Science News Explores

December 2023/January 2024

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A FROZEN OASIS

BIZARRE BLACK HOLES

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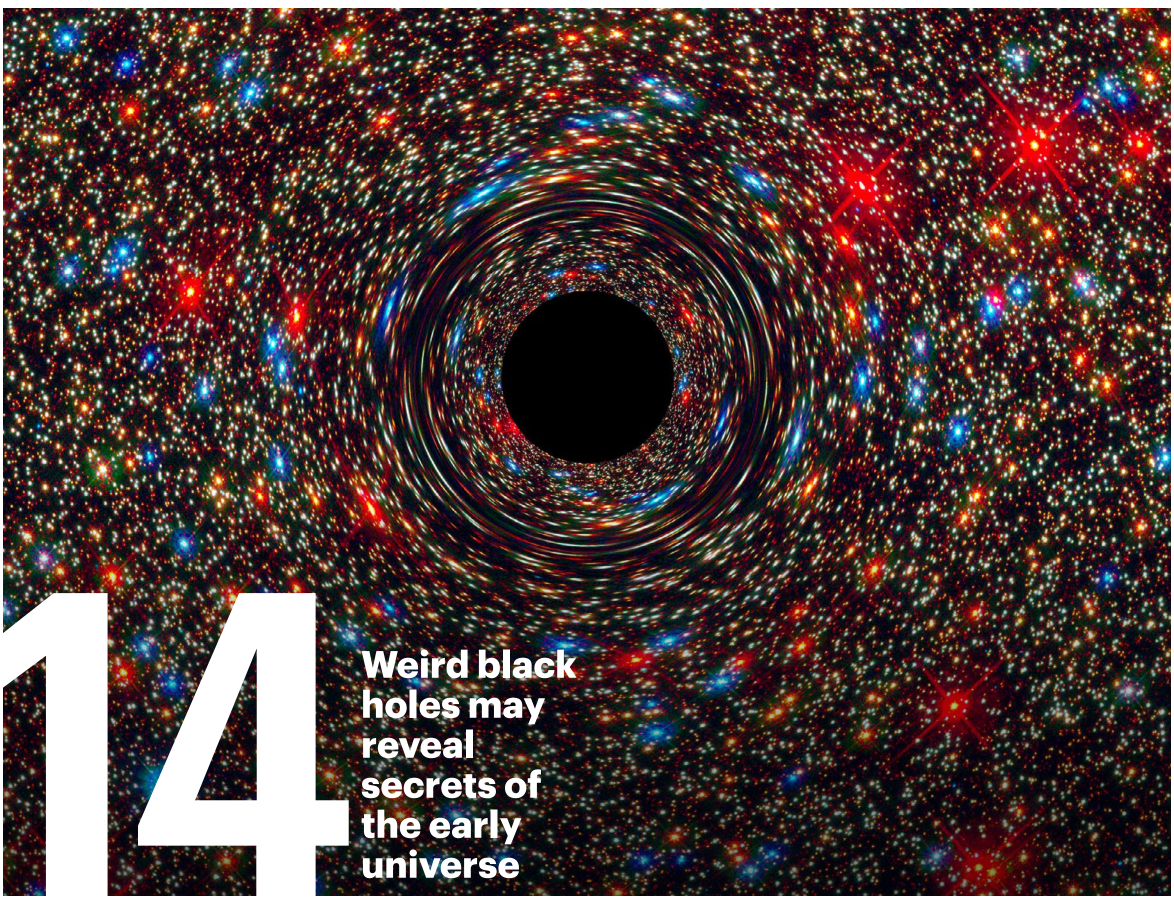

NASA, ESA, AND D. COE, J. ANDERSON, AND R. VAN DER MAREL (STSCI)

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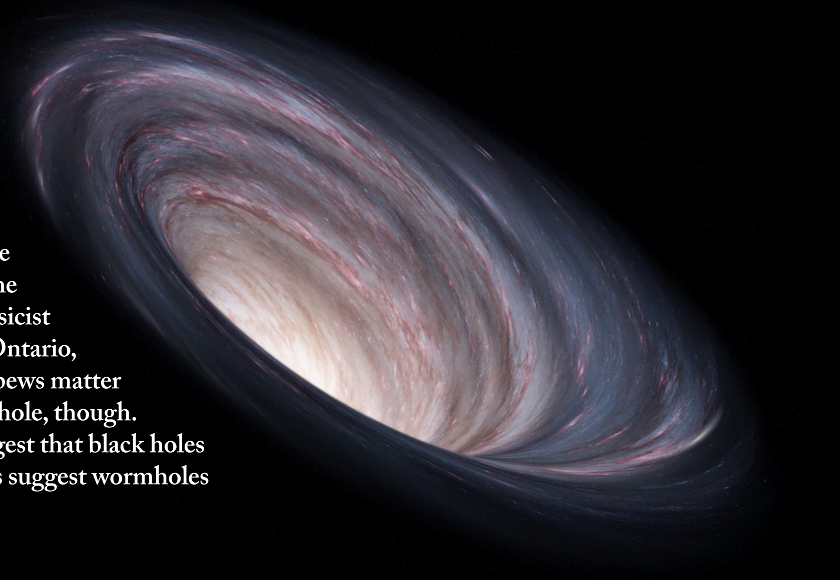


Q Is there a white hole on the other side of a black hole?

— Briar R.

A A black hole is an area of space where gravity is strong enough to pull in any nearby matter. This gobbled-up matter is crunched into a point of infinite density known as a singularity. A white hole works in the opposite way, says Farshid Soltani. This theoretical physicist studies black holes at Western University in London, Ontario, in Canada. Instead of sucking matter in, a white hole spews matter out from its singularity. No one has ever found a white hole, though. For now, they only exist in theories. Some theories suggest that black holes transition into white holes, says Soltani. Other theories suggest wormholes connect black and white holes.

Q How can uterus-owning people sync up their periods?

— Charlotte

A Menstrual bleeding, or a period, happens when the body expels the lining of the uterus. So far, scientists have found little evidence for people syncing their periods — when two or more people have their period at the same time. In 1971, a researcher at Harvard University in Cambridge claimed to have observed synced periods while studying 135 college students living in a dormitory. When other scientists looked at her work, however, they found flaws in how the study was conducted. Since then, experiments trying to repeat those results have failed. For now, synced periods seem unlikely. Medications, stress and long-term illness, though, can all affect when — and if — someone experiences menstrual bleeding.

Q Why does static electricity happen with some things, like balloons and wool socks, and not other things, like hardwood floors or glasses of water?

— Regina D.

A Static electricity builds up when negative charges called electrons pass from one object to another. This can happen when the two objects rub together. For instance, when you rub a balloon against your hair, some electrons from your hair move to the balloon, creating static charge. (The hair strands that lose electrons become positively charged. And since they have the same charge, they repel each other — causing your hair to stand up.) Some materials are better than others at releasing or gaining electrons. Hair, glass and wool easily release electrons. Rubber balloons, paper and silk more easily collect these charges. The more easily one object loses electrons and the more easily the other object gains them, the more static charge can build up between them. Wool tends to release electrons. Polyester and other common carpet materials tend to gain electrons. So when you shuffle your wool sock–covered feet against carpet, you get static electricity. But glass and human hands are both liable to lose electrons, so not much static builds up between them.

Do you have a science question you want answered? Reach out to us on Instagram (@SN.explores), or email us at explores@sciencenews.org.

Sarah Zielinski
Editor, *Science News Explores*

FIND OUT MORE USING THE QR CODES.

MUHAMMED BENCEH/SHUTTERSTOCK

MICROBES

The power of a single photon

Photosynthesis starts with just one particle of light

A single photon is enough to kick off photosynthesis.

Photosynthesis transforms sunlight into chemical energy. Plants, algae and some bacteria use the process to make the fuels they need to grow. And just one particle of light, or photon, can spark this amazing reaction.

A research team showed this with light-absorbing structures from a bacterium. Called LH2, they contain bacteriochlorophyll, which is similar to the chlorophyll found in plants. The structures normally trigger the first step of photosynthesis.

The team used a light source that makes just two photons at a time. One photon acted like a timekeeper to signal when the pair had been released. The second photon shone on the LH2 structures.

Absorbing that one photon caused LH2 to give off another photon with a different wavelength (light hue). The change of wavelength was a sign. It showed that energy had passed from one ring of molecules in LH2 to another. And that's a first step of photosynthesis.

The first steps in the process are pretty similar in plants and bacteria, says Graham Fleming. This chemical physicist works at the University of California, Berkeley. But in plants, four photons are needed to complete the process. He was part of the team that shared the finding in *Nature*.

Earlier experiments used light from lasers, which shine dense beams of photons. Using only a single photon more closely mimics natural photosynthesis, says Richard Cogdell. He's a biochemist who did not take part in the tests. He works in Scotland at the University of Glasgow.

"You can really work out what's happening," he says. It's as if "you could shrink yourself down and watch."

— *Emily Conover*

Rhodobacter sphaeroides bacteria (a group shown here) need just one photon to start photosynthesis.

PLANTS: FOTOHUNTER/SHUTTERSTOCK; INSET: ARGONNE NATIONAL LABORATORY (CC BY-NC-SA 2.0)

What's on your mind? A brain decoder might be able to tell

But it only works if you let it

Like Dumbledore's wand, a scan can pull long strings of stories straight out of a person's brain. But it only works if that person cooperates.

This "mind-reading" feat has a long way to go before it can be used outside the lab. But the result could lead to devices that help people who can't talk or communicate easily. The research was described in *Nature Neuroscience*.

Scientists have tried to pick up people's thoughts by implanting devices in their brains. Such devices have been able to "read" some words from thoughts. This new system, though, requires no surgery. And it works better than other no-surgery attempts to listen to the brain.

The researchers tested the new method on three people. Each person lay inside a bulky MRI machine for at least 16 hours. They listened to podcasts and other stories. At the same time, the machine measured changes in blood flow in the brain. These changes give a general idea of brain activity.

Alexander Huth and Jerry Tang collected the data from the MRI scans. Both are computational neuroscientists at the University of Texas at Austin. Then they added another tool: a computer language model. This model was built with GPT — an early version of the same models used by today's AI chatbots.

The language model helped the researchers match patterns of brain activity to certain words and ideas. Then the team worked backwards. They used brain activity patterns to predict new words and ideas. The process was repeated over and over. A decoder ranked the likelihood of different combos of words. Then it used the brain activity patterns to help pick the most likely. In this way, it pulled out main ideas.

The word-for-word error rate was high, over 90 percent. But it paraphrases pretty well, Huth says. "It gets the ideas." For instance, a person heard, "I don't have my driver's license yet." The decoder then spat out, "She has not even started to learn to drive yet."

The research does raise concerns about eavesdropping on private thoughts. "We know that this could come off as creepy," Huth says. "It's weird that we can put people in the scanner and read out what they're kind of thinking."

The researchers addressed this in the study. Each decoder was quite personalized. It worked only for the person whose brain data had helped build it. What's more, a person had to cooperate for the decoder to work. If a person wasn't paying attention to an audio story, the decoder couldn't pick that story up from brain signals. People could block the eavesdropping effort by ignoring the story and thinking about something else.

"I'm glad that these experiments are done with a view to understanding the privacy," says Gopala Anumanchipalli. Though not part of the study, he's a neural engineer at the University of California, Berkeley. "I think we should be mindful, because after the fact, it's hard to go back and put a pause on research."

— *Laura Sanders*

Brain scans plus computer language models let scientists figure out the gist of what people were thinking.

DRAFTER123/DATA VISION VECTORS/GETTY IMAGES PLUS

MATERIALS

Recycled diapers helped build this house

Using diapers as construction materials could cut landfill waste

There are diapers in this house — but not where you might think. Used diapers partly make up its floors, columns and walls.

To build a new house, researchers mixed recycled disposable diapers into concrete and mortar. The single-story home has two bedrooms and a bathroom. Recycled diapers replace nearly 2 cubic meters (70 cubic feet) of its building materials. The researchers described their project in *Scientific Reports*.

Repurposing diapers to make building materials would shrink the amount of trash that goes to a landfill. It could also make homes more affordable. That's a big need in developing countries such as the Southeast Asian nation of Indonesia.

Environmental engineer Siswanti Zuraida is from Indonesia. She now works at the University of Kitakyushu in Japan. Zuraida and her colleagues tried replacing some of the sand, gravel and other materials in mortar and concrete with used diapers.

The team washed, dried, sterilized and shredded diapers. Then they made six samples of concrete and mortar. Each used differing amounts of diapers, cement, sand, gravel and water. Crushing the samples in a machine revealed how much weight each could bear. Adding more diaper material reduced the mixture's strength.

The team designed a small home based on the maximum amount of diaper waste they found they could use. In their one-story house, recycled diapers could replace up to 27 percent of the materials in load-bearing structures, such as columns and beams.

A three-story home could only use up to 10 percent disposable diapers in load-bearing structures. But parts of homes, such as walls that divide rooms, don't have to support a lot of weight. There, shredded diapers could replace up to 40 percent of the sand.

But there are big hurdles to adopting diapers as building materials, Zuraida says. Diapers' plant-based fibers can be used for building. But their plastic parts would have to be separated out. Plus, it's tricky to separate dirty diapers from waste and sanitize them.
— *Carolyn Gramling*

MUHAMMAD ARIEF IRFAN

Homes made partly of recycled diapers could help reduce landfill waste and make housing more affordable.

Think you know what you're seeing? Find out on page **32**

A FROZEN OASIS

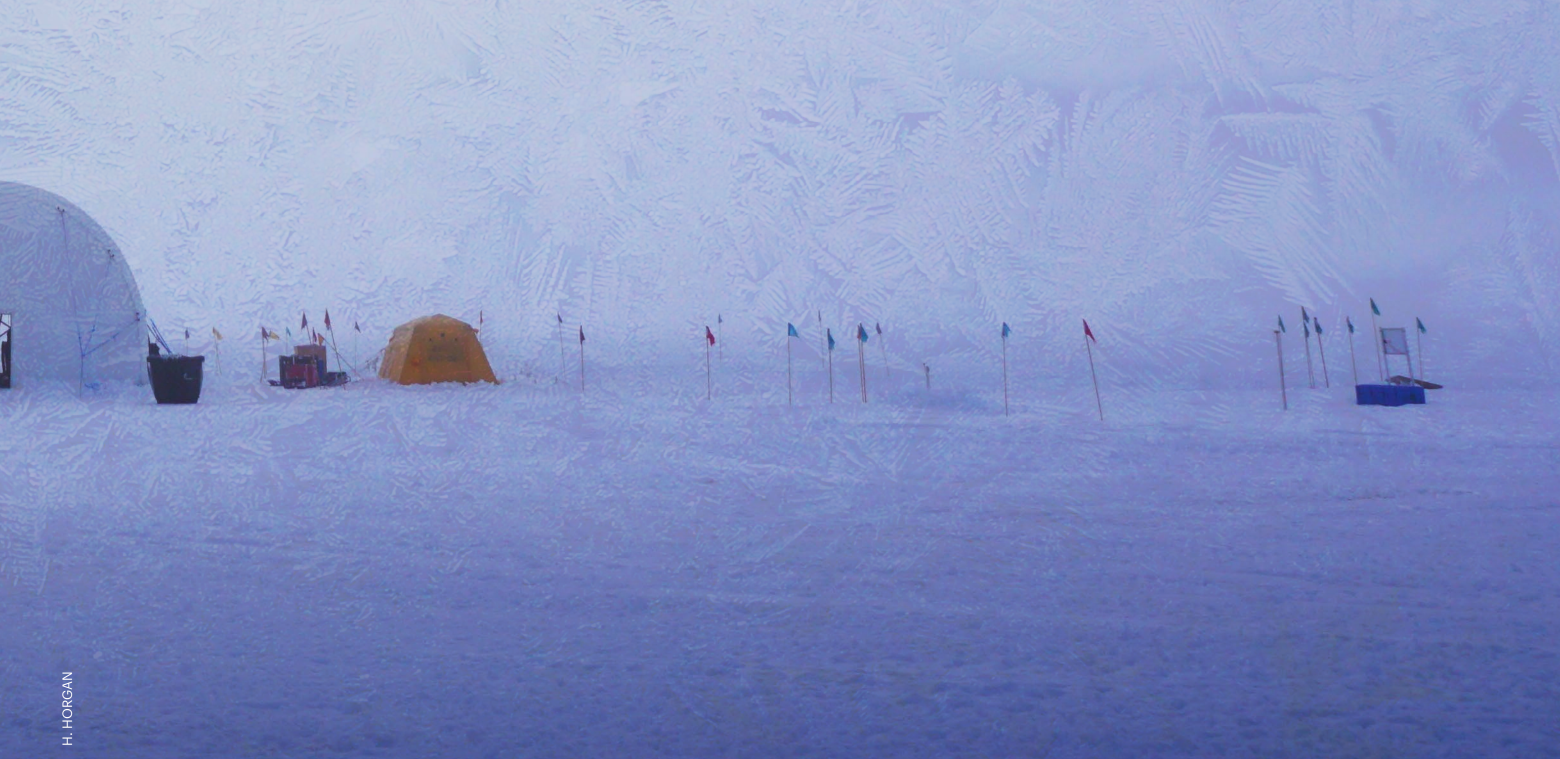
Scientists set up this camp on the Kamb Ice Stream in December 2021. The big tent housed a hot-water drill used to melt a deep hole in the ice.

By **Douglas Fox**

A natural ‘cathedral,’ deep under Antarctic ice, teems with life >>

The coastal plain of the Kamb Ice Stream hardly seems like a coast at all. Some 800 kilometers (500 miles) from the South Pole, this glacier is oozing slowly off the coast of West Antarctica. From atop it, you see nothing but flat white extending in every direction. As this conveyor belt of ice flows out beyond the coast, it forms a floating shelf that extends hundreds of kilometers (miles) out to sea.

But this flat, boring landscape hides a secret.



H. HORGAN

Beneath roughly 700 meters (2,300 feet) of ice sits a vast, muddy marsh. Through it meanders a river that eventually empties into the ocean. Along the way, that river has been carving a massive cavern into the ice above.

This cathedral-like structure is full of water. And it's huge: 10 kilometers (6.2 miles) long and nearly tall enough for the Empire State Building to stand inside.

Until recently, no human had ever seen inside this cavern. But in late 2021, scientists from New Zealand melted a narrow hole through its icy roof. They lowered a camera through the hole for the first peek into this water-filled structure.

Craig Stevens will always remember his first look. He stared as the camera's floodlights raked across delicate crests and waves etched into the cavern's icy ceiling. They resembled the dreamy ripples that might take thousands of years to form in a limestone cave. Stirred up by rising currents, bits of reflective silt drifted like snowflakes through the cavern's water.

Stevens is an oceanographer. He works for New Zealand's National Institute of Water and Atmospheric Research in Wellington. The video seemed to show "the interior of a cathedral," he says. A cathedral of ice.

That cavern offers a window into a major subglacial river. That river flows beneath the ice on its way to the ocean. In some ways, it's like an artery. By listening to it, scientists can take the pulse of the ice sheet. They can eavesdrop on the private life of the ice, which is changing rapidly as the climate warms.

Rivers running uphill

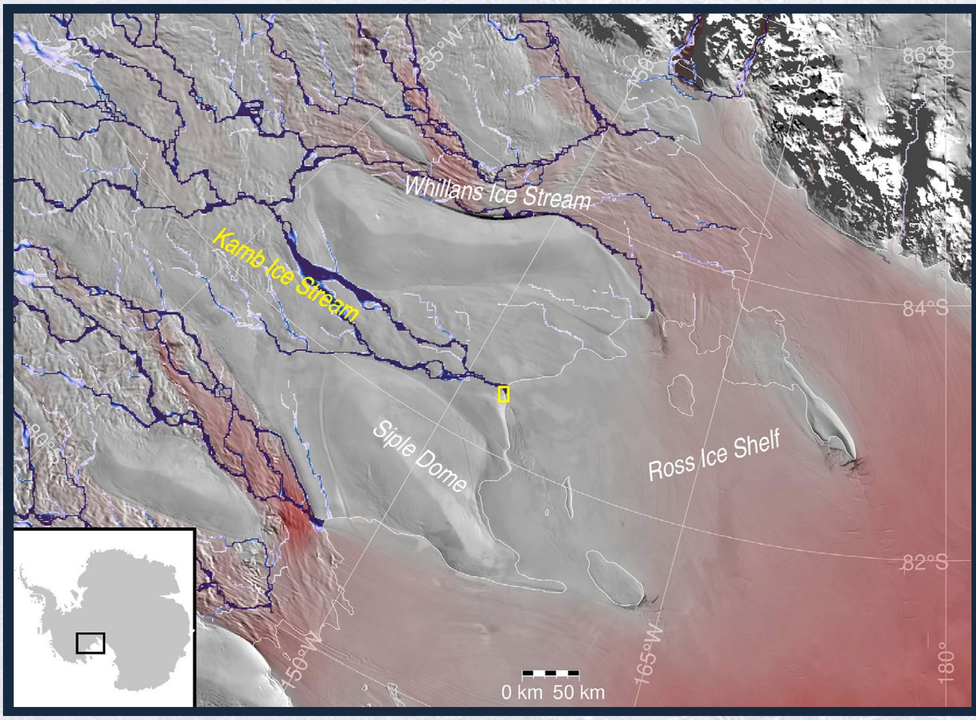
Roughly 98 percent of Antarctica is covered in glacial ice. Its thickness ranges from a few hundred meters to nearly five kilometers (three miles). Scientists had long believed that a thin film of liquid water sits beneath much of this ice. That water comes from ice melting on the glacier's underbelly. Heat seeps into the ice from deep inside the Earth. It melts slowly — at a rate of several penny-thicknesses a year.

In 2007, Helen Amanda Fricker reported that the meltwater can collect, forming large subglacial lakes. At times, they can overflow, unloading huge floods of water.

Fricker is a glaciologist at the Scripps Institution of Oceanography in La Jolla, Calif. Ice sitting above a lake, she noticed, rises as the lake fills then falls as it empties. To measure this up and down motion, she analyzed data from satellites. These spacecraft shine laser beams onto the ice and then time how long it takes that light to reflect back up. The ice can move up and down by as much as 10 meters (about 33 feet) over a couple of years, she found. This method allowed her to map the locations of lakes under the ice.

More than 600 of these lakes have now been mapped. A couple dozen sit under the Kamb Ice Stream and neighboring glaciers.

These lakes have generated great interest. Biologists expected them to harbor life. And in 2013, a U.S. team found plenty in one lake that Fricker had discovered. Called Lake Whillans, it sits beneath



The Kamb Ice Stream (middle left) is a glacier that oozes off the coastline of West Antarctica (see inset). The wiggly blue lines show the likely paths of subglacial rivers — rivers that flow beneath the ice. The small yellow box near the center shows the location of the Kamb ice cavern, where one of these subglacial rivers flows into the sea.

A. WHITEFORD ET AL/*JOURNAL OF GEOPHYSICAL RESEARCH: EARTH SURFACE* 2022

Scientists got their first glimpse into the hidden landscape in late 2021, when they drilled a borehole through 500 meters of ice and lowered instruments (inset) to observe the cavern below.

800 meters (a half mile) of ice, just south of the Kamb Ice Stream. Its water was teeming with single-celled microbes — some 130,000 per milliliter (fifth of a teaspoon) of water, scientists found.

By the time the lake was drilled, scientists were also becoming interested in the rivers flowing under the ice. But finding those rivers was hard. We normally expect rivers to flow downhill. In Antarctica, though, the weight of ice pressing down on a river also influences its flow. So beneath glaciers, water flows from places where the overlying ice is thick (and the pressure high) to spots where the ice is thinner (and the pressure lower). This means some subglacial rivers will actually run uphill!

Exploring a hidden world with radar

In 2015, a lucky clue led Huw Horgan to one such river.

Horgan is a glaciologist. Back in 2021, he worked for Victoria University of Wellington, in New Zealand. (He has since moved to ETH Zurich, in Switzerland.) While looking at a satellite photo of the Kamb Ice Stream, he noticed a dark spot. It marked a long, shallow groove on the surface of the ice. Horgan wondered if the ice sagged there because it was being melted from below. That groove might mark a river flowing toward the ocean.

But he would not grasp the sheer size of what lay beneath the ice until December 2019. That's when he visited the location with Arran Whiteford, a PhD student also at the Victoria University of Wellington.

Antarctica's ice is generally quite flat. So the surface groove was obvious to Whiteford when he arrived. It slanted no more dramatically than a rolling cornfield in Iowa. Yet in contrast to the surrounding ice, he recalls, it "looked like this massive chasm."

For 10 days, Whiteford mapped the buried river channel using ice-penetrating radar. Horgan and another graduate student helped.

It was tedious. For six to 12 hours a day, they towed the radar behind a snowmobile. At night, the researchers huddled in a tent looking at the radar traces. Their data painted a dramatic picture.

Based on the size of the surface groove, the researchers expected the river channel on the bottom to cut 10 or 20 meters (33 to 66 feet) up into the ice. But it was larger. Much larger.

Below their boots sat a vast, water-filled passage with steep sides. They had discovered the Kamb ice cavern. It was like a train tunnel — but *really* big. It cut halfway through the overlying ice, to a height of 350 meters (more than 1,100 feet). It gaped 200 meters (650 feet) to a kilometer (3,280 feet) wide. And it really did resemble a river, says Whiteford, as "it kind of meanders downstream."

An upside-down waterfall

Once back in New Zealand, Whiteford examined old satellite images. These, too, showed the surface groove that marked the cavern below. That cavern had started forming at least 35 years earlier, the images showed.

Far below the ice, it began as a short blip where the mouth of the river pours into the sea. Over decades, the cavern got longer. It followed the path of the river, reaching ever further upstream and inland.

Whiteford and Horgan have a theory of how the cavern formed. The river's water is probably less than 0.1 degree Celsius (0.18 degree Fahrenheit) above freezing. That's not warm enough to melt much ice. So Horgan believes that to erode the ice and form this cavern, the river has been stirring up warmer ocean water at its mouth.

These rivers can exert really powerful mixing forces, says Christine Dow. She's a glaciologist at the University of Waterloo in Ontario, Canada. As they empty into the ocean, some of these rivers are moving up to two meters (6.6 feet) per second, she calculates. That's as fast as a whitewater river.

The subglacial river contains much less salt than seawater does. So it's far less dense. As the river water enters the ocean, it rises quickly against the upward-slanting ceiling of ice. As it rises, it pulls turbulent swirls of ocean water up with it. "I think of it as an upside-down waterfall," says Dow. "It's bringing up this really warm ocean water to melt the base of the [glacier]."

The ice is melting quickly there — some 35 meters (115 feet) per year, Whiteford and Horgan estimate. And they think the canyon is still growing. Fueled by intruding ocean water, it is burrowing further upstream along the river's path.

Mapping the cavern with radar was just the first step for Horgan. "We are almost prospecting," he says. "We are looking for scientific targets beneath ice sheets."

Entering the cathedral

On December 4, 2021, two tractors reached the spot where Horgan and Whiteford had visited. The tractors had traveled 16 days from New Zealand's Scott Base, on the edge of the continent. They towed a convoy of sleds packed with 90 metric tons of food, fuel and scientific gear across a thousand kilometers (620 miles) of floating ice.

Workers erected a huge tent and then assembled a hot water drill. With it, they melted 54 tons of snow. They jetted this now-hot water down through the hose and into the ice. This bored a narrow hole no wider than a dinner plate into the ice until they reached the cavern.

On December 29, the researchers lowered a camera into that hole, all the way down to the muddy river bed. What came into view astonished them.

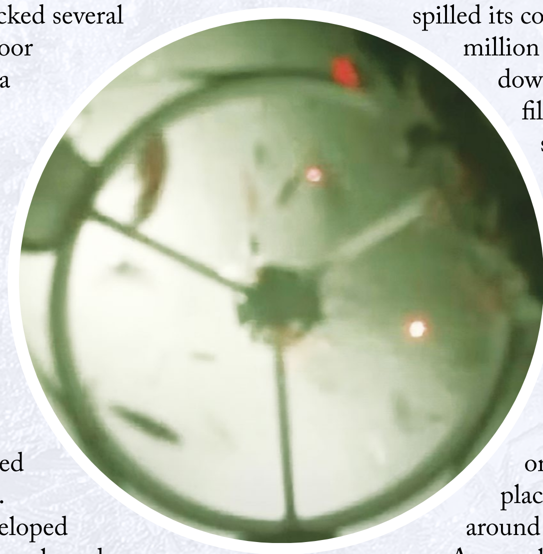
Dozens of orange shapes darted back and forth through the camera's lights. They were later identified as amphipods — shrimp-like crustaceans. Seeing them was "just complete shock," says Horgan. No one is certain how these animals are surviving in an isolated nook, 500 kilometers (more than 300 miles) from the nearest sunlit ocean.

In the days that followed, Stevens lowered several instruments to measure the water's temperature, saltiness and currents. These data seemed to confirm that the subglacial river is melting the ice by stirring up seawater.

Field work in Antarctica (above) can be quite rugged. When Arran Whiteford and Huw Horgan mapped the Kamb ice cavern in late 2019, they often cooked and ate their meals outdoors. Here, they sit in a pit behind a snow wall, to shelter from the wind.

A. WHITEFORD

A video still (right) from a camera lowered into the cavern showed swimming animals. They are thought to be shrimp-like crustaceans called amphipods, which are common in the deep oceans. But it was a surprise to find them some 500 kilometers (roughly 300 miles) inland from the edge of the ice.



Later, Gavin Dunbar plucked several cylinders of mud from the floor of the cavern. At the Victoria University of Wellington, he specializes in studying aquatic sediments. And his samples produced another big surprise.

The ice sheet's hidden pulse

Dunbar had viewed many mud cores from the seafloors around Antarctica. They always contain a jumbled mix of mud, sand and gravel. That jumble would have developed during past ice ages as glaciers plowed across the seafloor. But the cavern floor here looked different. It contained alternating layers of chunky gravel and fine mud.

Dunbar has seen this same pattern in steep seafloor canyons off the coast of New Zealand. Landslides occasionally sweep down those canyons. Each landslide leaves a single chunky layer. Between landslides, fine mud settles in.

Dunbar now believes something similar happens at the Kamb ice cavern. River floods may flush through now and then — the same type that Fricker detected with satellite data in 2007.

One flood might have passed through the cavern 10 years ago. Satellite signals showed that a small lake 20 kilometers (12 miles) upstream of the cavern spilled its contents. An estimated 60 million cubic meters of water gushed downstream. That's enough to fill 24,000 Olympic-sized swimming pools.

Studying these floods and sediment layers could help scientists understand how the subglacial landscape changes over time. In fact, scientists increasingly believe that lakes can move around as the overlying ice thins or thickens in different places — pushing the water around beneath it.

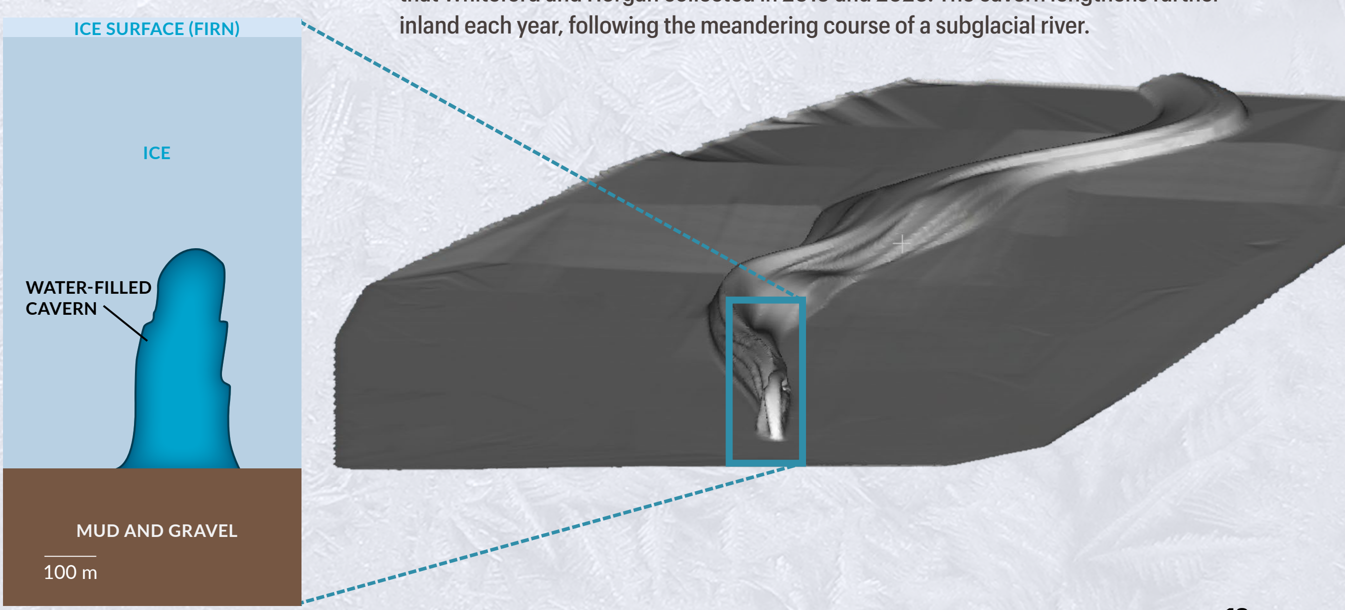
As people packed up camp at Kamb on January 11, 2022, workers widened the borehole. Then Stevens and his colleagues approached the hole one last time to lower a series of sensors.

These devices are continuing to measure the water's temperature, salinity and currents. A cable brings those data to the surface. There, a transmitter beams them to New Zealand. Horgan and Stevens hope that in this way, they can learn even more about this hidden world.

"That would just be outstanding," Horgan says. With radar, he can only see these rivers and lakes dimly. Finally, he says, "we've [been able] to stand at a river mouth and observe it." And with luck, future data might even reveal a subglacial flood rushing through the cavern.

THE CAVERN'S SIZE AND SHAPE

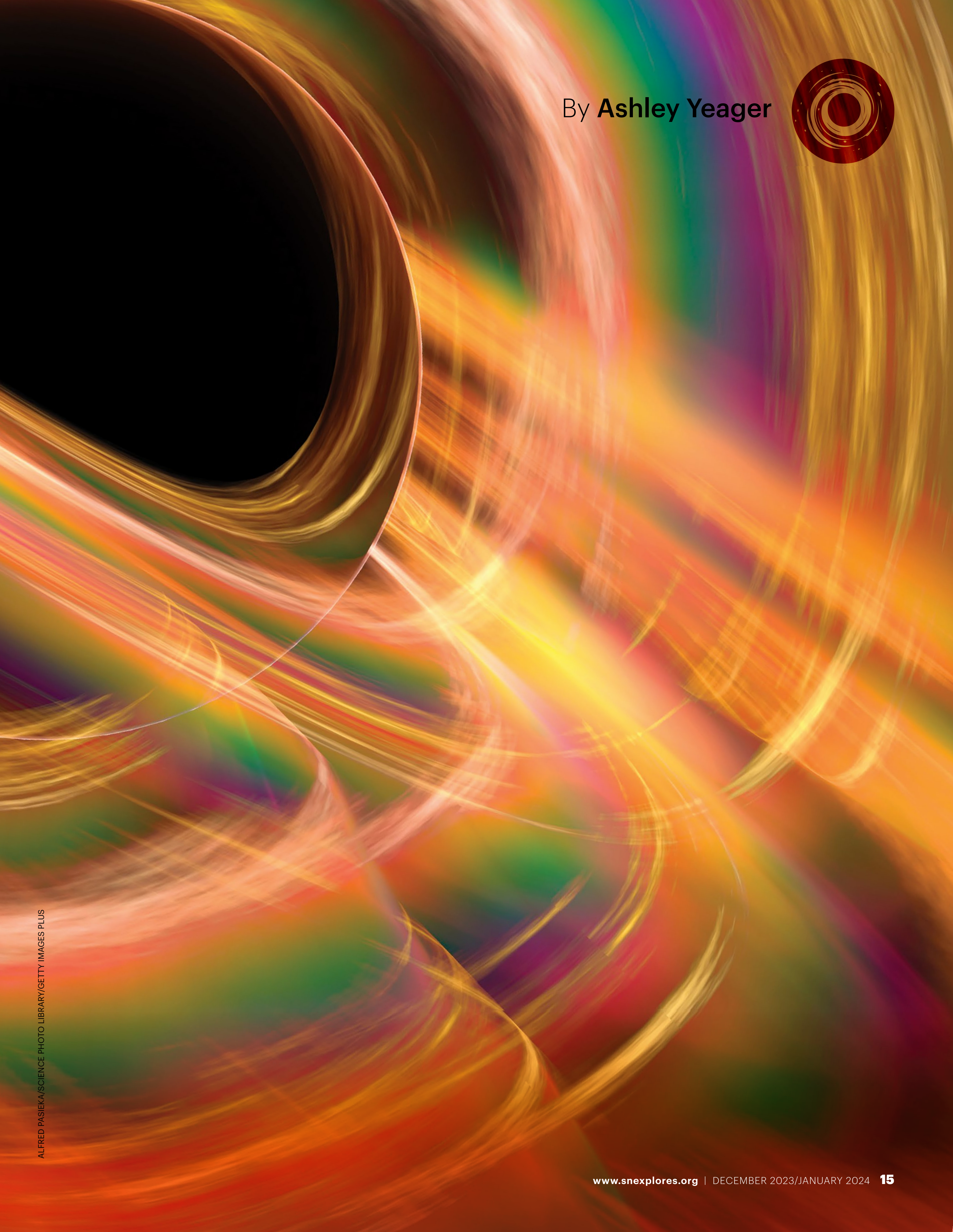
This 3-D illustration shows the shape of the Kamb ice cavern, based on the radar traces that Whiteford and Horgan collected in 2019 and 2020. The cavern lengthens further inland each year, following the meandering course of a subglacial river.



3-D: A. WHITEFORD ET AL/JOURNAL OF GEOPHYSICAL RESEARCH: EARTH SURFACE 2022; 2-D: E. OTWELL; VIDEO STILL: C. STEVENS/K862/NIWA

COSMIC ODDITIES

Weird black holes may reveal secrets of the early universe >>



ALFRED PASIEKA/SCIENCE PHOTO LIBRARY/GETTY IMAGES PLUS

By **Ashley Yeager**

A black hole at the heart of our galaxy is a hungry monster. This super dense pit of matter has a mass as much as 4 million suns. The pull of its gravity is so strong that it has swallowed nearly everything around it. And it gets heftier and heftier the more it eats. In that sense, the Milky Way's central black hole is a lot like the mythical Kammapa of the Sotho people of southern Africa.

But it's not alone.

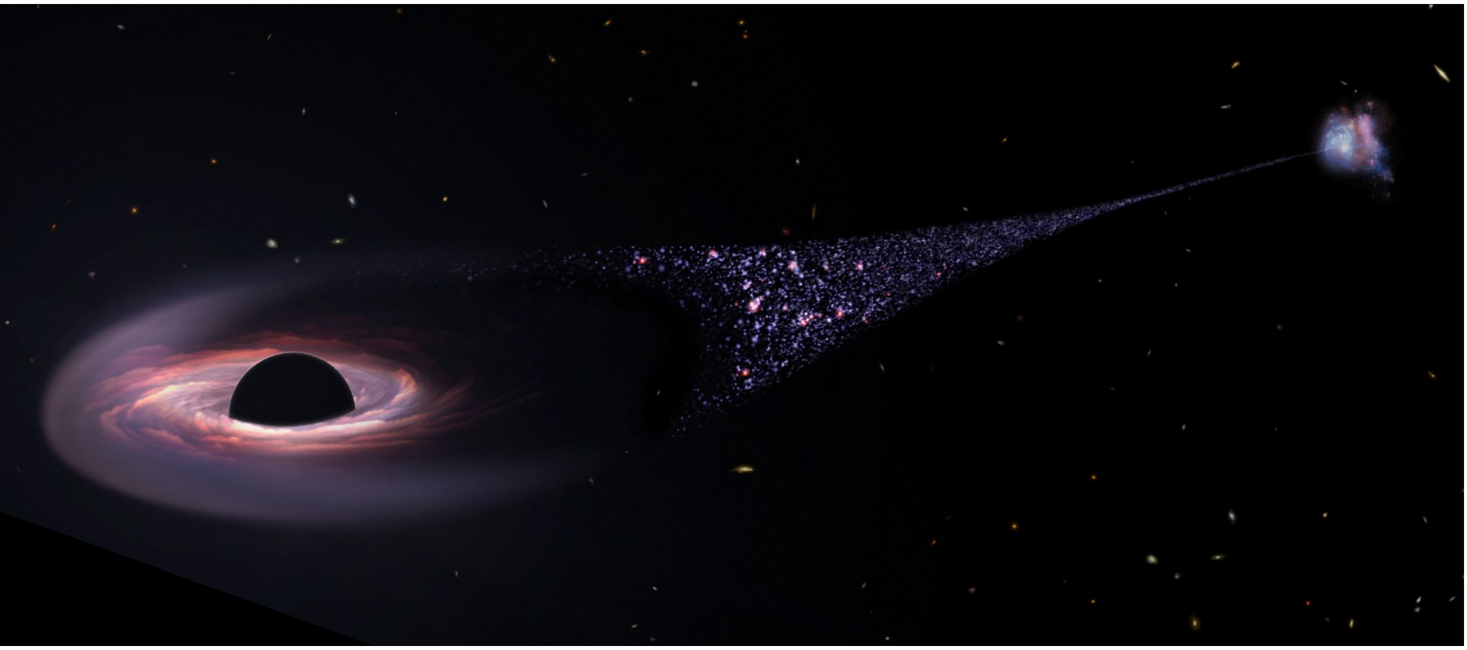
Similar supermassive black holes sit at the centers of nearly all known galaxies. Each one has a mass that's thousands, millions — sometimes even billions — of times as great as our sun's. For decades, scientists thought that such cosmic Kammapas could only be found in such places. After all, only massive galaxies were thought to have enough matter to feed these beasts.

How wrong scientists were.

About two decades ago, computer models of the earliest black holes started turning up oddities. In these models, big black holes showed up where they weren't expected. Many scientists thought those misfits were flukes. But others weren't so sure. They thought such oddballs should not be ignored.

Now, telescopes have turned up signs of several weirdo black holes. These include massive ones in the tiniest galaxies. Some of these black holes, surprisingly, don't even seem to sit at their galaxies' core. Even more intriguing, astronomers have spotted evidence of black holes wandering along the edges of their galaxies. In rare cases, some look like they're being kicked out of their galaxies altogether.

But perhaps these black holes aren't just weirdos. Maybe, in fact, they're big players in the story of our universe. If so, they could help probe one of the greatest mysteries of all. How did these cosmic Kammapas develop?



NASA, ESA, LEAH HUSTAK/STSCI; FEIG-ART

Little galaxies, big black holes

Our current understanding of how black holes get so big goes something like this. In the early universe, the cores of baby galaxies had baby black holes. Over time, galaxies grew, smashed into each other and merged. As they did so, the galaxies took on gobs of new stars, gas and dust. Meanwhile, the black holes in their centers merged and fed on all the new material.

As a result, as galaxies grew, so did their central black holes.

In this scenario, the black hole at the center of each galaxy should be around one-thousandth of the mass of its galaxy.

Not all of today's galaxies are as big as our Milky Way. Some "dwarf galaxies" have only about a ten-thousandth its mass. In order to have stayed so small, they must not have merged with many other galaxies. Each dwarf galaxy's black hole would likely have escaped merging with many other black holes.

By that logic, the black holes in dwarf galaxies should be runts — or nonexistent.

But computer models in the late 2000s started to cast doubt on this logic.

Those models showed how massive black holes could have evolved over the history of the universe. Even the smallest galaxies, they showed, could have large black holes — and right away. Some of those galaxies never grew or merged with any others. This left the galaxies small with big black holes for billions of years.

Astronomer Amy Reines found the first hints that such galaxies exist. More than a decade ago, she was looking through telescope data on a dwarf galaxy 30 million light-years from Earth. There, she spied extreme amounts of radio light and bright X-rays. That intense radiation signaled the presence of a huge black hole.

"I hadn't seen this before," recalls Reines, who now works at Montana State University in Bozeman. Like other scientists, she had assumed dwarf galaxies weren't big enough to have big black holes.

But a few months later, in 2011, Reines went to a meeting of scientists. There, she heard astrophysicist Jillian Bellovary speak. Bellovary presented some new models of galaxy formation. These suggested that even scrawny galaxies could have hefty black holes.

Reines was shocked to find her observations and Bellovary's models seemed to match.

Not long after that, Reines launched an effort to find more dwarf galaxies with outsized black holes. She is part of a team that scanned roughly 25,000 dwarf galaxies. Of those, 151 seemed to harbor a big black hole. The team shared its findings in 2013.

Like a living black hole, the mythical Kammapa devours every creature it comes across, growing bigger and bigger the more it consumes.

In 2023, astronomers spotted a black hole with the mass of millions of suns. They believe it got ejected from its host galaxy. That cosmic kick to the curb may have left a trail of stars (illustrated, left). Dwarf galaxy Henize 2-10 (above right) is located about 30 million light-years from Earth. Astronomer Amy Reines' work hints it may host another supermassive black hole.

X-RAY: CXC/NASA, UNIV. OF VIRGINIA, A. REINES *ET AL*; RADIO: NRAO/AUI AND NSF; OPTICAL: NASA, STSCI

Weighing origin stories

If models like Bellovary's were right, the observed dwarf galaxies with big black holes most likely formed that way in the early universe. Since then, they've been relatively untouched by mergers.

If true, looking at these ancient relics might tell us something about the very first generation of black holes to exist. That includes those that eventually grew into today's supermassive monsters, such as the one at the center of the Milky Way.

For instance, the mass of a black hole in some dwarf galaxy should be similar to the mass of some of the earliest black holes. So looking at black holes in dwarf galaxies could help astronomers figure out the starting mass of the original black holes. That, in turn, could help scientists tease out how those first black holes formed.

Right now, there are two leading ideas for how the first black holes developed. Each idea creates black holes of different masses.

The first idea has black holes forming as the first stars collapsed. This process would tend to create pretty lightweight black holes. The other idea: Those first black holes could have formed from giant gas clouds that collapsed in on themselves. Those black holes should start out heavier.

The dwarf galaxy that Reines observed seems to have a mass equal to a few million suns. That's a lot of suns. It's one point in favor of the cloud-collapse idea. But it's just one data point. And measuring the mass of black holes is not easy.

Luckily, there are other clues scientists can use to learn how the first black holes formed. These hints come from an even odder type of black hole: massive ones that don't sit right at the centers of their dwarf galaxies.

Wandering black holes

Remember Bellovary's computer models of the earliest black holes? Big black holes in scrawny galaxies weren't the only surprise her models turned up. Those models also suggested that some of those large black holes wandered near the edges of dwarf galaxies.

"I always like to think about the outliers, or the weird little rejects," says Bellovary. She's now based at Queensborough Community College in New York City.

Bellovary ran her models again. She zoomed in on the littlest galaxies. When she did, half of the massive black holes in dwarf galaxies would be off-center. She and her colleagues shared this finding in 2019.

As if on cue, a few months later Reines had data to support those models. Her team's observations came from radio telescopes in New Mexico known as the Very Large Array. The researchers peered at 111 dwarf galaxies. Thirteen most likely had big black holes. Of those 13, a few seemed to sit off-center from their galaxies' cores.

Finding wanderers was a jackpot. "Once a black hole starts wandering, it does not grow in mass anymore," says Marta Volonteri. That means stray black holes should roughly match the starting masses of the first black holes even *more* closely than those at the centers of dwarf galaxies. Volonteri is an astrophysicist. She works for the Institute of Astrophysics in Paris, France. It's at Sorbonne University.

Sadly, the mass of the wanderers is even harder to estimate than the ones at their galaxies' cores. That makes it difficult to judge whether they match the star-collapse or cloud-collapse theory, based on their weight. But the overall number of wanderers can offer hints about how they formed.

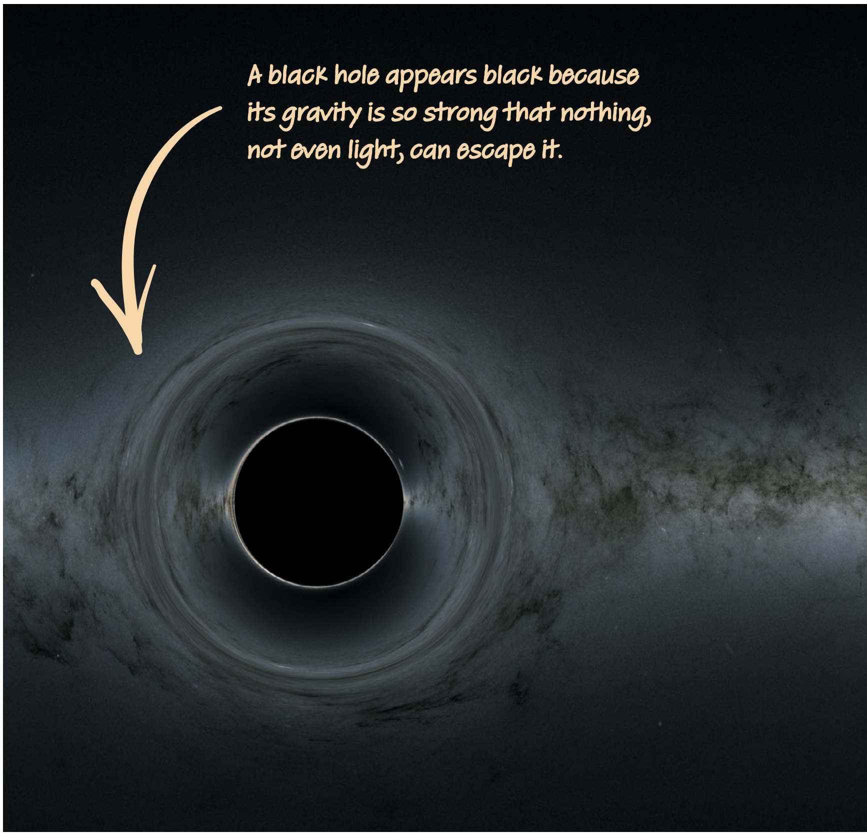
Studying weirdos

If the earliest black holes formed from huge gas clouds collapsing, then wanderers should be pretty rare in dwarf galaxies. That's because converting a gas cloud's mass into a black hole is quite hard. So that should make it a rare event. If the first black holes came from collapsing stars, though, they should be more common. The reason is that stars can collapse into black holes pretty easily.

Signs of wanderers keep popping up. That has researchers leaning away from the cloud-collapse idea. But scientists don't just want to know how the first black holes formed. They also want to know how some of them grew to become among the most massive black holes.

To find out, astronomers must look at a different type of cosmic weirdo.

X-ray light (pink in inset) coming from the edge of a galaxy some 4.5 billion light-years from Earth could be a wandering big black hole that was thrown from the center of its own galaxy. It would have gotten the boot when its home galaxy merged with another.



A black hole appears black because its gravity is so strong that nothing, not even light, can escape it.

Dwarf galaxies aren't the only ones with wandering black holes. Some massive galaxies appear to have them too. And some of those wanderers — or rogues — seem to be flying across their host galaxies at 10 times the speed of wanderers in dwarf galaxies.

Such rogues turned up in models, such as Bellovary's. Several years ago, the Hubble Space Telescope and other observatories also saw evidence of a huge black hole getting booted to the edge of its galaxy. Earlier this year, Hubble and the Keck Observatory might have seen the aftermath of a trio of interacting supermassive black holes. One of them seemed to have been kicked out of its galaxy.

Not all scientists have accepted those data as evidence that rogue black holes exist. But if they *do*, rogues could help explain how today's biggest black holes grew up.

Imagine that astronomers find many slow-moving wanderers. Those black holes probably haven't interacted with any others. Otherwise, they would have picked up an extra zing of speed. If astronomers find many black holes that haven't interacted with others, that might mean interactions between big black holes are rare. It would follow, then, that mergers between big black holes are rare. And that would put a damper on scientists' current idea that supermassive black holes grew through repeated mergers.

Now imagine the opposite. Lots of supermassive black holes are being shot out from the centers of their galaxies. That would suggest black hole interactions are pretty common. In turn, black hole mergers would likely be common, too. That would support the current merger theory of how the biggest black holes came to be.

The search continues

The complete story of how cosmic Kammapas form remains a mystery. So far, scientists have little to go on — only a few dozen possible oddballs in dwarf galaxies and a few possible far-flung rogues. More data would help clear things up. Luckily, more astronomers have joined the search.

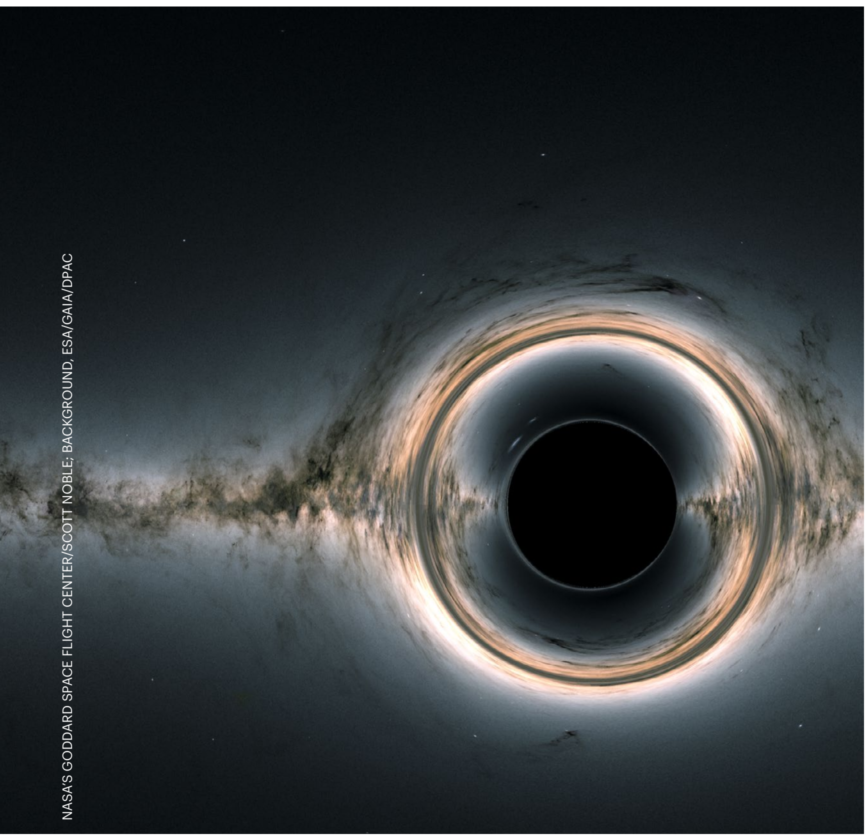
Future observatories may aid in the hunt, too. The Vera C. Rubin Observatory is supposed to turn on next year. That telescope in Chile could sweep the skies looking for wanderers. And the Laser Interferometer Space Antenna, or LISA, will try to detect massive black-hole smashups.

Time and new technology may someday tell all. For now, oddball black holes spark our imaginations. They prompt us to ask big questions and uncover new evidence to understand cosmic history more deeply.

With each discovery, you can't help but wonder: What else is hidden out there? Perhaps there are other oddities not yet discovered that could help explain the early universe, Bellovary says. But only if we're willing to chase the misfits and their stories.

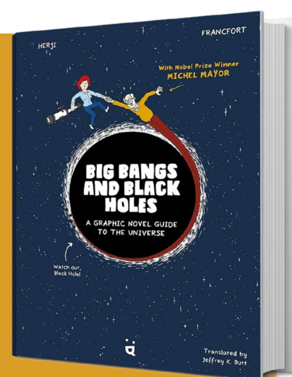
X-RAY: CXC/NASA, UNH, D. LIN *ET AL*; OPTICAL: NASA, STSCI

This image (below) is from a NASA simulation of two supermassive black holes. It shows how the gravity of the black holes distorts the surrounding light from the background stars and produces a dark silhouette of each black hole.



NASA'S GODDARD SPACE FLIGHT CENTER/SCOTT NOBLE; BACKGROUND, ESA/GAIA/DPAC

READ MORE



Big Bangs and Black Holes: A Graphic Novel Guide to the Universe

— by Jérémie Francfort, illustrated by HERJI, translated by Jeffrey K. Butt

With terms like quarks, dark matter and the Big Bang, the study of space can be confusing. Learn more about how the universe works in this graphic novel.

HELVETIQ

Black holes and activism inspire this astrophysicist

Mallory Molina looks for new ways to find elusive black holes

As a young child, Mallory Molina visited the Johnson Space Center in Houston, Texas, with their parents. It's where NASA trains astronauts. Molina left inspired, wanting to study space. Their parents, though, had some concerns. "They were afraid it wouldn't work out," says Molina. Now, Molina is an astrophysicist at the University of Utah in Salt Lake City and Vanderbilt University in Nashville, Tenn., where they study supermassive black holes tucked away in dwarf galaxies. These dwarf galaxies can help us better understand how black holes formed in the early universe, Molina says.

Molina's path to the stars wasn't always easy. But their struggles as a Mexican-American student inspired them to find a way to help others. They are one of the cofounders of Towards a More Inclusive Astronomy (TaMIA). The program allows students who experience the world differently to feel heard in their astronomy departments, says Molina. In this interview, Molina shares their experiences and advice with *Science News Explores*. (This interview has been edited for content and readability.) — *Aaron Tremper*

Q What inspired you to pursue your career?

A When I was little, I was amazed by all the things that we didn't understand about space and the universe. I remember being in awe of these giant planets millions of miles away from us. I knew nothing about them, but there was so much waiting for me to learn about and explore.

Q How do you get your best ideas?

A A lot of my ideas are built on previous observational work. For example, I'll look at the spectrum of gas around a black hole. I'll see interesting things, and it'll inspire me to look for something new. Having good collaborators and good discussions also leads to great ideas. You may have a starting idea, but it's always going to be improved by other people.

Q What was one of your biggest failures and how did you get past that?

A The lowest point in my career was in grad school. I was not doing as well as I had done in undergrad, and everybody else seemed to be so much further ahead. I felt isolated and was thinking of quitting. I was told by some people that I only had my spot because I was Mexican-American, that it wasn't fair to white people that I took their spot. Since I wasn't doing that well in school, I believed them.

I talked to my advisor about it. He was really helpful in encouraging me. He helped me find ways to create inclusive environments. I ended up cofounding TaMIA.

Q What do you like to do in your free time?

A I go hiking with my two dogs a lot. I also enjoy movies, reading and video games. Sometimes I like to bake. Now that I've got a one-year-old, a lot of my life is listening to Disney songs on repeat.

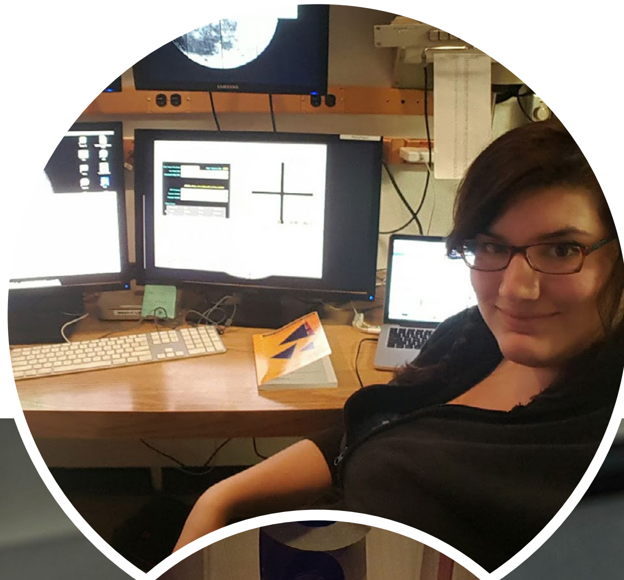
Q What piece of advice do you wish you'd been given when you were younger?

A Physics and science overall tend to be done in certain ways. Sometimes, this is necessary. But there's often a stereotypical path that people are recommended to take. You don't always have to take that path, though, or be exactly like everybody else to be successful. You can kind of create your own adventure, in a way.

"My parents told me it's important to be true to yourself no matter what field you enter. That's how you're going to be successful and happy," says Mallory Molina. "I think that was the hardest thing for me to learn."

M. MOLINA

> There's often a stereotypical path that people are recommended to take. You don't always have to take that path.



While in grad school, Molina visited the Kitt Peak National Observatory in Arizona (top inset, with the telescope's computers) and the Las Campanas Observatory in Chile (bottom inset).

PHYSICS

Build your own electroscope

Use a homemade device to measure static electricity in different materials

By Science Buddies

You can measure an object's static electricity by touching it to an electroscope. This transfers the object's charge to two metal pieces in the device. Since those pieces then have the same charge, they repel each other — with greater charges pushing them farther apart. Here, we build an electroscope of our own.

OBJECTIVE

Make an electroscope to test which materials produce the most static electricity

EXPERIMENTAL PROCEDURE

1. Poke a straw through two holes in a foam cup. Tape the cup to an aluminum pan.

2. Attach a marble-sized ball of aluminum foil to one end of a piece of string.

3. Tape the other end of the string to the straw, so the ball of foil hangs straight down and touches the edge of the pan. This is your electroscope.

4. Rub an object made of Styrofoam, plastic, wool or some other material against a blown-up balloon 20 times.

5. Place the object on a non-metal table. Put the electroscope on top.

6. Use a wooden ruler to measure how far the foil ball moves away from the edge of the pan. Record the result in a notebook.

7. Touch your finger to the electroscope to remove its electrical charge.

8. Repeat steps 4–7 twice more with the same object.

9. Repeat steps 4–8 with at least two other objects made of different materials.

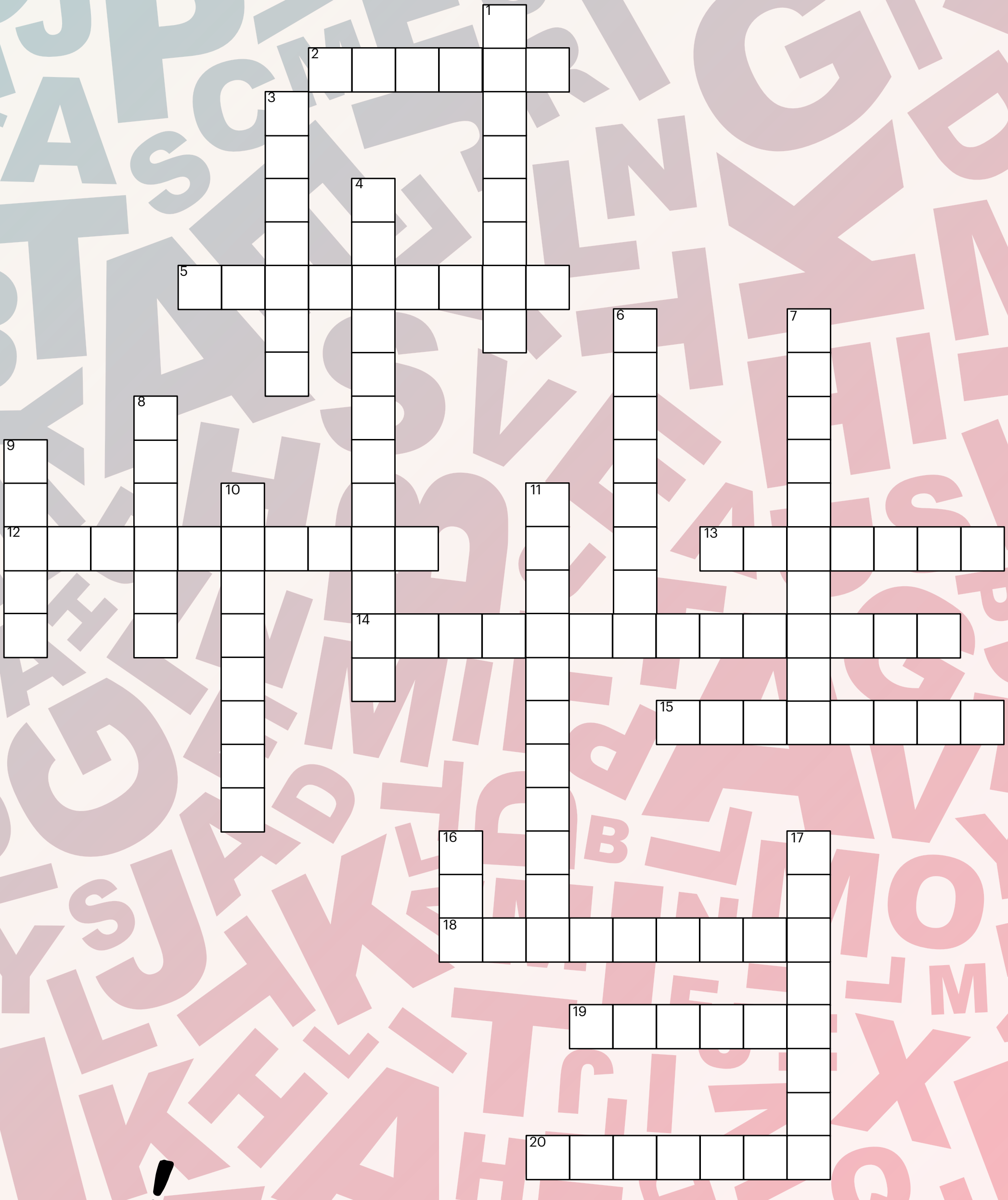
10. On a graph, list each material tested on the x-axis. Plot the average ball-to-pan distance for each material on the y-axis.

Find the full activity, including how to analyze your data, at www.snexplores.org/staticelectricity. This activity is brought to you in partnership with Science Buddies.

ALISON1414/ADOBE STOCK

Crossword

If you're having trouble figuring out the answers to the clues below, make sure you read all the stories in this issue. Check your work by following the QR code at the bottom of the page.



ACROSS

2. A single particle of light

5. The theoretical opposite of a black hole

12. The continent where you can find the South Pole

13. A type of ice found on some mountains

14. The process plants use to turn light into chemical energy

15. Rivers usually flow in this direction

18. Peer through one of these to see stars

19. The best shape for building underwater

20. A house built with these might cut landfill waste

DOWN

1. CO_2 and H_2O are examples of this

3. These birds build spiky nests, probably to keep other birds away

4. A device used for measuring static electricity

6. This is another word for the saltiness of water

7. Shrimp and amphipods are this type of animal

8. The Milky Way is one of these

9. These can break up a forest into fragments

10. Most of Greenland is covered by one of these

11. A green pigment needed for photosynthesis

16. A computer language tool used in some AI chatbots

17. Another name for decompression sickness

BEKULNIS/SHUTTERSTOCK

TECHNOLOGY

High-tech solar 'leaves' create sun-powered fuels

Water, carbon dioxide and sunlight combine to make more Earth-friendly fuels

Green plants are amazing. Powered solely by the sun, they make their own food, or fuel. Researchers have long sought a similar way to make fuels for human use. A new leaf-inspired device taps the power of sunlight to make a liquid fuel.

If it can be scaled up, the device might help cut carbon pollution released into the environment. That's a needed step toward limiting climate change.

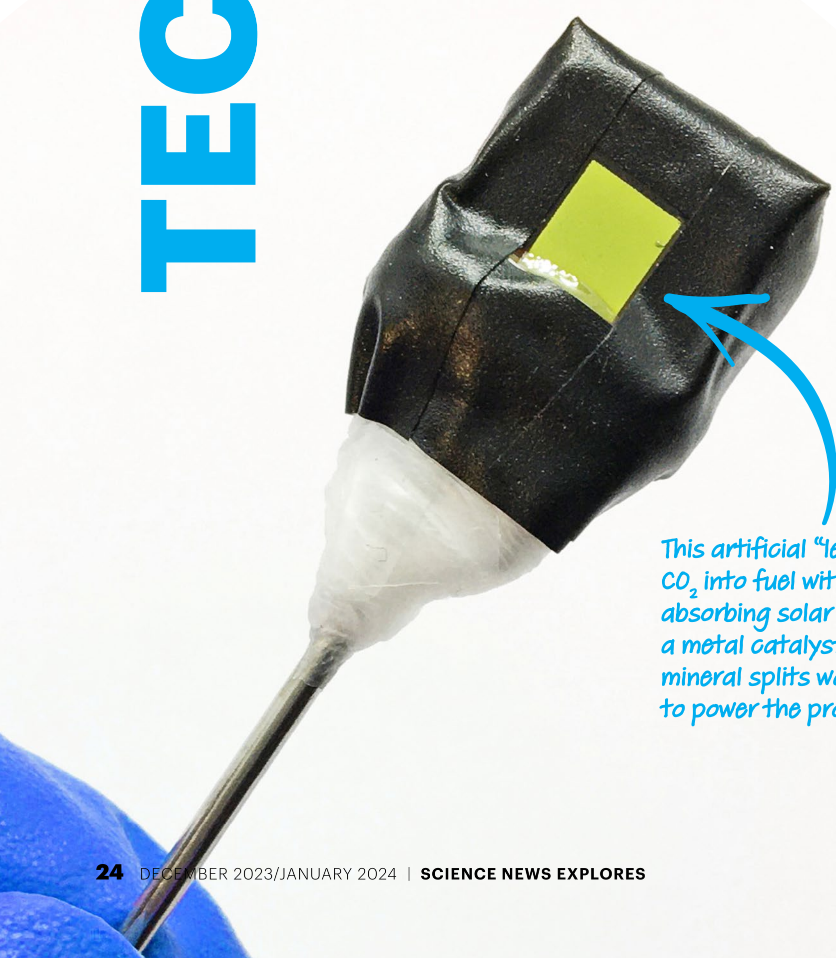
The leaves of most plants contain chlorophyll. In sunlight, this green pigment converts water and CO_2 into sugars and oxygen.

A key step in photosynthesis is splitting apart molecules of water. A protein in chlorophyll normally has this job, explains Yulia Pushkar. She's a biophysicist at Purdue University in West Lafayette, Ind. "In artificial photosynthesis," she says, "we try to mimic the function of [plant] proteins." That means finding some other way to split water molecules.

Breaking the bonds that link water's hydrogen and oxygen atoms releases energy. That's what powers the rest of photosynthesis. The end result is sugars that fuel a plant's growth. Researchers want to make Earth-friendly fuels that could replace fossil fuels. These might power heating systems or engines, such as those in cars and airplanes.

Researchers at the University of Cambridge, in England, have found one way to do this. They made an artificial "solar leaf." It makes alcohol fuels — ethanol and propanol — from CO_2 and water.

And it does this "using sunlight as the only energy source," says Motiar Rahaman. He is a Cambridge chemist who led the new work. Burning those alcohols will release energy, water and oxygen, this scientist notes — but no greenhouse gases.

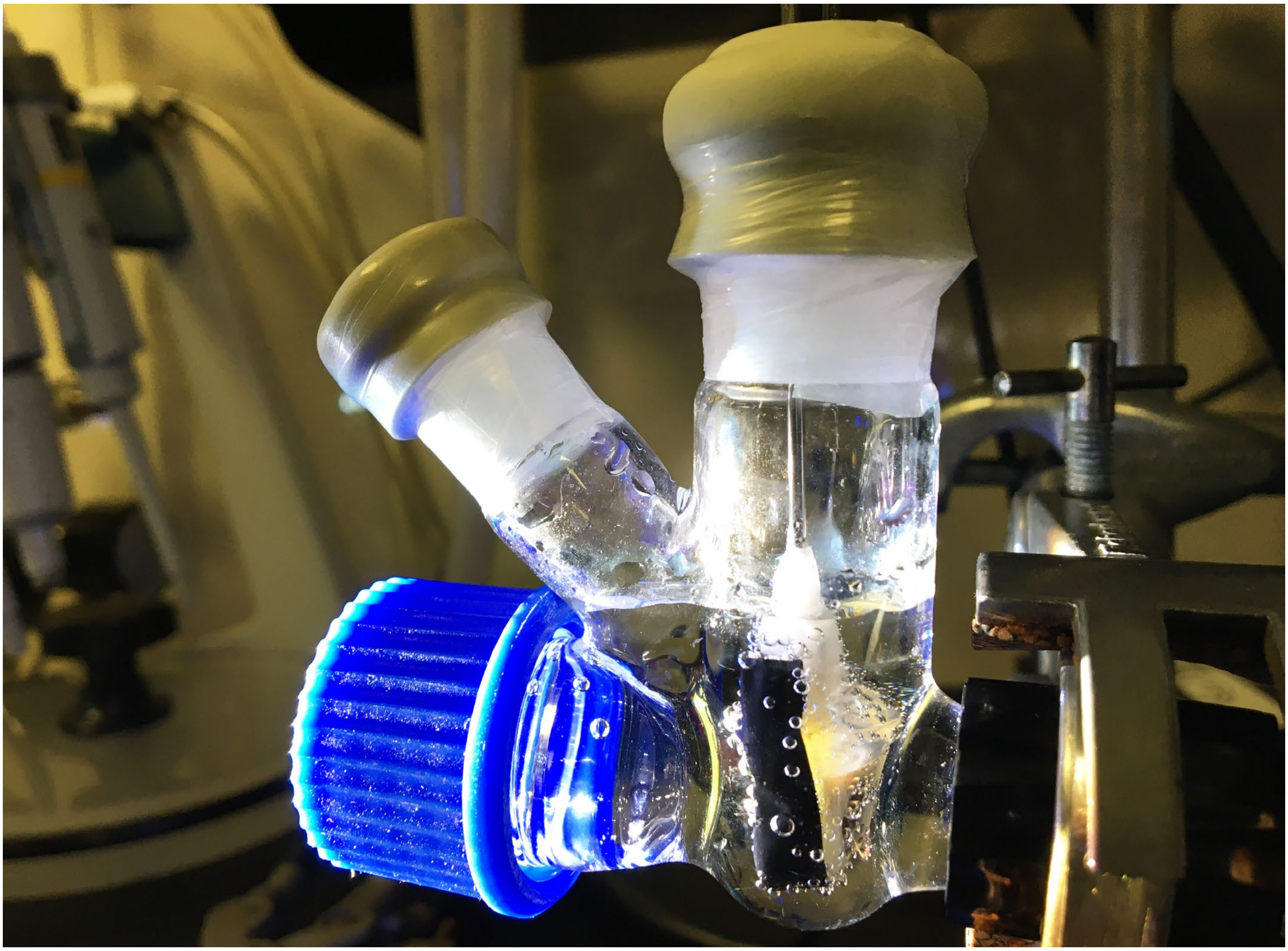


This artificial "leaf" turns CO_2 into fuel with a light-absorbing solar cell and a metal catalyst. Another mineral splits water molecules to power the process.

TURNING OVER A NEW 'LEAF'

Many different materials can split water molecules. The new device uses minerals for the task.

Their "leaf" has several parts. First, there's a solar cell made with a mineral, perovskite. It absorbs light and releases electrons. The solar cell is connected to a catalyst, made from copper and palladium.



M. RAHAMAN

The artificial leaf is submerged in water with carbon dioxide. In the presence of sunlight, the device can make a liquid fuel.

That converts CO_2 into an alcohol fuel. Finally, another mineral — bismuth vanadate — absorbs light and breaks water molecules apart, releasing oxygen.

As described in *Nature Energy*, the process kicks off when a solar leaf is put in sunlit water enriched with CO_2. The light triggers the minerals to split the water molecules. And the catalyst converts the CO_2 into alcohol fuels. The products: fuels and oxygen.

Peidong Yang at the University of California, Berkeley also works on artificial leaves. This chemist praises the Cambridge "leaf" for being able to make liquid fuels from the sun. But there are more efficient ways to make solar fuels, he notes.

Instead of using light-absorbing minerals, Yang's team works with bacteria. This method captures sunlight to split molecules of water into oxygen, electrons and protons. Bacteria then combine CO_2 with these ingredients to efficiently make the chemical acetate. This small fatty acid can later be converted into other types of fuels.

Partnering with bacteria creates more than just fuel, says Joanna Kargul. She's a biochemist at the University of Warsaw in Poland. There, she runs its Solar Fuel Lab. "We can make plastics, fertilizers and basically everything we use that currently relies on fossil fuels," she says of these bacterial systems.

Kargul, too, praises the Cambridge team's device. But she notes that it's challenging to take any of these devices beyond the lab and into the marketplace. The tools must first become far more efficient. And making them larger can run into new technical problems (such as short circuits).

Scaling up will also require lots of those light-absorbing minerals. So it's important they are readily available and not too costly.

Lanzatech, a company in Skokie, Ill., has just scaled up one type of artificial-leaf tech. Its system makes jet fuel, plastics and synthetic fabrics from bacteria fed with CO_2 pollution from nearby factories.

When will solar-derived liquid fuels become widely available? Kargul thinks portable systems should be able to make such fuels, as needed, in another 25 years or so. These systems won't rely on toxic products — or make pollution — while producing fuels straight from the sun.
— *Laura Allen*

OCEANS

What makes Aquaman special? He can take a lot of pressure

Here's why people won't be living under the sea anytime soon

In the Aquaman movies, the city of Atlantis steals the show. In this underwater kingdom, whales swim by glowing, disk-shaped buildings. Old ruins stack up like a huge coral reef made of condos.

It's enough to make anyone wish for life under the sea. But while that underwater life looks peaceful, it comes with a lot of pressure. (And not just because you might be fighting for your life against your enemies.) All that water weighs heavy upon a person, fish or Atlantean building. And that requires some special adaptations to survive.

Above water, all the air above you presses down. You don't notice it because your body is used to this pressure. Climb to the top of a mountain and there will be less air above you. That reduced mass means there is less pressure. But dive into the ocean, sink down and you'll quickly discover what real pressure is.

Water is heavier than air. The farther you sink below the surface, the more water that weighs down on you. Every 10 meters (or 33 feet) of depth adds another 6.6 kilograms per square centimeter (14.7 pounds per square inch) of pressure.

LIFESTYLE PICTURES, COLLECTION CHRISTOPHEL/ALAMY

"If you took an empty plastic water bottle and went down 75 feet [22 meters], it would be crushed flat," notes George Elvin. He works at North Carolina State University in Raleigh. There, he studies how people can build structures in extreme environments — underwater, for instance.

People are a bit tougher than empty plastic water bottles, of course. But they're not indestructible. Go deep enough, Elvin explains, and there will be so much pressure that any sack of air in your body — such as your lungs — would simply collapse. If your lungs don't expand, you don't breathe. Nice knowing you.

Roger Garcia is the operations director of the Aquarius Reef Base. It's an underwater habitat where scientists can live for a few days at a time while they study the ocean. It sits 15 meters (about 50 feet) below the surface of the ocean off the Florida Keys.

One of Aquaman's most impressive feats of strength may be surviving the crushing pressures of the deep sea.

The inside of this facility is filled with air kept at the same pressure as the water outside. At that depth, Garcia says, it doesn't really feel like the water is pressing in on all sides. Returning to the surface, however, isn't easy. As someone swims to the surface, the pressure drops. This allows gases dissolved in the body to form bubbles. If those bubbles form in the joints, they can cause joint aches. They can even burst vessels in the brain and rupture tissues in the lungs. This condition is known as decompression sickness or "the bends."

Aquaman may not have this problem. But the rest of us are not so lucky. To avoid decompression sickness, people in Garcia's reef base need to rise to the surface slowly. The base rises to the sea surface over 15 hours. This lets the people inside slowly adjust to the falling pressure and avoid those bubbles.

IN AN OCTOPUS'S GARDEN

When dealing with underwater pressures, people often opt to build with circles. Garcia's reef base, for example, is a giant steel tube. Submarines are rounded metal tubes. Even better than a circle, though, is a sphere. "The sphere is the best form for resisting high pressure," Elvin says. Its round shape distributes pressure evenly across a structure. The disk-shaped structures of Aquaman's Atlantis have flat tops that would still take a lot of pressure, Elvin says. But this design makes sense since a sphere is not easy for a human to walk around in.

Withstanding pressure is especially important when people want to live in those structures. Those structures have air inside that people need to breathe. "If there's water inside, you're set," Elvin says. When a structure is filled with water, the pressure on the inside is the same as the pressure outside. That makes building easy but living there a lot harder (at least for humans).

Building underwater also requires different types of materials. Those used to build on land "wouldn't work very well," Elvin says. Pressure is just one problem. "An underwater environment is very harsh, with different chemicals in the water," he notes. Wood rots. Steel rusts. The ocean can break down some plastics.

Atlantean building materials might therefore be something a bit more natural. "Look at materials that are comfortable underwater and use those," Elvin says. Calcium carbonate might be especially good. This chemical makes up the shells of organisms like mussels and corals.

In fact, Elvin notes, the director of the Aquaman movies, James Wan, was inspired by coral reefs when he imagined the city of Atlantis. "It's really intelligent and creative," Elvin says. "[Wan] wasn't thinking about how land-based buildings and cities would work underwater. He started underwater … looking at nature. We know the biggest structures on Earth are coral reefs. He's sharp to think of that."

— *Bethany Brookshire*

Calcium carbonate, found in the shells of many sea creatures, might make good construction material in the city of Atlantis, at the bottom of the ocean.

Explainer

EARTH

A quick guide to the world's ice sheets, glaciers and more

Icy masses come in a variety of types

Ice covers much of the Earth's poles. That includes nearly all of Antarctica. For much of the year, the Arctic, too, is covered with ice. As are Greenland and many of the planet's highest peaks. But it's not all the same kind of ice.

In Antarctica, ice can exceed 4 kilometers (2.5 miles) in thickness. It formed as snow piled up over many thousands of years. Gradually, the snow compacted into ice. This vast, frozen blanket is an *ice sheet*. Ice sheets also cover about 80 percent of Greenland.

An ice sheet may look stationary, but it is always moving. The lower layers are under crushing weight — in some places more than 350 times the pressure of Earth's atmosphere. This pressure squishes the hard ice like soft putty. The ice oozes. In some places, this flow is very slow — only a meter or so per year. But scientists have also found fast-flowing corridors where the ice moves hundreds of times that fast.

Much of the Arctic Ocean, in contrast, is covered by a relatively thin crust of *sea ice*. (Antarctica is also rimmed by sea ice.) Most of it is 1 to 4 meters (3 to 13 feet) thick. It forms as the surface of the ocean freezes during winter. Some of this ice melts during the warm months. Arctic sea ice reaches its smallest area at the end of summer, in September, before it starts growing again.

Unlike ice sheets and sea ice, *glaciers* are widespread on our planet. They can be found in mountain ranges around the world, from the Andes in South America and the Himalayas in Asia to the Alps in Europe. Fed by snow that falls on the mountains, glaciers flow down U-shaped valleys. Some will go on to feed rivers that empty into lakes or the sea — and provide water to farms, villages and cities along the way.

— *Douglas Fox*

Some 80 percent of Greenland (above) is covered in ice sheets. This ice, which has built up over thousands of years, appears to be motionless but is, in fact, always on the move.

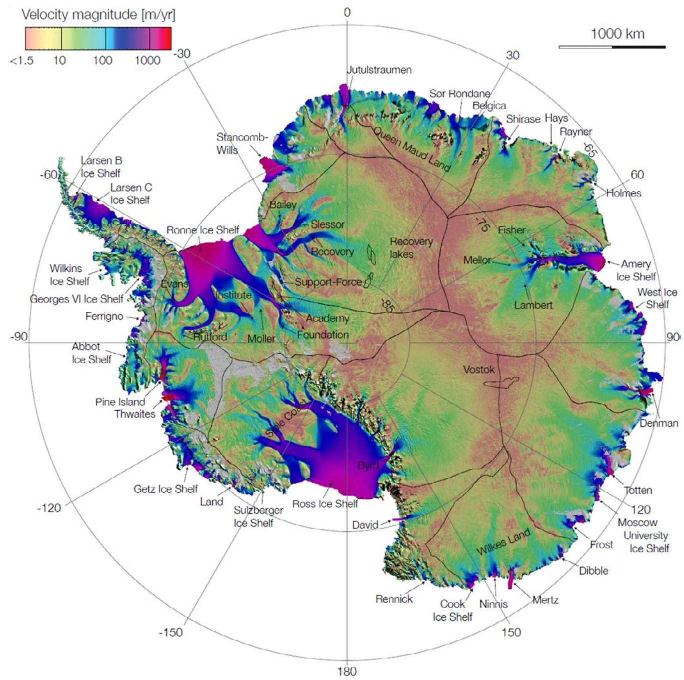
NEKOMURA/SHUTTERSTOCK

MORE TYPES OF ICE

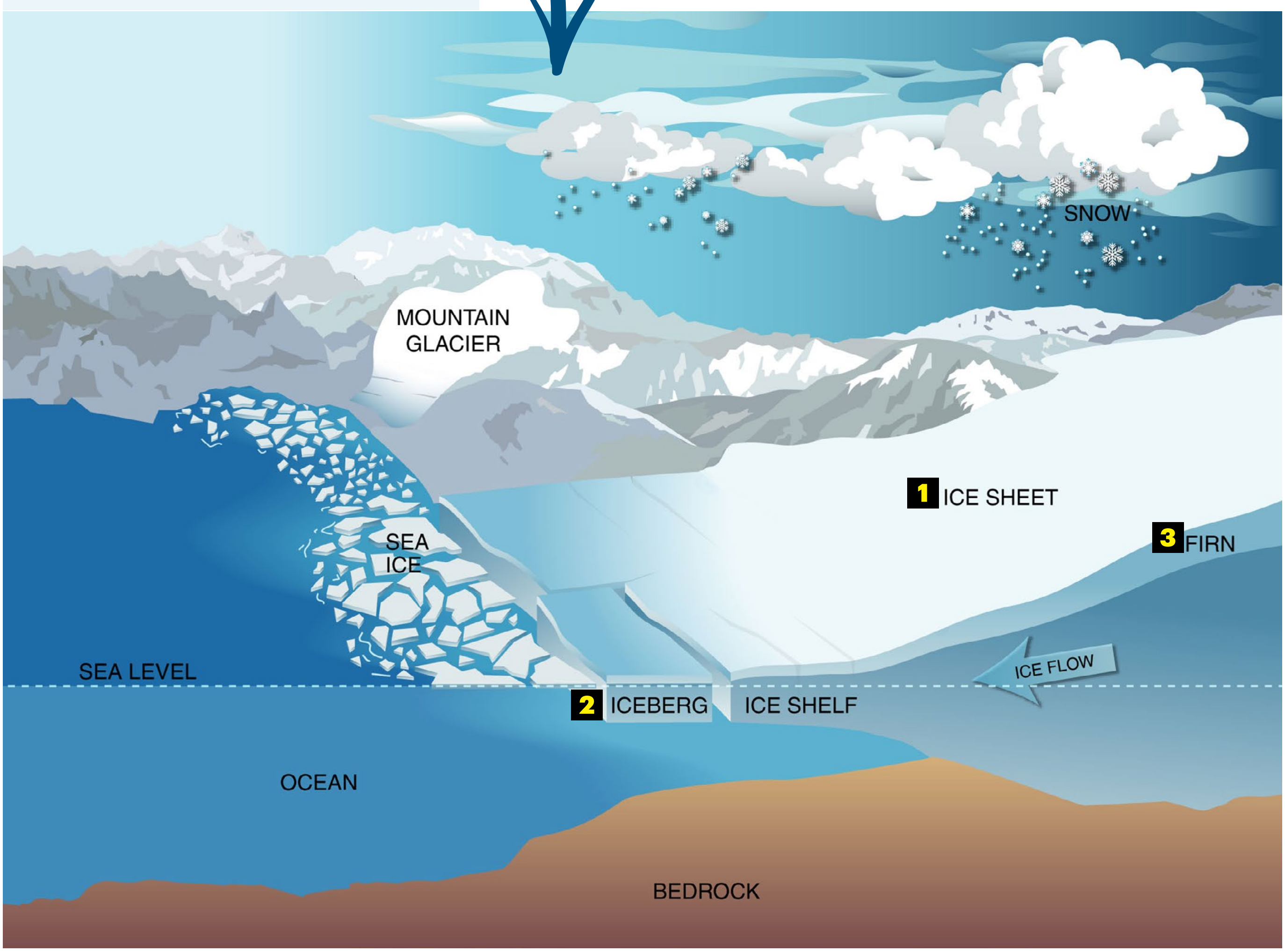
1 ICE SHELF
This end of a glacier or ice sheet forms a floating platform along a coastline.

2 ICEBERG
This large mass of ice has detached from a glacier or ice sheet and floated out to sea.

3 FIRN
Also called névé, firn is hard, granular snow at the surface of a glacier or ice sheet. It has not yet been compacted into ice.



Most of Antarctica's ice sheet is made up of slow-moving ice. This ice generally moves no more than a few tens of meters per year. But some corridors of ice flow much more quickly, hundreds of meters per year. On this map, the Antarctic Ice Sheet is color-coded according to how quickly the ice flows. Fast-flowing ice streams appear in blue and purple.



NASA; NASA/JPL-CALTECH/UCI

ENVIRONMENT

Tropical forests are getting patchier

Broken-up forests are less able to support their animal inhabitants

Fires, roads and logging all slice through swaths of forest, chopping them into fragments. Such forest fragmentation can harm the ability of these ecosystems to sustain their animal inhabitants. Now, a study reveals that the world's tropical forests may face the greatest risk of this damage.

Even if a forest's total area doesn't change much, breaking it up can drastically reduce its function, says Jun Ma. An ecologist, Ma works at Fudan University in Shanghai, China. Think of what happens when a glass cup breaks, he says. The same amount of glass remains, but the cup no longer holds water. Forest fragmentation is similar. Some forest-dwelling creatures require a lot of space. For example, a panda needs around 4 to 6 square kilometers (1.5 to 2.3 square miles) to support its normal life in the wild. A lot of small patches of forest that add up to that area won't do.

Ma and his colleagues analyzed maps of forest cover around the world from 2000 and 2020. They created a forest fragmentation index — a number that captures forests' patchiness. The researchers calculated this value for segments of forest that were 25 square kilometers (6,178 acres).

The index for each area was based on the size of forested spots, how closely such areas were packed together and the length of the forests' edges. Carving up a large area of forest cuts it into more pieces. The average area of each piece shrinks while the average length of the edges grows, Ma explains. The team compared each segment's index from 2020 with the one from 2000.

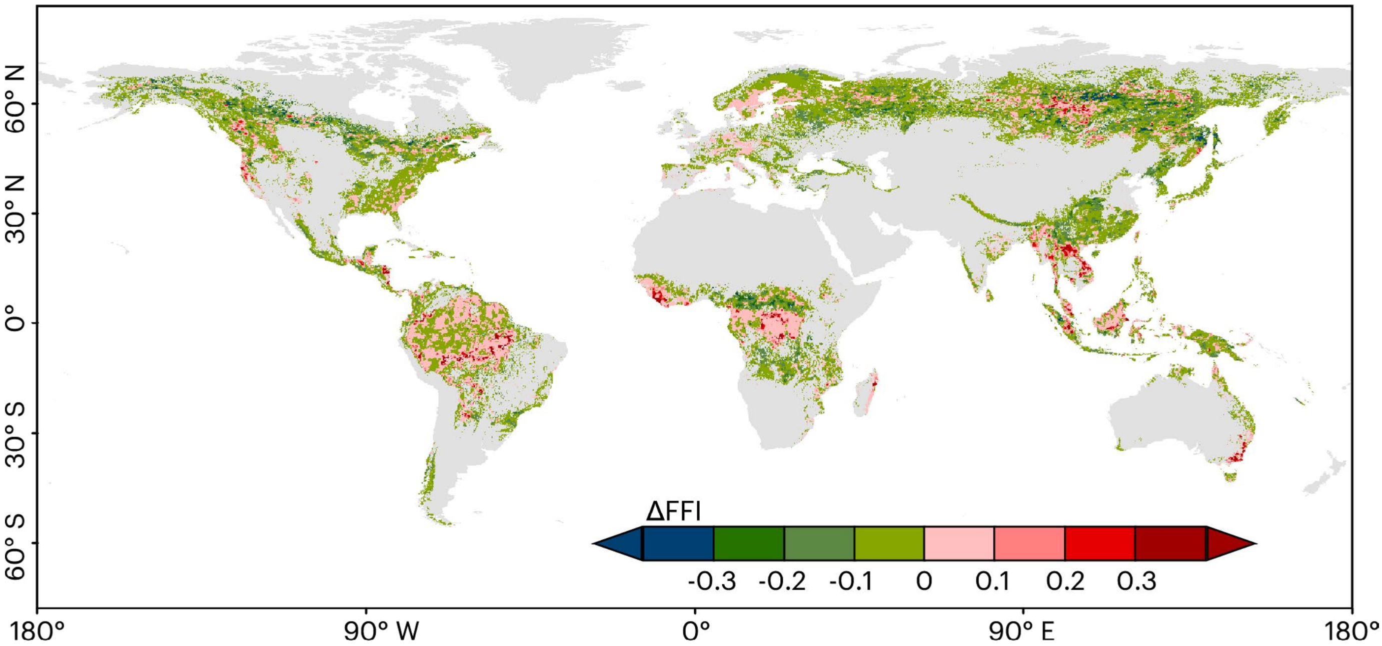
About 75 percent of Earth's forests decreased in fragmentation between 2000 and 2020, the team found. That's good news. But tropical forests — those found near Earth's equator — became more fragmented. That's worrisome because the tropics harbor much of Earth's plant and animal diversity, Ma says. The researchers shared their findings in *Nature Communications.*

Reducing the amount of logging in the tropics would help some of these forests, Ma says. People can also plant trees in previously unforested areas. But, he says, adding new forests should make forested areas bigger, not create more small patches.

— *Carolyn Wilke*

Although many forests have gotten less fragmented since 2000, tropical forests have gotten more chopped up.

IMAGO PHOTO/ADOBESTOCK



Researchers calculated a value they call the forest fragmentation index for forested areas around the world. That index measures how chopped up a forested area is. The team then calculated how this value changed in different forested areas from 2000 to 2020. A positive change in the index means that forest fragmentation increased over that period. A negative change in the value means that forest fragmentation decreased.

Pandas need around 5 square kilometers (2 square miles) of intact forest to support their bamboo-eating lifestyles.

DATA DIVE

1. Look at the bar with different colors. What do pink and red mean with regard to change in forest fragmentation? What do blue and green mean?

2. Now look at the map. Which parts of Earth have a lot of forest cover?

3. What are some places where forests have become more fragmented in the past 20 years?

4. Where has the change in forest fragmentation been greatest?

5. What are some places where forests have become less fragmented?

6. Can you think of some forest animals that might need a lot of space to survive? Why would they need this space?

J. MA *ET AL*/*NATURE COMMUNICATIONS* 2023; HUNG CHUNG CHIH/SHUTTERSTOCK

ANSWER

Home, spiky home

This bird nest becomes a 'fortress' using antibird spikes

This Eurasian magpie nest sits in a sugar maple tree in Antwerp, Belgium. Unlike most nests, it brims with roughly 1,500 "antibird" spikes that point out from its center.

"That is really like a bunker for birds," says biologist Auke-Florian Hiemstra. "Like this fortress which cannot be taken." Hiemstra studies nests and plastic pollution. He works in the Netherlands at Naturalis Biodiversity Center in Leiden.

The pointy strips normally line building eaves. They're meant to keep birds from landing there. Now, some birds have repurposed the spikes to line their homes.

Hiemstra is part of a team that described in *Deinsea* five such nests found in Europe. They were made by Eurasian magpies and carrion crows. Crows used the spikes as part of their nests' structure. Hiemstra believes the magpies also used them as they were intended: to ward off other birds.

Magpies are relatively small. Larger birds prey on magpie eggs and hatchlings. For protection, magpies create domed roofs over their nests and often adorn them with thorny branches or other materials. Some have used barbed wire or knitting needles. This study is the first to document birds nesting amid antibird spikes. — *Luis Melecio-Zambrano*

This Eurasian magpie nest contains more than 1,500 spikes meant to shoo birds off buildings. "I just love the irony of it," Auke-Florian Hiemstra says. "It's just the perfect comeback of the birds."

AUKE-FLORIAN HIEMSTRA

INSIDE THE MIND OF A SCIENCE AWARD WINNER

A Thermo Fisher Scientific Junior Innovators Challenge finalist answers four questions about her science

Science competitions can be fun and rewarding. But what goes on in the mind of one of these young scientists? **Sharanya Chudgar**, who competed at the 2023 Thermo Fisher Scientific Junior Innovators Challenge, shares some of her science inspiration and advice.

Q What inspired this project?

A "When I signed up to volunteer at our local trash cleanup, I saw how much litter pollution there was, and I knew that I had to fix this problem," Sharanya says. "People do have very limited time and resources, right? But robots don't. So it was then that my project idea formed in my head."

Q What was your favorite part of this project?

A "Building the robot," Sharanya says. "Ever since first or second grade, I've loved building Legos, and building my robot felt just like building a Lego. Except this time, I had to come up with the instruction manual."

Q What resources helped you complete your project?

A "My father. Throughout the project, I've had to use tons of power tools, and I even had to cut pieces of metal to certain lengths," Sharanya says. "Whenever I had to use a power tool, my dad was always there to supervise and help out if necessary."

Q Any advice for science project newbies?

A "Follow the scientific method. It might seem difficult at times, but sticking to this and changing just one variable at a time gets you the best results," Sharanya says. "And honestly, don't be afraid of making mistakes … making mistakes is a part of the whole learning process."

Thermo Fisher Scientific Junior Innovators Challenge finalist

Sharanya Chudgar

Sharanya, 14, built a solar-powered trash-collecting robot. The wheeled machine uses sensors to spot litter and a pan to scoop it up. The robot's metal-detecting sensor helps it sort garbage from recyclables. And a light sensor lets the robot's solar panel angle itself toward the sun, collecting as much energy as possible. Sharanya is an eighth grader at Challenger School–Shawnee in San Jose, Calif.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