letters*.

"James Webb is giving us a new dictionary to translate the language of the early universe," Muñoz says. But "before we say, 'Hey, we need to throw away everything we knew in cosmology,' we should understand this language."

The trouble began almost as soon as JWST first pointed its eyes at the distant universe. Some of its initial images contain far more galaxies than astronomers expected. A handful of the galaxies appeared incredibly bright, suggesting they were up to 100 times as heavy as theories had predicted. These galaxies were dubbed "universe breakers" because they flew in the face of scientists' assumptions about cosmic evolution (*SN: 8/12/23, p. 18*).

The problem with the observations has to do with dark matter. Under the standard model of cosmology, dark matter formed clumps known as halos within a few hundred million years after the Big Bang. These halos gravitationally attracted ordinary matter and eventually formed stars and galaxies. The standard model predicts the existence of far fewer dark matter halos than could account for the vast number of big galaxies that JWST spotted in the early universe.

But, Muñoz says, perhaps scientists simply need to be more careful when interpreting what they've been seeing.

He and colleagues used existing Hubble data to gut check JWST's results. Though the older telescope can't see quite as far back in time as its successor, both instruments can capture light from galaxies between 450 million and 750 million years after the Big Bang. JWST sees these galaxies in infrared wavelengths, whereas Hubble can snag their ultraviolet light.

"If there were 10 times more dark matter structures [than expected], there would be 10 times more galaxies in James Webb, but there would also be 10 times more galaxies in Hubble," Muñoz says.

The team tallied how many galaxies Hubble saw across a range of brightnesses and calculated how different populations of dark matter halos in the early universe would have altered that census. Any change in the number of halos big enough to match JWST's observations sharply contrasts with Hubble's data, the team found.

JWST can see more galaxies than Hubble can in a given epoch, but Hubble has been staring at the universe for longer. That means Hubble's data are more representative of what's out there, Muñoz argues, so scientists should look for conventional explanations rooted in physics.

Perhaps the environment in the early universe allowed for higher rates of star formation than expected, which would have created the unusually bright galaxies JWST saw. Star formation might have also been more episodic, with large numbers of supernovas going off every now and then. In that case, JWST would have captured some galaxies at moments of intense brightness that made them look weightier than they actually are.

It's also possible that feasting supermassive black holes in these galaxies contributed to some of the light JWST captured, which would mean the galaxies aren't quite as massive as presumed.

JWST is observing the universe breakers to confirm their early ages. "If even one — especially one of the really massive ones — is there, it is a problem," says astrophysicist Erica Nelson of the University of Colorado Boulder.

As scientists become familiar with JWST's views of the early universe, they will learn how to better understand what they're seeing. "We're doing this translation in a land where we don't speak the language," Muñoz says. "But you never know if your language skills are good enough." ■

In this image from the James Webb Space Telescope, some early galaxies (reddish and bluish blobs) look too bright and thus too big to be explained by the standard model of cosmology.

NASA, ESA, CSA, STScI

GENETICS

How apes may have lost their tails

A 'jumping gene' unique to the primates cut off tails in mice

Apes including chimpanzees (shown) and humans may lack tails because of a genetic parasite. New research suggests that the parasite, known as a transposon, inserted itself into a gene important for tail development when apes and monkeys diverged from a common ancestor.

BY ERIN GARCIA DE JESÚS

A genetic parasite may have robbed apes — including humans — of their tails.

About 25 million years ago, this parasite, a small stretch of repetitive DNA called an Alu element, ended up in a gene important for tail development, scientists report in the Feb. 29 *Nature*. The single insertion altered the gene *Tbxt* in a way that seems to have sparked one of the defining differences between monkeys and apes: Monkeys have tails, apes don't.

"It was like lightning struck once," and ape behinds ultimately became bare, says geneticist Jef Boeke of New York University Langone Health.

The tweak may also hint at why some people are born with spinal cord defects, such as spina bifida — when the tube that holds the cord doesn't close all the way.

Alu elements are part of a group of genetic parasites known as transposons, or "jumping genes." These genes can hop across an individual's genetic instruction book, inserting themselves into new spots in their host's DNA. When a jumping gene slips itself into a piece of host DNA that is passed from parent to offspring, the insertion becomes a permanent part of the host genome.

Over 1 million Alu elements are found throughout the human genome, says geneticist Bo Xia of the Broad Institute of MIT and Harvard. Researchers once thought of them and other transposons as genetic waste, but some have played key roles in evolution. Without transposons, the placenta, the immune system and the insulation around nerves may not exist (SN: 3/9/24, p. 6). And humans might still have tails.

To find out how apes lost their tails, Xia, Boeke and colleagues analyzed 140 genes involved in vertebrate tail development. The *Tbxt* gene stood out: All apes have a unique Alu element in this gene that other primates do not. It was a "eureka moment," Boeke says. The insertion may have appeared about 25 million years ago when apes and Asian and African monkeys diverged from their last common ancestor.

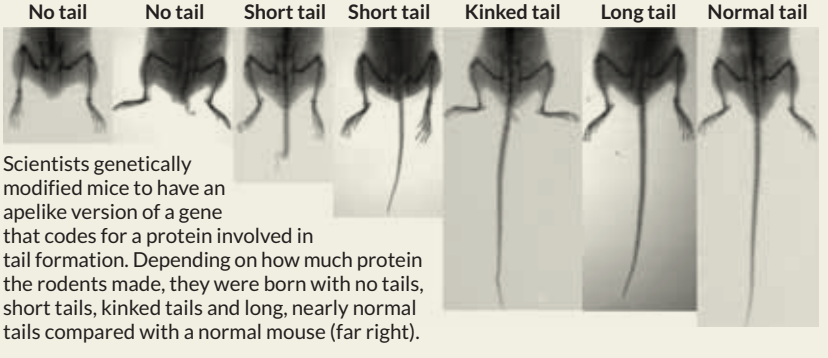
But the Alu element is located in an intron, a portion of a gene that doesn't code for protein. "So why would that even matter?" Boeke asks. A closer look at *Tbxt*'s genetic structure provided an explanation. The ape-specific genetic parasite sticks to a different Alu element that's found in both apes and monkeys, which tweaks *Tbxt* in a way that results in a shortened protein.

Experiments in mice support the hypothesis. Mice genetically engineered to have one apelike *Tbxt* were born with shorter tails or none at all. Some of the rodents also had spinal cord defects similar to spina bifida, suggesting that tail loss may have drawbacks. (Mice with two apelike versions of the gene did not survive.)

Other genes may also be involved in tail loss. Many more Alu elements scattered among human introns could have had effects on other aspects of human evolution, the team says.

While the study begins to unravel how apes lost their tails, why it may have been advantageous is still unclear, says biological anthropologist Gabrielle Russo of Stony Brook University in New York. Research from the early 1900s linked tail loss to muscle changes that helped humans stand upright. But other apes don't walk upright, and humans' shift to two feet came millions of years after the Alu element insertion (SN: 9/25/21, p. 20). So, it's unlikely the new findings will shed light on these human traits, she says.

A next step, Russo says, is to explore whether the genetics of tail loss in apes also happened in other animals with short or no tails, such as koalas and bears. ■



Scientists genetically modified mice to have an apelike version of a gene that codes for a protein involved in tail formation. Depending on how much protein the rodents made, they were born with no tails, short tails, kinked tails and long, nearly normal tails compared with a normal mouse (far right).

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Metabolism wrenches developing guts

Experiments in tadpoles provide clues to intestinal malrotation

BY HELEN BRADSHAW

Inside the African clawed frog, intestines grow like those of humans: neatly coiled counterclockwise. Experiments now show how that process can go awry.

Interfering with tadpoles' metabolism leads to a chain of cellular disruptions that causes intestines to grow in the opposite direction, scientists report in the February *Development*. The finding offers new insight into how a similar birth anomaly known as intestinal malrotation may occur.

"Anything that illuminates how we could protect the embryo and the fetus early in development and prevent any type of congenital abnormalities is to me fascinating, and it's exciting," says Mehul Raval, a pediatric surgeon at Ann & Robert H. Lurie Children's Hospital of Chicago who was not involved in the research.

Intestinal malrotation occurs in as many as 1 in 500 babies in the United States. But because the condition can go undetected for a long time, it's possible there are even more cases, Raval says. It's most often detected when the gut gets so twisted it leads to obstructions or blocks blood flow — complications that are treated with surgery.

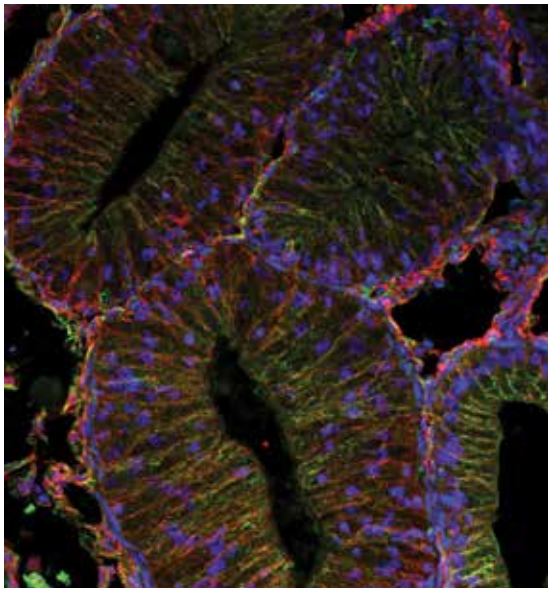
"Think of the intestine as a garden hose," says developmental biologist Nanette Nascone-Yoder of North Carolina State University in Raleigh. "You have to pay careful attention as you wind it up to avoid kinks and knots."

Malrotation can happen alongside other anomalies, but there is no known cause, says pediatric surgeon Janice Taylor of the University of Florida in Gainesville, who was not involved in the research.

Nascone-Yoder and colleagues turned to frog embryos because their intestines are long and looping, like those in humans. Plus, the embryos develop outside of mom's body and are transparent, so growth is easy to monitor.

In frogs — and in people — the intestine typically winds counterclockwise as it develops. This happens early in a tadpole's development, roughly between the third and fourth day. The researchers exposed *Xenopus laevis* embryos to atrazine, a common herbicide and known hormone disruptor in humans, both before and during this stage of development. They found that many of the frogs' intestines coiled clockwise — the wrong direction.

Further tests revealed that atrazine disrupted the metabolism of the tadpoles, creating a domino effect that prevented the complete conversion of glucose to energy. "We can infer that [this reaction] inhibits the ability of cells to arrange in the developing intestine," Nascone-Yoder says. In addition to coiling clockwise, the tadpoles' intestines were too stunted to fill the space they ordinarily would.



Exposure to the herbicide atrazine disrupted the metabolism of tadpoles, which made their intestines coil clockwise, as shown in this colorized microscope image.

In tadpoles, intestines typically coil counterclockwise, just as they do in humans.

BOTH: JULIA GRZYMKOWSKI

The study doesn't mean atrazine causes intestinal malrotation in humans. In fact, the team exposed tadpoles to atrazine levels that were 1,000 times as high as what's normally found in the environment. But the finding does hint that metabolic disruption plays a role. "It's possible that either an environmental [effect] or some sort of genetic defect, like an inborn error of metabolism, for example, could subtly affect the lengthening of the GI tract in humans as well," Nascone-Yoder says.

Tadpoles exposed to atrazine also had increased levels of oxygen molecules called free radicals. In excess, free radicals can harm processes that help grow intestines. But they can be combated with antioxidants. More than half of tadpoles that were given antioxidants before atrazine developed normal, healthy intestines.

While the study doesn't reveal what causes intestinal malrotation in humans or if antioxidants can prevent the condition, it does "open up new avenues to look at," Nascone-Yoder says. "Prior to this, there really [wasn't] a whole lot of explanation." ■

Toxins in the venom of black mambas (one shown) and other snakes can paralyze snakebite victims. A lab-made protein that targets the toxins may be a step toward a universal antivenom.

HEALTH & MEDICINE

Lab-made protein foils snake toxins

The synthetic antibody saved mice from paralyzing venom

BY MEGHAN ROSEN

The antivenom for a black mamba's bite could one day work for a slew of other snakes.

Scientists have developed an antibody that shuts down paralyzing toxins in the venom of black mambas, king cobras and dozens of other sharp-toothed serpents. The antibody — a single protein manufactured in the lab — protected mice from otherwise lethal doses of venom, protein engineer Joseph Jardine and colleagues report in the Feb. 21 *Science Translational Medicine*.

That antibody "will be a critical component of an eventual antivenom," says Jardine, of the Scripps Research Institute in La Jolla, Calif.

Across snakes, venoms come from just a handful of toxin families. If scientists could mix together antibodies targeting each of those types, the result might be "one vial of antivenom that works against any snake in the world," Jardine says. Such a universal antivenom might still be many years away. But "theoretically, this is possible," he says.

Scientists have tallied hundreds of venomous snake species across the globe. In North America, a person might stumble upon a western diamondback rattlesnake; in Africa, a puff adder; in South Asia, a saw-scaled viper. A bite from any one of these snakes can maim or kill. Venomous snakebites kill up to about 140,000 people each year, according to the World Health Organization.

Lifesaving antivenoms exist, but they are "built with 100-year-old technology," Jardine says.

That technology involves injecting animals like horses or sheep with snake venom and harvesting the venom-targeting antibodies that their immune systems churn out. A snakebit patient would then get an infusion of horse or sheep antibodies — if doctors have them in stock.

The process has major drawbacks, Jardine says. Each animal produces antibodies for just the one type of venom injected. Currently, bites from a yellow-bellied sea snake, cottonmouth or inland taipan would all require different treatments. Another issue is the health effects of the antivenom itself. "You're putting a whole bunch of horse antibodies into a person," Jardine says. People can get sick or even go into anaphylactic shock.

A researcher in eastern India "milks" an Indian spitting cobra for its venom. In experiments in mice, treatment with a synthetic antibody protected against the venom.

His team's approach could glide past those problems. In a collection of more than 60 billion lab-made antibodies, the team hunted for ones that target a particularly vicious venom component in some snakes: long-chain three-finger alpha-neurotoxins.

These molecules look like a small hand with three fingers, says biotechnologist Andreas H. Laustsen-Kiel of the Technical University of Denmark in Kongens Lyngby. When delivered into a person's bloodstream via a snakebite, the hand literally gives victims the finger. The toxin's middle finger pokes into a protein needed for movement, shutting down muscles and paralyzing the body.

Antibodies that grasp the finger can block its toxic touch, Laustsen-Kiel says. Last year, his group reported several new antibodies, including a human antibody that neutralizes three-finger toxins like the one in Jardine and colleagues' study. But their antibody "looks like it's even better than ours," Laustsen-Kiel says. It appears to grab a wider array of toxins and with a tighter grip, he says.

In mice given venom from a black mamba and an Indian spitting cobra, injecting the antibody saved the rodents' lives, Jardine's team reports. The scientists are now working to develop antibodies that target other venom toxins.

Still, the idea of creating a single, universal antivenom may not be realistic, Laustsen-Kiel says. "It simply doesn't make sense from a product perspective," he says. Instead, Laustsen-Kiel envisions antivenoms that are tailored for use in specific regions of the world.

Whatever the formulation of these future antivenoms, research on snakebites (*SN: 9/26/20, p. 16*) — considered a neglected tropical disease — is underfunded, Jardine says. Though millions of cases occur in hard-hit places such as rural India and Africa, there is relatively little money available for improving treatments, he says. (Jardine has funding from the Wellcome Trust, a global health charity headquartered in London.) But for anyone who encounters venomous snakes, losing life or limb to a bite is devastating. ■

FROM TOP: SUEBG1 PHOTOGRAPHY/MOMENT/GETTY IMAGES PLUS; KARTIK SUNAGAR

Why is syphilis making a comeback?

U.S. cases are soaring, especially among mothers and newborns

BY AIMEE CUNNINGHAM

Once on the path to eliminating syphilis, the United States has reversed course, with cases of the sexually transmitted infection surging.

From a low of under 32,000 cases in 2000, the number of people with syphilis has rocketed to more than 207,000 in 2022, the U.S. Centers for Disease Control and Prevention reported in January. That's 62 cases per 100,000 people.

The crisis is hitting pregnant people and babies especially hard. The maternal rate for syphilis during pregnancy rose from 87 per 100,000 live births in 2016 to 280 per 100,000 live births in 2022, the CDC reported February 13. Without treatment, a pregnant person can pass syphilis to the fetus. That can cause congenital syphilis, miscarriage, stillbirth, premature birth, severe health problems after birth or the infant's death. More than 3,700 babies were born with syphilis in 2022, roughly 10 times the number in 2012.

Testing is a crucial step in finding cases. Syphilis is "the great pretender," says infectious disease clinician Allison Agwu of Johns Hopkins School of Medicine. "It can look like a bunch of other things." The disease moves through several stages, at times featuring symptoms common to other conditions and at other times having no symptoms. People can get tested by primary care providers or at urgent care facilities or public health clinics. With infection rates so high, "if you have been sexually active ever, you should have a syphilis test," she says.

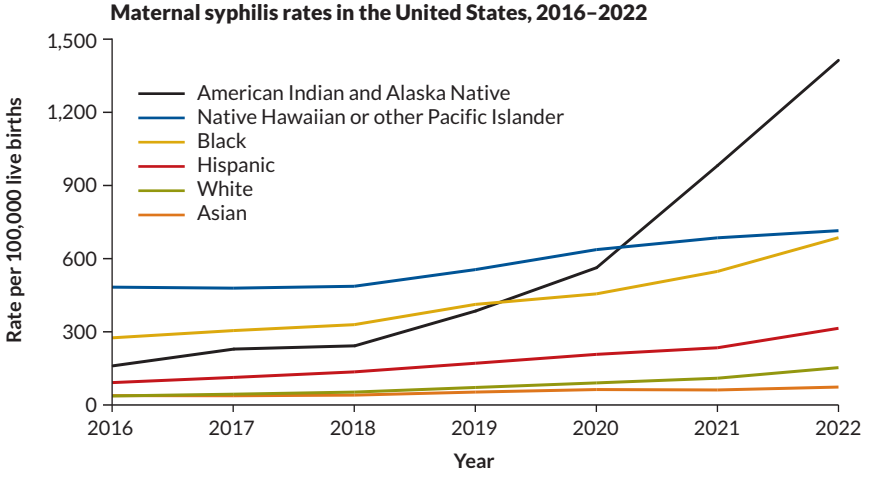
Agwu talked to *Science News* about the surge in cases and what can be done better to prevent infection. The conversation has been edited for length and clarity.

What's behind the rise in cases?

It's multifactorial. Syphilis is oftentimes asymptomatic, so people can have it for years and not know they have it. We have a whole public health infrastructure imploding with decreased access and funding. The impact is magnified in communities that have the least access to begin with and that are relying on those clinics or places that funding is being pulled from. There is stigma. There have been medicine shortages.

The infrastructure [built] to control syphilis — almost eliminating the disease a few decades ago — has really collapsed. We're at this perfect storm for increases in syphilis and, as a result, congenital syphilis.

Rising rates The maternal syphilis rate, defined as the number of live births to women with syphilis per 100,000 live births, increased for all groups in the United States from 2016 to 2022. The biggest jump occurred among American Indians and Alaska Natives. SOURCE: CDC



C. CROCKETT

Where are there gaps in testing?

I've been in the infectious disease field for a long time. We've had the 80-year-old woman who comes in and she's confused or disoriented. That's neurosyphilis [a complication of syphilis that impacts the brain and nervous system] from never being treated for a syphilis infection. We all should be thinking about syphilis, particularly with the rates that we're seeing. Health care providers should just test people.

There's testing in early pregnancy. If someone is diagnosed with syphilis, they should be treated in pregnancy. This is one of the times you absolutely need to treat them to avert transmission to the baby. Part of the challenge with syphilis in pregnancy — actually, all sexually transmitted infections in pregnancy — is that oftentimes there are people that society thinks of as sexual beings and those that we do not. I've talked to pregnant women who say, "I got my testing, but there was not a conversation about how I can stay negative." So the counseling around staying negative, I think we may miss that.

We certainly have had scenarios where the baby comes, and the mom or the birthing parent has had no prenatal care. [In that case] we're testing at delivery.

What needs to happen to bring syphilis cases back down?

It's education, and not in a way to scare people, but just: This is what you can have and the different ways you can get it, and here's how you can test for it, here's where you can test for it.

We need to normalize sexuality and sexual exploration and not vilify it. We need to destigmatize the diagnosis so people are more likely to then tell their partners, so their partners can also get tested and treated.

COVID-19 really highlighted the problems we were having with our public health infrastructure. We need to think about how we can effectively provide sexual health care and give testing, prevention and treatment all in a way that is packaged in a positive light. Take it out of the dark. ■

Hurricane Florence gained new intensity as it swept over waterlogged soils in the Carolinas in 2018. The resulting rainfall broke records, and bloated rivers continued flooding towns such as Conway, S.C., (shown) two weeks after the storm had passed.

CLIMATE

Wet soils give hurricanes new life

Moisture helps storms last longer and travel farther inland

BY CAROLYN GRAMLING

BALTIMORE — Once a hurricane makes landfall, it's usually the beginning of the end for the storm. But passing over warm, waterlogged ground can give the storm a jolt of energy that refuels its fury, scientists reported in January at the American Meteorological Society annual meeting.

This phenomenon, called the brown ocean effect, mimics how the ocean fuels tropical cyclones by giving the storms a ready supply of water and heat. Understanding the effect, scientists say, could help forecasters warn residents that an inland tropical storm might get stronger.

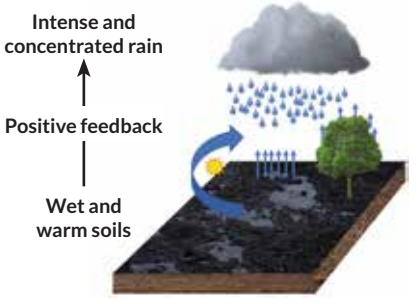
Using satellite measurements of wind speeds, rainfall and soil moisture, geologist Dev Niyogi of the University of Texas at Austin and colleagues examined whether the brown ocean effect was at play for Hurricane Florence, a relatively weak storm when it made landfall in the Carolinas in 2018. The data revealed a powerful feedback mechanism: As Florence passed over already-soaking soil, the storm's rains intensified, leading to record-breaking rainfall and flooding.

The finding, Niyogi says, is one of the first observational confirmations of this long-hypothesized phenomenon. The effect also can help storms stay strong longer as they travel over land, thus allowing them to travel farther inland before dissipating (*SN: 12/5/20, p. 14*).

Researchers Marshall Shepherd and Theresa Andersen described the brown ocean effect a decade ago, in part due to the strange evolution of Tropical Storm Erin in 2007. Weak and disorganized when it made landfall in Texas, the storm suddenly strengthened and even formed an eye as it drifted over ground that had been flooded by heavy rains.

Computer simulations have long suggested that very wet soils can intensify monsoon rains and cyclones. "Water evaporates from the ocean as water vapor, but when it gets into hurricanes, it condenses," says Shepherd, an atmospheric scientist at the University of Georgia in Athens. As the water vapor changes from gas to liquid, it releases a jolt of storm-strengthening energy in the form of heat.

Andersen, now at the University of Colorado Boulder, identified more than a dozen other storms between 1979 and 2008 that were probably strengthened post-landfall by the brown ocean effect. There's now a growing body of scientific studies hunting for the fingerprints of this effect in specific storms, Shepherd says.



Soil-fueled cyclones Humidity from warm, wet soil and trees injects energy into hurricanes and tropical storms as they travel over land, resulting in intense bursts of rainfall. This phenomenon, dubbed the brown ocean effect, has now been confirmed with observations.

In the new study, Niyogi and colleagues used high-resolution satellite data on soil moisture, temperature and changes in rainfall before, during and after Hurricane Florence arrived on land. As the storm system moved, "you could trace the source of moisture, see rainfall maxima," Niyogi says.

The data revealed a powerful positive feedback between bursts of intense rain and soil moisture. How long the soils were wet before the storm passed over them also made a difference, as did higher soil temperatures, the team found.

The heaviest rains occurred over soil that had already been saturated for about three days. That's about how long soil evaporation helped keep the atmosphere just above the ground humid — an ideal condition for feeding energy to a storm. The team also reported the findings in 2023 in *Geophysical Research Letters*.

Shepherd coauthored a separate study, also presented at the January meeting, that detailed how the brown ocean effect contributed to flash floods in Texas during Tropical Storm Bill in 2015.

Among the most striking recent cases came in 2021, when Hurricane Ida roared ashore in Louisiana, at almost the same location as 2005's Hurricane Katrina. But Ida lingered over land for longer, probably because rain had soaked the ground and increased humidity ahead of Ida's arrival, scientists reported in 2022 in the *Bulletin of the American Meteorological Society*.

These data show that "the brown ocean effect exists, if you look for it," Niyogi says.

Weather models need to incorporate the influence of land, which is important for forecasting the danger these storms might pose to inland residents, Shepherd says. "If a storm moves inland, the model needs to capture that there's wet soil there." ■

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ANIMALS

Cedars threaten Galápagos tortoises

Invasive trees are closing in on the reptiles' migration routes

BY JAKE BUEHLER

After trudging upslope for weeks, a giant tortoise slows to a stop. Dense woods defended by blackberry brambles block its path. After a brief foray into the painful prickles, the tortoise backs out and plods on, searching for a way through the woods.

Spanish cedar trees (*Cedrela odorata*) and blackberries (*Rubus niveus*) have become invasive to the tortoise's island home since the plants were introduced in the Galápagos in the 1950s and '60s. If they can, the titanic turtles avoid the troublesome woods on their seasonal treks to find food, scientists report in the February *Ecology and Evolution*. But if *Cedrela* one day manages to block the reptile's migration altogether, the consequences for the tortoises and the island ecosystem could be dire, the scientists say.

A giant tortoise follows a trail lined by Spanish cedar seedlings on Santa Cruz Island. Migrating tortoises typically avoid paths that take them through patches of the invasive trees.

Wildlife biologist Stephen Blake of Saint Louis University and colleagues have been studying the movements of Western Santa Cruz tortoises (*Chelonoidis niger porteri*) since 2009. Tracking the reptiles' positions with GPS tags previously revealed that tortoises migrate to and from Santa Cruz Island's highlands between July and November, during the dry season. The travelers lumber as much as 400 meters above sea level to feed on vegetation that flourishes under a moist cloud bank.

Years into the tracking project, Blake noticed that the critically endangered reptiles' migration corridors appeared to line up with gaps in the Spanish cedar forests. The next logical question: Were the invasive trees a problem for the tortoises?

Using about 10 years of migration data from 25 tagged adult tortoises, Blake's team overlaid 140 migration routes atop a map of the island's Spanish cedar forests. Most of the tortoises funneled between *Cedrela* stands through small gaps, some of which range from about 140 meters to a kilometer wide. This is fairly slim considering that a few thousand tortoises might converge on these strips. Only three tortoises trekked through cedar stands. Five tortoises consistently stopped their migration either just inside of a forest or at its blackberry border.

"We've seen a few tortoises sort of bludgeon their way in through these thick patches of blackberry and can't move," Blake says. Some turn around and walk back out. For those that make it through, the cedar forest interior is well shaded, which makes it hard for the tortoises to stay warm, Blake and colleagues suspect. There's also little food in the forests.

Whether the gaps between cedar patches could someday be closed by

ENVIRONMENT

Nocturnal nitrate erases floral cues

Air pollution buildup strips aromas of their pollinator lures

BY SAUGAT BOLAKHE

Air pollution may blunt the signature scents of some night-blooming flowers, jeopardizing pollination.

When the aroma of a pale evening primrose encounters certain pollutants in the night air, the pollutants destroy key scent molecules, lab and field tests show. As a result, moths and other nocturnal pollinators may find it difficult to detect the fragrance and navigate to the flower, researchers report in the Feb. 9 *Science*.

The finding highlights how air pollution can affect more than human health (SN: 1/14/23, p. 8). "It's really going deeper … affecting ecosystems and food security," says atmospheric scientist Joel Thornton of the University of Washington in Seattle.

Increasing industrialization has pumped ozone, nitrogen oxides and other pollutants into the air. Sunlight typically breaks down ozone. But at night, the pollutant accumulates and reacts with nitrogen dioxide to produce nitrate radicals. These reactive molecules can affect plant fragrances, research has suggested, but the details weren't clear.

Thornton and colleagues collected scent molecules from a pale evening primrose (*Oenothera pallida*) and released the fragrance into a wind tunnel containing hawk moths. The scientists could see the moths "easily flying upwind and tracking the odor," says biologist Jeff Riffell of the University of Washington.

But it was a different story when the researchers added ozone and nitrogen dioxide to the mix. Hawk moths flew in zigzag patterns, searching fruitlessly for scent cues.

Exposing hawk moth antennae to each of the molecules in the fragrance pinpointed the primary cues that the moths use to find flowers: two types of aromatic compounds called monoterpenes. Molecular analysis revealed that the compounds break into pieces when they encounter nitrate radicals, stripping the primrose of most of its aroma.

"It was surprising [that] a seemingly subtle change in concentration of only two compounds — out of more than 20 — was sufficient to eliminate the flower's attractiveness," Riffell says.

The effect is akin to putting a blindfold on someone and then asking them to go fetch a cup of coffee, says Jose Fuentes, an atmospheric scientist at Penn State who was not involved in the research.

To test the findings in nature, ecologist

S. BLAKE

the trees' spread is still unknown. But if migration routes are choked off, the tortoises might be forced to eat a subpar diet, which could hurt their growth, health and reproduction, Blake says. And because the tortoises spread seeds, turn up soil, bulldoze vegetation and create microhabitats wherever they shamble, travel disruptions might have broader ecosystem effects.

Plant invasions can have major impacts on animal behavior, says ecologist Peter Stewart of the University of Stirling in Scotland. They can alter "the ways that animals communicate, where they build their nests and lay their eggs, how they hunt for prey or avoid their own predators, and more," he says. "These behavioral changes can have some quite profound consequences for the animal species, as well as for the wider ecosystem."

Countering the *Cedrela* invasion is a thorny task. Eradicating the trees, which grow throughout the Galápagos, could allow blackberry brambles to take over and create new problems, Blake says. The trees' timber also has become important to local economies. More research on where and how fast the cedars are spreading, and if they can be removed, is crucial. ■

Jeremy Chan, now at the University of Naples Federico II in Italy, planted a field of real and faux primroses about 280 kilometers east of Seattle. Some of the fakes emitted lab-made primrose fragrance, while others released the fragrance as well as chemicals that react in the air to make nitrate radicals. Cameras recorded the number of times moths visited the experimental buds.

Moths visited real and fake primroses that emitted unsullied scent an average of two to three times per night. For fake flowers with polluted fragrances, the average number of nightly visits was less than one, the team found.

Scientists need to learn how the observed insect behavior may impact foraging, Fuentes says. If insects are becoming more confused in places where air pollution is getting worse, "it will impact pollination, crop productions [and] health of native plant species." ■

During hot summers in southern Spain, *Carlina corymbosa* flowers can stay nearly 10 degrees Celsius cooler than surrounding air temperature.

C. HERRERA

PLANTS

This thistle somehow beats the heat

Flowers stay cool to the touch even in scorching temperatures

BY DARREN INCORVAIA

In the mountains of southern Spain, one type of thistle seems to have built-in air-conditioning.

Carlina corymbosa flowers are 3 degrees Celsius cooler than the surrounding summertime air on average, ecologist Carlos Herrera of the Spanish National Research Council in Sevilla reports in the March *Ecology*. The most extreme cooling — sometimes nearly 10 degrees C — occurs during the hottest part of the day. That means when the air temperature reaches 45° C (113° Fahrenheit), the plant's flowers can remain close to a relatively cool 35° C (95° F).

"Those are substantial coolings relative to the air next to it," says Christopher Still, an ecologist at Oregon State University in Corvallis. "It's a nice, careful study."

In the Sierra de Cazorla mountains, scorching summers leave many plants dead, dried out or dormant. This brown expanse is broken up by bursts of yellow as *C. corymbosa* peeks above the vegetation. On a recent trek, Herrera touched a thistle to check for nectar and found its flower curiously cool, considering it was the hottest time of day. Using an electric thermometer, he took the temperatures of seven thistles across two sites for multiple days. The flowers consistently cooled down as the day grew hotter, he found.

Many plants cool down by passively allowing water to evaporate through leaf pores, a process that's analogous to sweating. But in many cases, leaves don't get colder than the surrounding air. When they do, Herrera reports, the difference in temperature is less drastic than seen in the thistle flowers.

There's probably some truth to the idea that the thistle's flower cools more than leaves do, but because their temperatures are measured differently, it's hard to say for sure, Still says.

Because the thistles begin cooling at the hottest part of the day, it's possible that the plants actively turn on and off a self-refrigerating mechanism.

The idea that plants might control their internal temperatures was introduced in the late 1980s. However, it's a rare trait, Still says. A 2022 study he led found no evidence that leaves in forest canopies across North and Central America were cooler than the air around them.

Herrera and Still both suspect the thistle flower's shape and structure enable it to cool so effectively. Water in the bud evaporates and takes heat with it, but because of the flower's shape, the heat isn't replenished by the sun, Herrera suggests. This might allow the plant to cool below the air temperature, a phenomenon that Herrera calls the botijo effect. It's the same principle by which pore-sweating pitcher plants — called botijos in Spanish — cool themselves in dry, hot air, he says. But the idea needs to be tested.

Still is curious to know if being cooler than the surrounding air benefits the thistle by attracting pollinators trying to escape the heat.

Herrera plans to look for the botijo effect in other thistles and has mapped out an experiment to probe how access to water may influence cooling ability. ■

ASTRONOMY

New U.S. lunar probe phones home

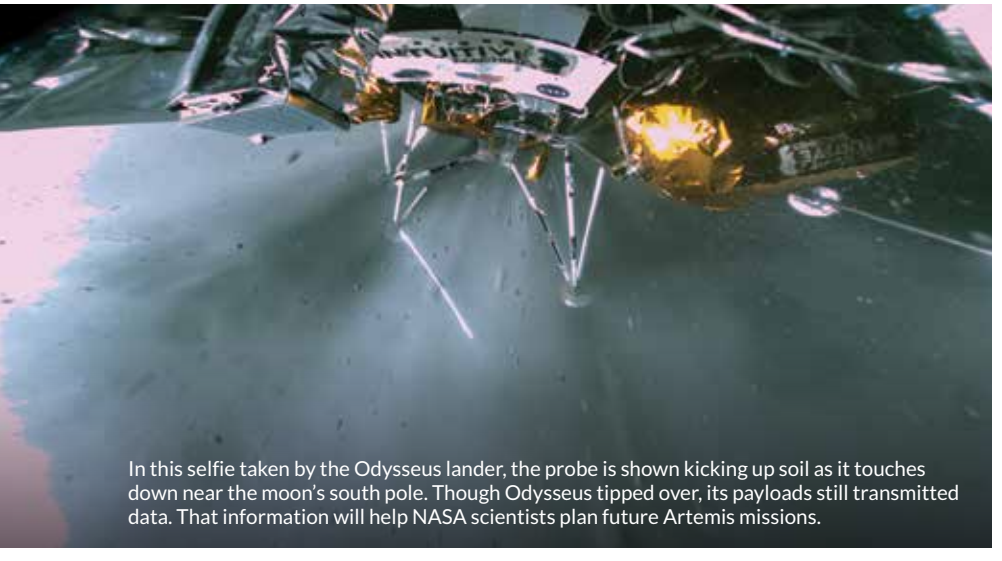
The United States has taken one small step back to the surface of the moon. A solar-powered robotic lander named Odysseus touched down near the moon's south pole on February 22, making it the first U.S. vehicle to perform a controlled descent to the lunar soil since Apollo 17 landed in 1972.

Odysseus — built and operated by the Houston-based private company Intuitive Machines — carries payloads from NASA, private companies and a university. The venture is part of NASA's Commercial Lunar Payload Services program, wherein the agency hires companies to scout the moon in support of the Artemis program. Under Artemis, NASA aims to land humans on the moon in 2026.

Even though Odysseus tipped over upon landing on the slope of a crater called Malapert A, all of the NASA instruments aboard have transmitted useful data, NASA confirmed February 28. Scientists are learning about radio energy on the surface, precision landing technologies and more.

But Odysseus began running out of power on February 26 as night set in, so scientists put the lander into sleep mode. As of press time, the team was still waiting to see whether Odysseus could be revived.

— Christopher Crockett and Adam Mann



In this selfie taken by the Odysseus lander, the probe is shown kicking up soil as it touches down near the moon's south pole. Though Odysseus tipped over, its payloads still transmitted data. That information will help NASA scientists plan future Artemis missions.

OFFICIAL INTUITIVE MACHINES PHOTOS (CC BY-NC-ND 2.0 DEED)

HEALTH & MEDICINE

Diabetes drug curbs opioid cravings

DENVER — A drug used to treat diabetes and obesity has shown promise to treat another disorder: opioid addiction. Early results from a small clinical trial, presented February 17 at the annual meeting of the American Association for the Advancement of Science, suggest that a relative of the weight-loss drug semaglutide lessened opioid cravings in people with opioid use disorder.

"For them to have any time when they might be free of that craving seems to be hopeful," Patricia Grigson, a behavioral neuroscientist at Penn State College of Medicine in Hershey, said at the meeting. The vast majority of overdose deaths in the United States are due to opioids (*SN: 2/10/24, p. 16*).

Like semaglutide, the studied drug — called liraglutide — mimics the hormone GLP-1, which the body releases after people eat. It's unclear how these drugs lead to weight loss, but scientists think GLP-1 dupes prompt the body and brain to make people feel full (*SN: 12/16/23 & 12/30/23, p. 26*).

There are hints that such drugs could work for addiction. People taking Wegovy or Ozempic (brand names for semaglutide) have reported lessened desire for alcohol and nicotine. And previous work by Grigson's team found that liraglutide decreased heroin-seeking behavior in rats.

To test whether the drug might treat opioid addiction in people, the scientists gave liraglutide to 20 volunteers receiving treatment for opioid use disorder. Ten people received increasing doses over 19 days and 10 people received a placebo. Patients dropped out of the trial at high doses due to gastrointestinal upset, a known side effect. Still, the treatment began reducing opioid cravings at the lowest dose. Overall, desire for opioids was reduced by 30 percent, Grigson said. That's equivalent to the effect of about 14 days of treatment at a residential center. The results need to be confirmed in larger trials. *— Erin Garcia de Jesús*

AGRICULTURE

Microbial tincture ups tea theanine

Researchers may have gotten to the root of tea's soothing effect.

The qualities of a cup of chai can be enriched by modifying the microbial community that populates the tea plant's roots, scientists report in the Feb. 26 *Current Biology*. The secret is to inoculate roots with bacteria that boost the synthesis of the amino acid theanine.

Some studies suggest theanine is the ingredient in tea that helps us wind down, says plant cell biologist Zhenbiao Yang of the Shenzhen Institute of Advanced Technology in China. What's more, theanine gives tea an umami taste.

Yang and colleagues analyzed the microbes living on the roots of two oolong tea plant varieties: a sweet, low-theanine cultivar called mao xie and a spicy, high-theanine variety called rougui. On the rougui roots, the team found more types of microbes that metabolize nitrogen, which tea plants use to make theanine.

The team concocted a microbial medley, called SynCom, with 21 bacterial strains from rougui roots. Adding the mix to several varieties of tea plants that had been disinfected and grown in sterilized soil boosted the plants' theanine levels. Mao xie given live SynCom had about 0.007 milligrams of theanine per gram. That's 0.005 mg/g more theanine than mao xie given dead SynCom had. Yang's team plans to refine SynCom to make scaling up production easier. *— Nikk Ogasa*

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Sekazi Mtingwa was one of two key developers of the theory of intrabeam scattering, which has been applied in the building and operation of particle accelerators across the world.

NSF

Apostle of SCIENCE

Accelerator physicist Sekazi Mtingwa is a mentor, activist, policy expert and humanitarian

By Elise Cutts

Ask physicist Sekazi Mtingwa how he ended up where he is today, and he'll start with his grandmother's deeply religious home. Growing up there in Atlanta, young Mtingwa somehow got the idea that he was the second coming of Christ.

"I believed that for years," Mtingwa recalls with a laugh. That only changed after a Sunday school lesson as a schoolboy. It was about Jesus sacrificing himself for murderers and thieves. "I looked around the room, and all these bad boys in my class, I couldn't give my life for any of them—let alone murderers," he says.

That was it for the Jesus plan, Mtingwa says. But his desire to serve humankind never waned. Today, says Mtingwa, who remains religious, "I like to think of myself as an apostle of science."

Apostle of science gets close to the essence of Mtingwa's career. Over the decades, he's had many professional titles. As an accelerator and particle physicist, Mtingwa is nationally recognized for his work building accelerators and for developing an important theory that describes how particles scatter when they're squeezed into high-energy beams. But he's also a nuclear policy expert, mentor, administrator, activist and founder of dozens of organizations in the United States and abroad dedicated to creating new opportunities in science for people who have been historically kept at its margins.

"People's everyday lives are impacted and improved by his efforts," says Robbin Chapman, one of Mtingwa's mentees who is now associate dean for diversity, inclusion and belonging at Harvard Kennedy School. That impact is expansive, Chapman says, "whether it's the actual research, whether it's the teaching or whether it's the networks he's bringing together across countries and continents."

A new theory and a new name

Born in 1949, Mtingwa attended segregated schools in Georgia. Back then, he had a different name—Michael Von Sawyer. Other kids teased him for the name, he says, calling him a "mad German scientist." Having given up on being Jesus, Mtingwa says, "I had to look for another career." All that jeering got him thinking it might be science.

Mtingwa devoured books about science at the local library and concocted a project that won him first place in botany at Georgia's state science fair. It was the first year that the contest was racially integrated. His science fair prize included a box of science books. A few were on general relativity. And with that, his interest in physics ignited.

As an undergraduate at MIT, Mtingwa studied physics and mathematics and learned to channel his ambition to serve others into activism. It was the "turbulent 1960s," Mtingwa says, and the campus zeitgeist crackled with the energy of the Civil Rights Movement and Vietnam War protests. He got involved in student groups advocating for racial equity, was a founding member of MIT's Black Students' Union and participated in a student takeover of a faculty lounge.

"That really drove into me the need to serve," he says. "But I always had this philosophy that you can't serve until you first take care of yourself — better yourself, get your education, establish your career." After that, he believes, one can start to reach out to help individual people and, eventually, build systems that go beyond individuals to the world.

After MIT, he earned his Ph.D. at Princeton University working on high-energy particle physics. It was during that time that Mtingwa, who calls himself a Pan-Africanist, chose his name with the help of a fellow graduate student from Tanzania. Shortly after graduating, he joined other Black physicists to found the National Society of Black Physicists in 1977. He'd met several of his cofounders at MIT, which he describes as having been a kind of hub for Black physicists.

But Mtingwa says his academic career nearly ended just a few years later. After two stints as a postdoc, he struggled to find a job even as his white colleagues seemed to float up the academic ladder. A Ford Fellowship he received in 1980 saved him, he says, sending him to Fermilab, a leading particle physics laboratory in Batavia, Ill., for a year.

That year snowballed into seven, during which he and theoretical physicist James Bjorken developed the theory of intrabeam scattering — which describes how charged particles spread out when packed together into high-energy beams. In particle accelerators, which create high-energy beams and often use them to smash particles together or into other targets, this spreading can hurt performance if it's not properly accounted for.

The theory Mtingwa helped develop has been put to work in the design of particle accelerators across the world, from small synchrotrons used to generate intense light for chemistry and biology experiments to the Large Hadron Collider at CERN, near Geneva.

"Any accelerator physicist knows about the Bjorken-Mtingwa theory," says Mark Palmer, an accelerator physicist at Brookhaven National Laboratory in Upton, N.Y. "This has had a very, very deep impact on broad portions of the scientific endeavors that depend on accelerator performance with very-high-energy beams."

> "People's everyday lives are impacted and improved by his efforts."
>
> **ROBBIN CHAPMAN**

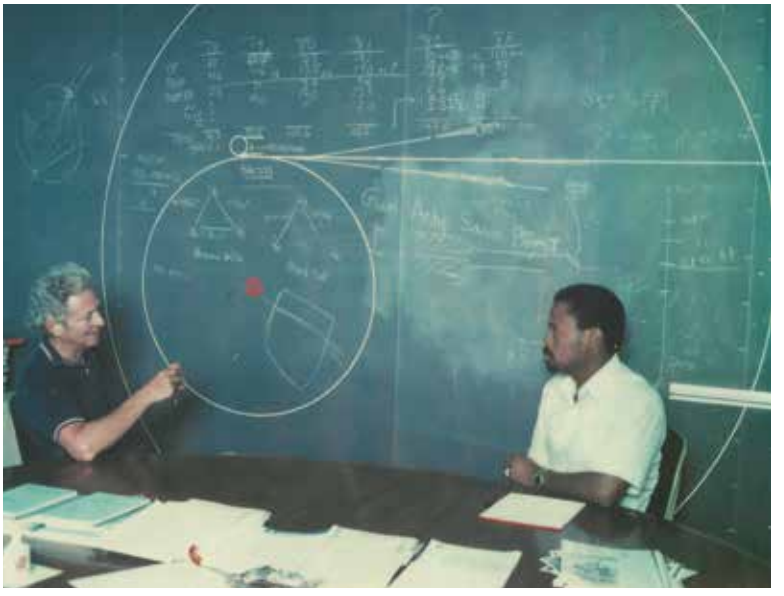
Opening science to others

Mtingwa continued his work on the theoretical physics of particle accelerators. But he also started to build them.

While at Fermilab, he helped design systems for producing and collecting antiprotons — the antimatter counterpart to protons — so they could be accelerated into beams. Colliding streams of protons and antiprotons in Fermilab's Tevatron accelerator ultimately revealed the existence of the top quark, a fundamental particle and a long-sought, essential piece of the standard model of particle physics.

And at Argonne National Laboratory in Illinois, Mtingwa worked out the theoretical underpinnings of plasma wakefield accelerators — a type of particle accelerator that speeds up particles using pulsing waves of plasma, which Argonne scientists experimentally demonstrated for the first time in 1988.

In 1991, after years working at some of the top national laboratories, Mtingwa made a decision that he says baffled some of his colleagues:



Sekazi Mtingwa is shown above in the 1980s with Nobel Prize–winning physicist Leon Lederman, then director of Fermilab. Last year, Mtingwa was awarded the Philip Hauge Abelson Prize for "significant contributions to the scientific community" (left).

FROM TOP: FERMI NATIONAL ACCELERATOR LABORATORY; ROBB COHEN PHOTOGRAPHY AND VIDEO

UNSUNG CHARACTERS

This article is part of a *Science News* series highlighting people of science — past and present — who we believe should be better known. Watch for more of these stories, and send your ideas to editors@sciencenews.org

Mtingwa's work on intrabeam scattering was key to the operation of Fermilab's Tevatron particle collider (shown), which revealed the existence of the top quark in 1995.

REIDAR HAHN/FERMILAB

He became a professor at North Carolina Agricultural and Technical State University in Greensboro, a historically Black university that, back then, didn't have a graduate program in physics at all.

"I had at Fermilab and at Argonne worked with students — high school and college — for the summer. And I had gotten interested in surrounding myself with the young, African American students to try to be able to make a difference," Mtingwa says.

Mtingwa had taken care of himself. Now, he wanted to start taking care of others.

At North Carolina A&T, Mtingwa established a master's program in physics and laid the groundwork for new Ph.D. programs. Over his many years teaching at North Carolina A&T, Morgan State University in Baltimore, Harvard and his alma mater MIT, he mentored countless people, including Chapman — who now mentors students herself.

"He really captured what I realized is the essence of supporting anyone, but particularly scholars of color as they are moving through their academic careers," she says. Rather than seeing life and work as separate things, Mtingwa taught Chapman to see them as part of one ecosystem of excellence. "He's a systems thinker," she says, with a keen eye for how people fit into their full context and what that means for how they work.

Today, Mtingwa is in what he describes as "that third stage" of serving the world: building institutions. When he talks about this stage, his stories focus on "we" more than "I," to the point that it becomes hard to keep track of which "we" he's talking about. Over his long career, he's built, nurtured and then carefully entrusted to others a dozen or so programs, institutions and nonprofits.

> "I was put on Earth to serve mankind, so that's what I'm trying to do now."
>
> **SEKAZI MTINGWA**

Mtingwa helped found not only the National Society of Black Physicists, but also the National Society of Hispanic Physicists and the African Physical Society, among several other professional organizations in the United States and abroad, with a focus on places where scientific infrastructure and opportunities are more limited. He is actively leading efforts in Africa, the Caribbean, the Middle East and Asia to train scientists to use synchrotron light sources — small particle accelerators that generate intense light that are vital for many types of research in chemistry and biology — and build synchrotron light source facilities.

The point, Mtingwa says, is to create more opportunities for more people in science. He'd like to see a day without discrimination, when anyone's scientific career could flourish — no matter who or where they are.

"I realized I wasn't Jesus Christ," Mtingwa says. "But I was put on Earth to serve mankind, so that's what I'm trying to do now — to be of service." ■

Explore more

- To find out more about Sekazi Mtingwa's life and science, check out this oral history interview from the American Institute of Physics: bit.ly/Mtingwa
- For more on synchrotron light sources from SLAC National Accelerator Laboratory, visit stanford.io/4bSYhWw

Elise Cutts is a freelance science writer based in Graz, Austria.

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Patient as Scientist

Sufferers of understudied conditions are taking up research to move medicine forward

By Betsy Ladyzhets

Melissa Red Hoffman was "feeling really stuck" last summer. A 50-year-old surgeon in Asheville, N.C., Hoffman had been struggling with long COVID since getting infected with the coronavirus two and a half years earlier. "Deafening fatigue" was one of her worst symptoms, she says. "I feel tired behind my eyes from the moment I get up to the moment I go to sleep." She managed to work part time, but much of her work had shifted to administrative tasks that she did from her couch.

"I was really at a point where I had tried so many different things myself, with so many different providers," she says, "not really sure what the hell to do next."

Then she found Remission Biome. It's a research project started in early 2023 by Tamara Romanuk and Tess Falor, two people with myalgic encephalomyelitis/chronic fatigue syndrome, or ME/CFS, a chronic disease that shares symptoms with long COVID. Project participants have taken medical research into their own hands to determine whether and how changes to their gut bacteria can improve their health. After an initial test with three participants led to some symptom relief, Romanuk and Falor announced last July that they would recruit 50 people with ME/CFS, long COVID or both for a larger test of the project's protocol.

Hoffman was one of 500 people who applied within 36 hours of the call for volunteers. By the fall, she and 49 other people, dubbed the "Renegade 50," had joined the project.

Remission Biome's protocol is a multistep process, which participants undertake in consultation with their physicians. Initial steps involve patients collecting samples of their guts, immune systems and other connected organ systems, either at home or at a health care provider's office. After those samples are analyzed by a lab to get baseline data, participants take a regimen of over-the-counter supplements, such as probiotics to cultivate certain types of gut bacteria, and then a prescribed antibiotic. Next comes further testing to examine if and how the regimen altered the composition of the gut microbiome. Throughout the process, participants track their symptoms and learn about past research on the microbiome that informed the project, ensuring that they understand the rationale for every step.

Early in the testing process, Hoffman's fatigue started to lift, she says. "That's been exciting, just to feel a little bit of a change."

Alleviating symptoms — which can include debilitating fatigue, trouble sleeping, intense allergic reactions and cognitive problems — motivates many members of the Renegade 50, who come from different countries, age groups and stages of illness. But participants also aim to collect and publish data that will give the broader scientific community more information about ME/CFS and long COVID, two complex, often fluctuating conditions.

> "Biomedical research has blind spots."
>
> **SUSANNAH FOX**

Participant María Richardson, a 36-year-old former educator in Mexico City, has dealt with progressively worse ME/CFS symptoms since high school. She received her diagnosis in the United States in 2015, but when she moved back to her native Mexico, where knowledge of the condition is limited, trying to get care "was like starting from zero," she says. Remission Biome helped her better understand her own symptoms and share scientific information with the ME/CFS community in Mexico, through the ME/CFS advocacy group Millions Missing Mexico.

Remission Biome is one effort in the growing movement of patient-led research, which seeks to investigate chronic conditions that have been underresearched by academic and clinical scientists yet impact many people's lives.

"People who were ignored by the American health care system … often need to turn to each other in order to gather the data that gets the attention of the mainstream," says health care researcher Susannah Fox, author of the new book *Rebel Health: A Field Guide to the Patient-Led Revolution in Medical Care*.

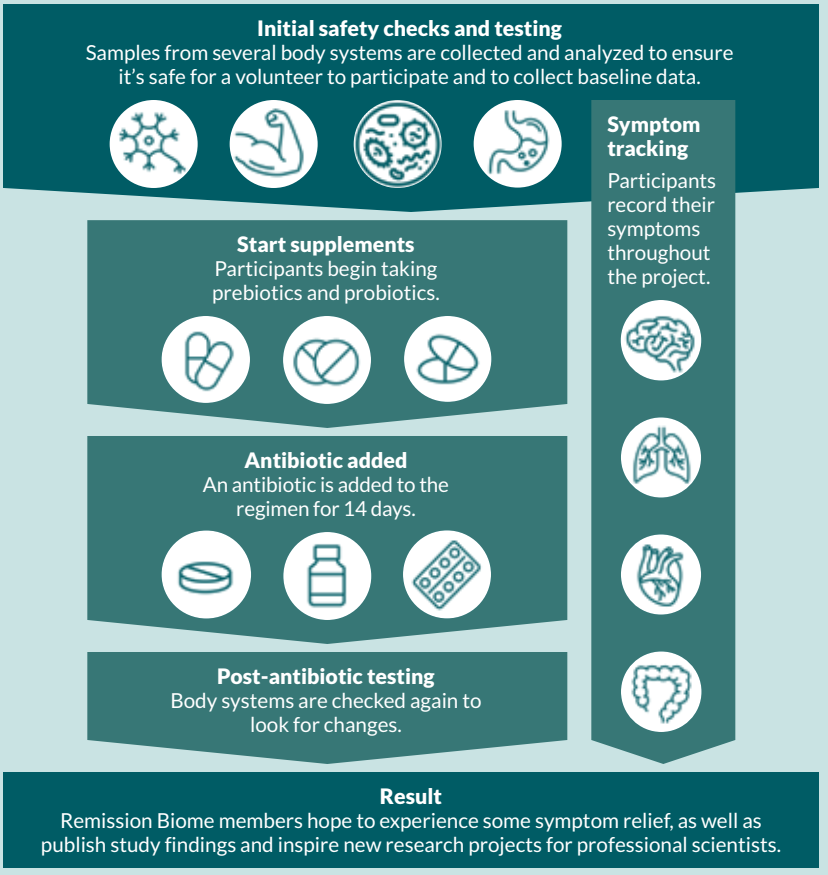
Compared with mainstream medical research that tends to focus on finding biological causes and disease cures, patient-led work is more often rooted in what's immediately relevant to patients' daily lives, like identifying symptom triggers or relievers. But the approach faces challenges — particularly a lack of funding and other research resources — as scientific institutions aren't set up to support these projects.

Patient-researchers and their scientist collaborators say the patient-led approach has big potential to move chronic disease research forward, making it more

Patient-led research grew from earlier forms of patient activism. In the '70s, the Black Panther Party set up screenings for sickle cell disease, which in the United States primarily affects Black people.

OPPOSITE PAGE: PETE RYAN; THIS PAGE: BOB FITCH PHOTOGRAPHY ARCHIVE, © STANFORD UNIV. LIBRARIES

Experimental design Remission Biome is studying whether changes to the gut microbiome can improve the health of people with ME/CFS or long COVID. Participants follow a protocol that includes taking prebiotic and probiotic supplements and a course of antibiotics. SOURCE: REMISSION BIOME



informed, quicker and more poised to directly improve patients' lives.

Projects like Remission Biome "are going to change how research into these chronic, multi-organ-system diseases is going to be done," Hoffman says. The approach may someday become a standard part of more mainstream research.

A history of leading the way

About 1.3 percent of adults in the United States have ME/CFS, according to the U.S. Centers for Disease Control and Prevention. Scientists first noticed the condition in the 1930s, but since then, it's been hard to define and hasn't attracted extensive research attention. Initial observations noted outbreaks characterized by fatigue, chronic pain and other symptoms now associated with ME/CFS, often occurring — but not always — after viral infections. Scientists started to link these mysterious outbreaks in the 1980s under the umbrella term chronic fatigue syndrome.

Progress on identifying the disease's triggers has been slow, in part because of the wide variety of symptoms across many organ systems and in part due to relatively limited research funding. And some doctors have dismissed patients' symptoms as all psychological — a factor that some experts connect to the disease's higher burden on women.

Combined, these challenges have contributed to a lack of treatments for people with ME/CFS, despite the illness's potentially devastating impact on patients. Long COVID — which 6.8 percent of U.S. adults currently have, according to data from the CDC and U.S. Census Bureau — raised the profile of ME/CFS during the pandemic because of the two conditions' similarities.

Remission Biome started thanks to a Twitter conversation in fall 2022. Falor and Romanuk realized they had both independently experienced what they call "remission events," in which symptoms recede for a few hours or days after courses of antibiotics. These events led each of them to look into the possible connection between ME/CFS symptoms and the gut microbiome, an emerging area of study with many unanswered questions. The pair were also both working scientists before their symptoms became debilitating. Falor had worked as an aerospace engineer at NASA; Romanuk had been a biologist studying microbiomes.

The two scientists set out to replicate their remission events — and collect extensive data on how their microbiomes and bodily systems changed to better understand the underlying biology of these events. They started with a self-test in early 2023, which included taking a lengthy list of supplements chosen to either increase or decrease levels of specific bacteria with possible ME/CFS connections. In addition to Romanuk and Falor, Isabel Ramirez-Burnett, a 50-year-old engineer and health coach in Rhode Island who has lived with ME/CFS since childhood, participated in the experiment.

The testing "went even better than we could have expected," Falor says, with two of the three participants experiencing remission events. So Remission Biome expanded to the Renegade 50 cohort and fundraised through a crowdfunding campaign, grants and sponsorships to support this larger project. The team also recruited the participants' physicians, to help ensure safety, along with scientists to collaborate with the participants and other volunteer researchers working on the project. Scientists regularly attend research meetings hosted by Remission Biome, Falor says, which include presentations and discussions about new, relevant findings in other ME/CFS and long COVID research.

Theoharis Theoharides is one of those scientists. As director of the Center of Excellence for Neuroinflammation Research at Nova Southeastern University in Clearwater, Fla., he has decades of

B. PRICE, BODY ICONS: PHOTOTECHNO/GETTY IMAGES; DRUG ICONS: DSTARKY/ISTOCK/GETTY IMAGES PLUS

experience studying mast cell activation syndrome, a chronic condition characterized by intense allergic reactions that is often diagnosed alongside ME/CFS and long COVID. "They're very bright, very dedicated," Theoharides says of Falor and Romanuk. He has provided feedback on Remission Biome's regimen of supplements and plans to help analyze microbiome and blood samples taken from the Renegade 50 participants to look at how immune system changes may connect to their gut bacteria.

Another collaborator is Tatyana Dobreva, cofounder and CEO of the San Francisco–based biotech start-up ImYoo, which operates remote clinical trials and other research. ImYoo is assisting Remission Biome with genetic analysis of patient blood samples. The Renegade 50 study is similar to other ImYoo projects studying conditions such as IBS and sickle cell disease, in which participants tie symptom tracking to data from medical testing, Dobreva says.

Remission Biome adds to a long history of patients with complex and contested illnesses advocating for their communities, Fox says. "Every decade of the 20th century had an example of people who were either being ignored or who were being discriminated against" by scientists and doctors, and who "banded together to innovate or gather data," she says. Examples include Black people with sickle cell disease in the 1970s and people with HIV/AIDS in the 1980s. In some cases, this translated to patient-informed research, in which patients consult on scientific projects, informing everything from research questions to how results are disseminated.

In the 21st century, the internet aided patient-led projects, with patients actually doing research, as like-minded patients could more easily find each other, as happened with Romanuk and Falor, Fox says. In these projects, patients also closely follow scientific studies about their disease and may collaborate with academic experts to develop scientific frameworks, rather than self-experimenting individually.

ME/CFS patients have been particularly motivated to pursue their own research, says Emily Taylor, vice president of advocacy and engagement at the ME/CFS organization Solve M.E. One key motivator is "the failure of the medical establishment to provide any sort of support or treatment or quality of life improvements for this population," she says. Previous ME/CFS research done without patient input, such as a now-debunked clinical trial examining exercise as a potential treatment, has led patients to push back with their own studies.

"There was a desperate need to validate the anecdotal stories of patients in a formalized way," Taylor says.

In spring 2020, during the first months of the pandemic, patients whose symptoms persisted for weeks after the initial infection started documenting their complex symptoms in real time. The Patient-Led Research Collaborative, or PLRC, formed out of a long COVID support group, led by members who had scientific experience.

PLRC released its first report in May 2020, documenting symptoms common among the group's hundreds of members. "We saw a need to start collecting people's experiences and really try to take things into our own hands," says PLRC cofounder and long COVID patient Lisa McCorkell.

Patient and expert

Patient-led and patient-informed research can be a win-win for both patients and scientists, advocates say. For patients, this work is more likely to address questions that are meaningful to their daily lives, says Jaime Seltzer, director of science and medical outreach at the advocacy group #MEAction. In one pre-pandemic example, a patient group focused on polycystic kidney disease proposed potential treatments to scientists at the University of Cambridge, leading to clinical trials at a new patient-led research hub.

Patient leadership can also inspire people to participate in clinical trials, as the interest in joining Remission Biome demonstrates. And study designs informed by patient experience often prioritize accommodations for people with different levels of symptoms or access to care, meaning a more diverse group of patients may be able to participate. With a patient-led, "decentralized" approach to research, "we can reach more people in more diverse areas" who don't live near medical facilities in big cities or aren't able to travel for clinical trials, Dobreva says.

Connor, a member of the Renegade 50 who asked that only his first name be used to maintain medical privacy, "couldn't participate in a traditional study," says his wife, Nicole Bruno. Since a COVID-19 infection two and a half years ago, he has faced a severe case of both long COVID and ME/CFS, leaving him bedbound in a dark room.

"He could never go to a lab" or a doctor's office to have samples collected, Bruno says. But with Remission Biome's remote framework and individual support, he can be a patient-researcher. In addition to flexibility in locations, each member of the cohort is going through the testing protocol at their own pace, incorporating their microbiome test results, other diagnoses and input from their physicians. Flexibility also helps with logistical challenges; for example, test kits take longer to ship internationally.

> "There was a desperate need to validate the anecdotal stories of patients in a formalized way."
>
> EMILY TAYLOR

For scientists, patient-led studies may move a field forward by highlighting key questions and hypotheses that might not emerge from traditional research. "Biomedical research has blind spots," Fox says. McCorkell points to a paper from the PLRC, published in *eClinicalMedicine* in 2021, that expanded upon its 2020 survey work by describing 200 long COVID symptoms across 10 organ systems based on a detailed survey of about 3,800 people.

"It is still, to this day, one of the most cited papers in long COVID," McCorkell says. Without this paper, she adds, other scientists might still be investigating "a small, limited set of symptoms" rather than the full scope of the condition. David Putrino, a long COVID clinician and

director of rehabilitation innovation at Mount Sinai Health System in New York City, also points to the PLRC paper as an example of successful patient-led research that informed later studies.

Patient-led research "moves orders of magnitude faster than traditional modes of research," Putrino says, because it focuses on the questions that are of greatest concern to patients, leading more quickly to impactful results. Patient-led groups may also be able to start new studies more quickly than institutions that have to, say, go through formal academic procedures, he says. In that way, this research is similar to how start-ups move faster than large corporations.

1.3 percent
U.S. adults who have ME/CFS

6.8 percent
U.S. adults who have long COVID

In addition, patients can help scientists design studies that are more likely to provide accurate results. For example, feedback from members of Remission Biome and other patient representatives helped David Esteban, a biologist at Vassar College in Poughkeepsie, N.Y., who was looking for people who had gotten COVID-19 but didn't develop long COVID and could serve as control patients in a project funded by PLRC.

"Their perspective was, many people who recover from acute COVID go through a period where they feel better, but then get worse again," he says. "I hadn't really thought about that." But that insight helped Esteban establish how long after a COVID-19 infection to wait before declaring a patient past the threshold for developing long COVID.

After studies are completed, patient teams may be more thoughtful about communicating results back to patient communities. In sharing a recent paper about managing ME/CFS that she coauthored with clinicians at the Mayo Clinic in Rochester, Minn., for instance, Seltzer anticipated questions that ME/CFS patients might have about the study. She explained up front that the paper was a concise review and could not include every relevant study, as patients would want to know "why I hadn't mentioned their favorite paper," she says. Such communication can "save a research group a lot of time and energy," Seltzer says, and can encourage patients to bring the paper to their doctors so that the findings might inform their health care.

Groups like PLRC are working to build infrastructure to help scientists better engage with patients, including experienced patient-researchers and others who haven't done scientific work before.

In January 2023, PLRC and the Council of Medical Specialty Societies introduced scorecards for academic teams interested in these collaborations. The scorecards can help teams evaluate success. "Our scorecards were developed with the intention of trying to change the baseline of what's considered acceptable patient engagement," McCorkell says, moving away from "tokenizing" engagement that she and other PLRC members have experienced. Taylor, at Solve M.E., would like to see the scorecards or a similar evaluation incorporated into traditional funding applications at scientific institutions.

Challenging work

Current institutional and financial support for patient-led research projects is limited. These projects typically are not eligible to apply for academic and government grants, leading them to seek money from nontraditional sources. Patient-researchers also don't tend to have access to laboratory space, clinical tests and other research resources.

"We're limited in the type of research that we can do," McCorkell says. As a result, surveys and self-experimentation are the most common methods.

Internal capacity is another challenge: Chronically ill people tend to have limited energy to devote to projects; they must balance this work with managing their symptoms. Patients tend to be more ambitious than their available energy can support, Seltzer says. Sometimes a patient-researcher might have to take a break from a project to recover from a symptom flare-up. Projects like Remission Biome take these crashes into account when designing experiments and distributing tasks.

"If I disappear for a week," it's OK, says Katrin Boniface, a doctoral student studying the history of horses at the University of California, Riverside who had her own remission experience before joining the Renegade 50. But these constraints might frustrate academic or clinician collaborators who want patient-researchers to answer emails at all hours or pull together a last-minute grant proposal.

Nonpatient scientists might also be skeptical of results from patient-led research, as many in the scientific community haven't yet recognized how lived experience can improve studies, Seltzer says. Although many patient-researchers have scientific backgrounds, they might not be experienced in biomedical research, leading to perceptions that they are underqualified and that their work is not rigorous or may even be biased.

Advocates like Seltzer argue that patient-researchers are more incentivized than anyone to make sure their results are accurate. "If we're wrong, we and people like us suffer," she says.

Taylor argues that data from patient-led research should be added to the types of evidence that regulatory agencies like the U.S. Food & Drug Administration consider for approving treatments. The FDA and the National Institutes of Health took one step in this direction earlier this year by soliciting data from long COVID patients and doctors about their experiences with treatments approved for other diseases.

But some scientists and doctors are concerned that patient-led projects might encourage some patients to self-experiment on their own without appropriate safety measures. This has been a big challenge for Remission Biome, especially after its members posted about remission events during the project's first phase in early 2023. Initially, the plan was to openly share all aspects of the project, including protocols and results, says Ramirez-Burnett, one of the three early participants. "But then we realized that people were starting to pick pieces of the protocol in order

to do it, which is not safe," she says. "So we had to close that document."

Now, when asked about the full protocol, as they often are on social media, Remission Biome participants typically encourage safety and emphasize that more testing is needed before it's widely shared. In the future, Ramirez-Burnett hopes to educate more clinicians about the project so they can work with patients outside the Remission Biome infrastructure.

Patient-led projects may also struggle with logistics. This has been the case for Remission Biome. Its two founders split in December over disagreements about the project's pace, its handling of safety aspects and how to incorporate the project as a formal business. As a result, Romanuk and the group parted ways.

The Renegade 50 test was put on hold until mid-March while Falor and other project members addressed this leadership change and set up as a nonprofit, she says. The team is also adding more safety steps and participant education on the antibiotic in the testing protocol because that antibiotic may have negative side effects for some people with ME/CFS. Falor expects the Renegade 50 phase will be completed later this year, after which the project will share preliminary results and begin setting up a cohort of 500 participants.

Tests and supplements for that next cohort will require more financial support, which Remission Biome will continue to raise from its GoFundMe campaign and grants. The project has also secured sponsorships from supplement and testing companies, such as the probiotics provider FitBiomics, to provide research supplies to participants. Financial support is especially important for participants living in places where it's difficult to receive medical care for ME/CFS, says Richardson, the Renegade 50 member in Mexico. Many patients globally could benefit from this work, she says.

Remission Biome is also working toward scientific publications, based on data from the Renegade 50 cohort and from side projects. But the 50-person test might not lead to publishable results, says scientist-collaborator Theoharides. The microbiome is extremely complex, and, unlike a clinical trial, the Renegade 50 group does not include control patients not taking the treatments. But he hopes "the information that will come out of this study might actually give us some new directions." One key advantage, he says, is that each participant is testing many supplements rather than focusing on one at a time; ME/CFS and long COVID are such complex diseases that it's unlikely for a single treatment to work for all patients or have a lasting impact.

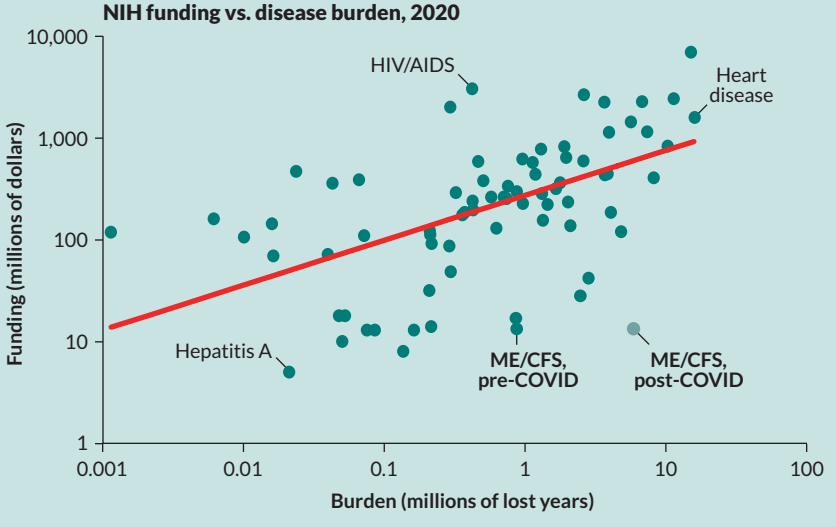
Esteban, the biologist at Vassar College, similarly hopes to examine how different antibiotics might work together to alleviate symptoms. "I'm already thinking about experiments that I could do," he says, such as work in lab animals that would "start to explore some of the proposed mechanisms that might underlie the effects they're seeing with the antibiotic treatments."

While Remission Biome's participants are excited to contribute to research, their most important goal is to provide "solutions for the ME/CFS community," Ramirez-Burnett says. "So people don't have to lose their jobs, lose their relationships, not get proper care."

Among the three Renegade 50 participants who had completed the testing protocol as of January, one experienced a remission event, signifying a potential success, Falor says. Meanwhile, the project's frequent meetings, Slack group, apps for shared symptom-tracking and other communication options could provide models for other patient-research efforts.

Remission Biome participants who have dealt with ME/CFS for a long time, like Richardson, feel particularly motivated to help find answers for the millions around the world newly struggling with long COVID. "People with mild long COVID sound like what I experienced 20 years ago," Richardson says. She hopes that the lessons learned from Remission Biome and other projects like it can help prevent new long COVID patients from experiencing decades of symptoms. ■

State of funding Of 73 diseases (dots) with research funding from the National Institutes of Health, ME/CFS is among those underfunded relative to its disease burden, the total number of healthy years lost due to premature death or disability from illness. The graph includes an estimate of ME/CFS burden with the arrival of COVID-19. The red line is expected funding levels based on burden. SOURCE: A.A. MIRIN, M.E. DIMMOCK AND L.A. JASON/*FATIGUE* 2022



B. PRICE

Explore more

- Learn more about the Patient-Led Research Collaborative at patientresearchcovid19.com

Betsy Ladyzhets is a freelance science journalist based in Brooklyn, N.Y., and edits The Sick Times, an online publication covering long COVID.

MEET THE SCIENCE NEWS LEARNING AMBASSADORS

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Karisa Boyer (above left) of Joplin, Mo., is creating a multisubject data visualization guide for STEM teachers. Robert Palmer (center) of Red Wing, Minn., is compiling a checklist for teachers to develop standards-based lesson plans using Science News Learning resources. Maria Cheryl Diangco (right) of Brooklyn, N.Y., is developing strategies to scaffold lesson plans for language learners.

Explore Science News Learning: sciencenews.org/learning

FILM

What does space travel do to mental health?

NASA engineers must quantify everything. But no matter how many equations they use to calculate launch windows, estimate exposure to cosmic radiation or create flight trajectories, there's one thing they can't quantify: the mental health of astronauts.

And for a while, NASA could get away with it. Early astronauts certainly faced mental challenges — worries over mission failures, the fear of the unknown. But it wasn't until the arrival of space stations that astronauts began spending months away from home. In 1994, with the building of the International Space Station under way, NASA formed a psychological unit.

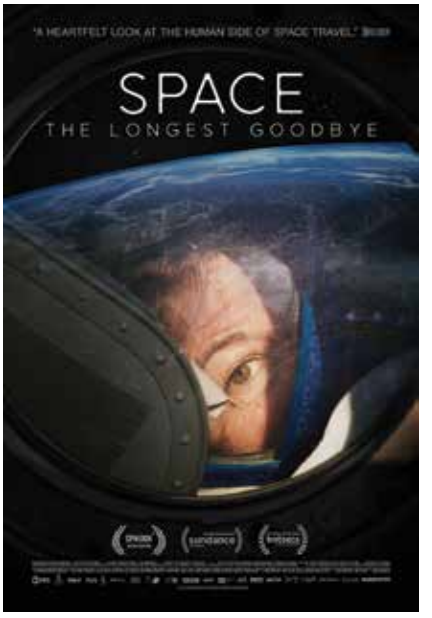
Now, astronauts may soon embark on even longer trips. Long-distance relationships are hard enough on Earth. But on a three-year, round trip trek to Mars, navigating the unparalleled separation could be one of the biggest challenges.

Space: The Longest Goodbye, a documentary directed by Ido Mizrahy, follows the journey of mentally preparing astronauts for long hauls and reflects on the history of NASA's psychological unit.

The film primarily follows astronauts Kayla Barron — a member of the Artemis program, which aims to send people to the moon and Mars — and Cady Coleman, who has spent over 100 days aboard the International Space Station. Perhaps the most poignant narrative is Coleman's. In 2010, she entered space and left her son, Jamey, when he was in fourth grade. Spotty video chats show Jamey's growing anguish as his mom orbited Earth for several months. Coleman wipes tears that float away in zero gravity, which emphasizes her own homesickness.

Longing for loved ones isn't the only psychological issue. Coleman details the near-constant surveillance she was under, from cameras following her every move to check-ins with psychological evaluators. The endless scrutiny made her take stock of how many feelings she should share to avoid being deemed unfit for space and then grounded, literally.

The film also tackles the coping strategies being devised in collaboration with NASA psychologists, including the development of a friendly robot intended to avert loneliness. Woven between long, wide shots of the vast emptiness of space, these vignettes provide respite for viewers who begin to vicariously experience the loneliness of space.



Space: The Longest Goodbye
NOW STREAMING
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Space: The Longest Goodbye is terrifying and hopeful, wistful and thrilling, reflective and overwhelming, all the contradictions present in the reality of being an astronaut. — *Helen Bradshaw*

On the Move
Abrahm Lustgarten
FARRAR, STRAUS AND GIROUX, $30

BOOKSHELF

A sobering look at climate migration

Ellen Herdell's nerves were nearing a breaking point. The forty-something, lifelong Californian had noticed her home was increasingly threatened by wildfires. After relatives lost their house to a blaze and the constant threat traumatized her 9-year-old daughter, Herdell found herself up at 3 a.m. one night in 2020 searching Zillow for homes in Vermont.

She's not alone. Across the United States, people facing extreme fires, storms, floods and heat are looking for the escape hatch. In *On the Move*, Abrahm Lustgarten examines who these people are, where they live, where climate change may cause them to move and how this reshuffling will impact the country.

At about 300 pages, the book is a relatively quick read, but Lustgarten's reporting is deep. Leaning on interviews with such high-profile sources as former U.S. Secretary of State John Kerry and on published research, Lustgarten explains the scientific and political sides of climate migration. Anecdotes from people across the socioeconomic spectrum reveal the mind-sets of people at the front lines of the climate crisis. And the author's decades of experience as a climate journalist result in a particularly accessible analysis of the insurance landscape, which has long lent a false sense of economic safety to people living in places vulnerable to climate change.

Where will climate migrants end up? Lustgarten looks to scientists and economists for answers. Ecologist Marten Scheffer, for example, has repurposed tools for predicting where plants will thrive to identify zones that humans will find most habitable in the future.

But the book offers no list of the best places to live, as "safe" climate is only one consideration. Other necessities and comforts will also be factors, and some people won't have the resources to move to an optimal spot.

Like Herdell, Lustgarten is a Californian who has watched his state burn. Will he or Herdell leave? To find out, you'll have to read the book. — *Saima Sidik*

GERARD SOURY/THE IMAGE BANK/GETTY IMAGES

The drastic decline of migratory fishes

Migratory species don't travel with a passport, but they cross borders all the time. This makes the animals' conservation a uniquely challenging, international effort.

That effort needs a lot of work, researchers argue in the first "State of the World's Migratory Species" report, published February 12 by the United Nations Environment Programme.

The report is the most comprehensive tally of the over 1,000 species protected under an international treaty called the Convention on the Conservation of Migratory Species of Wild Animals, or CMS. Nearly half of CMS species are experiencing population declines. Of those, fishes are faring the worst: Ninety-seven percent, roughly 56 species, face extinction. That includes Chilean devil rays (*Mobula tarapacana*, shown above).

"It's that real decline in fish species that … is keeping me up at night," Kelly Malsch of the U.N.'s World Conservation Monitoring Centre said at a news conference in February.

The goal of the report is to guide strategies for the protection of migratory species, including mammals, birds, reptiles, amphibians and insects. These groups overall are faring better than fishes, but the report still shows that 1 in 5 of all species covered by the treaty are at risk of extinction. While much of the data are alarming, success stories like the recovery of humpback whales may provide ideas for protecting other species, including fishes.

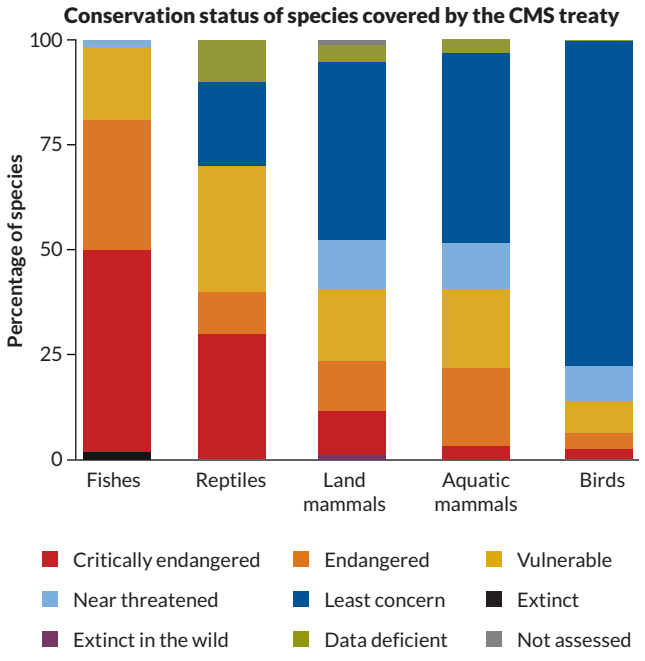
U.N. researchers reviewed data from the International Union for Conservation of Nature Red List of Threatened Species and found a 90 percent average decrease in the abundance of CMS-listed fishes since 1970. No other group of CMS-protected animals experienced an average decrease. The main culprits for fish declines include bycatch (the accidental catching of fish), overfishing and pollution, the report notes.

The report also identifies as vulnerable almost 400 other migratory species not under the treaty's protection, including more than 200 fish species — most of which have decreasing populations, like the zebra shark (*Stegostoma tigrinum*).

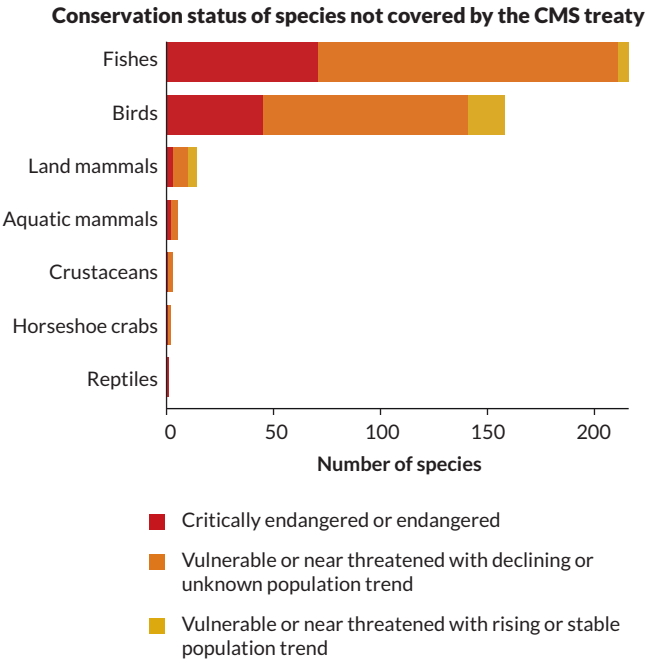
"When you drill down into it, very few fish species are actually protected," says Richard Caddell, an expert in marine and environmental law and policy at Cardiff University in Wales. Only a few, like those heralded for caviar, are well protected, mainly because of their commercial value.

Protecting migratory species on land across multiple countries is hard enough. But when it comes to animals in water, it's a whole other beast. Most of the ocean is a mystery, and new environments are still being discovered, making conservation efforts harder.

And fish have another problem — they're not sexy, Caddell says. Fish don't draw conservation funding and international recognition the way gorillas, elephants and other charismatic megafauna do. "People think of a fish as being something that



Danger zone A tally of how over 1,000 migratory species are faring shows fishes are doing much worse than other groups. Among all animal groups covered by the CMS treaty, fishes have the highest percentage of critically endangered or endangered species. Insects are not shown because the treaty covers just one species: monarch butterflies (*Danaus plexippus*). While the species as a whole is classified as being of least concern, migratory monarchs are considered endangered.



In need of protection The CMS treaty covers only about a quarter of all migratory species. Of about 3,300 species not covered by the treaty, nearly 400 (shown above) are considered endangered, vulnerable or near threatened. As with those covered by the treaty, fishes top this list as well.

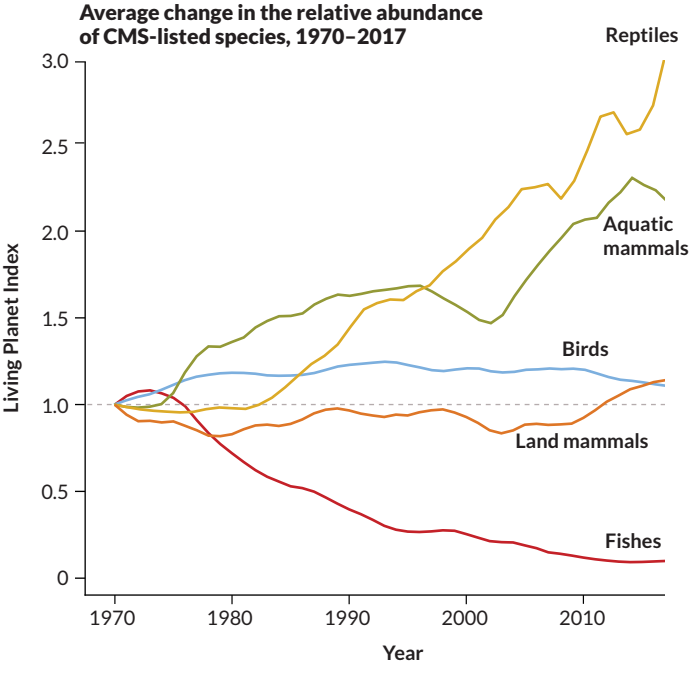
ends up on their plates," he says.

This report might help change that. It recommends ways to protect migratory fish species from pollution and bycatch, like attaching LED lights to nets to deter certain fish. But it also keeps fishes in the spotlight, weaving the discussion of them throughout the report. Making their decline central to the report may help others take notice, Caddell says.

"States not acting might not be [failing to protect fish] out of malice or negligence," he says, "but out of sheer ignorance as to the true conservation status of a number of these animals, which is why a report like this is brilliant."

More than 100 countries have signed and ratified the CMS since its establishment in 1979. The United States is not one of them, but it has agreed to elements of the treaty focusing on marine mammals and sharks. But even for nations that have ratified the CMS, there are no real legal penalties if they don't follow the treaty. Instead, Caddell says, reports like this new one remind those involved to do better.

"I think this report is a very, very welcome development," he says. "There's an opportunity here to build a little bit of political momentum to try to think about fish in a different way. And to move away from ... we're just there to eat them." — *Helen Bradshaw*



Fish in decline Most groups of migratory animals covered by the CMS treaty saw either an average increase in population from 1970 to 2017 or a stable trend. But migratory fishes plummeted, experiencing an average population decline of about 90 percent. The trends above track the Living Planet Index, a widely used metric for describing the average relative population change among species in each group.

ALL: T. TIBBITTS; SOURCE: U.N. ENVIRONMENT PROGRAMME

FEBRUARY 10, 2024

A taste for toxins

Researchers have identified a protein that may help a poison dart frog collect toxins from food and transport them to the frog's skin, ***Erin Garcia de Jesús*** *reported in "How poison dart frogs hoard toxins in their skin"* (SN: 2/10/24, p. 4).

Poison dart frogs eat toxic insects. Reader **Robert Schier** wondered about when frogs eat a nontoxic diet: "Do they not have poisons in their skin?"

In the wild, poison dart frogs chow down on insects that may pick up toxic alkaloid compounds from plants. In captivity, the frogs are fed nontoxic food, and they don't have poisonous skin, **Garcia de Jesús** says. Researchers at the Smithsonian's National Zoo and Conservation Biology Institute are exploring whether adding alkaloids to frog food can make captive frogs destined for reintroduction to the wild "spicy" again—to ensure the frogs return home with their defense mechanism against predators.

Tardigrade survival

Changes to an amino acid trigger hardy tardigrades to go into a state of suspended animation. In this dormant state, the microscopic animals curl up, turn their insides to glass and slow their metabolism to imperceptible levels, allowing them to be nearly invincible when times are tough, ***Tina Hesman Saey*** *reported in "Here's the key to tardigrade survival"* (SN: 2/10/24, p. 10).

Reader **Robert Schier** was curious to learn more about this feat of survival. "If some metabolism is continuing, does that mean the animals will eventually starve or that waste products will continue to build up?"

Scientists debate whether tardigrades have metabolism in the dormant state at all. Comparative physiologist **Hans Ramløv** of Roskilde University in Denmark says tardigrades are essentially dead when their insides dry up and turn to glass. "How can they have metabolism? I mean, there's no bloody water!" Tardigrades can go dormant when exposed to temperatures as low as absolute zero, where, by definition, there is no metabolism, he says. (At least, no organized metabolism; some random chemical reactions may still occur.) Evidence also suggests that a tardigrade's biological clock stops during dormancy, an indicator that there's no metabolism.

Not every tardigrade can be revived after decades of dormancy. That may be because of extensive damage that the animals can't repair quickly enough upon reawakening, **Ramløv** says.

Correlation vs. causation

Teenage brains may be especially susceptible to the harms of THC, the main psychoactive chemical in marijuana, potentially upping the risks of addiction, psychosis, depression and other mental health concerns, ***Aimee Cunningham*** *reported in "Teen brains and THC don't mix well"* (SN: 2/10/24, p. 8).

Several readers said that the story seemed to imply that marijuana use caused teens' mental health problems, but most of the evidence presented was correlational.

"The article clearly shows that depressed teens use marijuana more frequently [than nondepressed teens do] but doesn't give evidence that the marijuana caused the depression," reader **Mark Sneeringer** wrote. Reader **Anne Barschall** made a similar point: "How do we know whether teens who use cannabis are not just a self-selecting group who are already experiencing mental illness symptoms and therefore more likely to be diagnosed later?"

Science News appreciates the feedback and the reminder to be more explicit that an association is a link between two factors and does not mean that one factor caused the other. We recognize that being precise about correlation vs. causation is especially important in stories regarding health.

Correction

"Mapping U.S. earthquake risks" (SN: 3/9/24, p. 32) mistakenly identified southwestern Missouri instead of southeastern Missouri as a ground-shaking hot spot.

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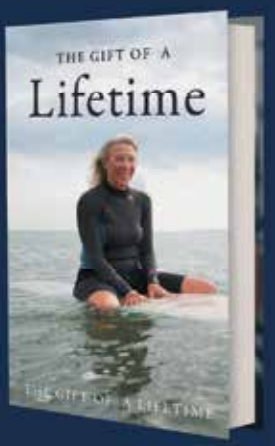

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