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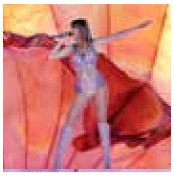

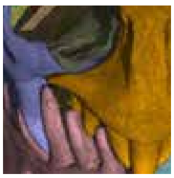

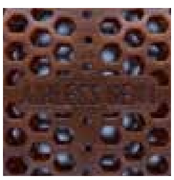

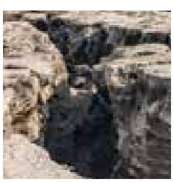

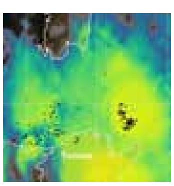

COVER IMAGE: N. ZELLER

ScienceNews Explores
A magazine by the Society for Science

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Mail: *Science News Explores*, P.O. Box 292933, Kettering, OH 45429-0255 **Web:** www.snexplores.org

Science News Explores (USPS 25676, ISSN: 2831-9966) is published monthly except in January and July by Society for Science, Inc, 1719 N Street NW, Washington, DC 20036. Periodicals Postage Paid at Washington, DC, and additional mailing offices. POSTMASTER: Send address changes to Science News Explores, PO Box 292933, Ketting, OH 45429. Subscriptions cost $29.95 (international rate $54.95 includes extra shipping charges). Single copies are $7.99 plus $1.01 shipping and handling (or for international, $5.01 shipping and handling).

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Q Are there an infinite amount of universes?

— Sara

A No one knows whether our universe is alone or if it is just one of many — possibly infinite — universes out there. But scientists have proposed lots of ideas for what a multiverse — or collection of universes — might look like. One idea is that every time something happens in our universe, there is an alternate reality where something different happens. At every moment, alternate realities branch off each other to form new universes. Another idea is that our universe is like one bubble in a vast cosmic foam, which is full of other bubble universes that may have different physical laws. Future observations could help tease out whether our universe is one of many. For instance, scientists might detect the gravitational pull of other universes on our own. Or look for signs of other universes bumping into ours, left as imprints on the ancient light, or cosmic microwave background, that fills our universe.

Q How does a carbon monoxide detector work? Ours went off and saved the day a few weeks ago, but I don't know how they work.

— Regina D.

A Carbon monoxide detectors contain sensors that measure the amount of this dangerous gas in the air. If there is enough carbon monoxide, or CO, in the air for long enough to be dangerous to people, then the detector will sound an alarm. Different detectors sniff out CO in different ways, notes the U.S. National Institute of Standards and Technology. The most common type of detector contains a solution that conducts electricity, called an electrolyte. Carbon monoxide that enters the detector triggers a chemical reaction that boosts the flow of current through the electrolyte. The amount that the current increases depends on the amount of CO in the air. Other detectors use circuits instead of the electrolyte. When CO encounters a chip inside one of these detectors, electricity begins to flow through the material more easily. This change in the material's electrical resistance depends on the amount of CO in the air. Still other carbon monoxide detectors contain a gel that changes color as it absorbs CO. A light sensor that tracks the gel's color can measure the level of this change and, therefore, CO levels.

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1. Publication Title	2. Publication Number	3. Filing Date
Science News Explores	2 5 6 7 6	08/12/2024

4. Issue Frequency	5. Number of Issues Published Annually	6. Annual Subscription Price
Published monthly except in Januar and July	10	$29.95

7. Complete Mailing Address of Known Office of Publication *(Not printer) (Street, city, county, state, and ZIP+4®)*
1719 N Street NW, Washington, DC 20036
Contact Person: Mike Pickett
Telephone *(Include area code)*: (916) 765-8480

8. Complete Mailing Address of Headquarters or General Business Office of Publisher *(Not printer)*
1719 N Street NW, Washington, DC 20036

9. Full Names and Complete Mailing Addresses of Publisher, Editor, and Managing Editor *(Do not leave blank)*
Publisher *(Name and complete mailing address)*
Michael Voss, Publisher, 1719 N Street NW, Washington, DC 20036
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11. Known Bondholders, Mortgagees, and Other Security Holders Owning or Holding 1 Percent or More of Total Amount of Bonds, Mortgages, or Other Securities. If none, check box → ☑ None

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12. Tax Status *(For completion by nonprofit organizations authorized to mail at nonprofit rates) (Check one)*
The purpose, function, and nonprofit status of this organization and the exempt status for federal income tax purposes:
☑ Has Not Changed During Preceding 12 Months
☐ Has Changed During Preceding 12 Months *(Publisher must submit explanation of change with this statement)*

13. Publication Title	14. Issue Date for Circulation Data Below
Science News Explores	09/01/2024

15. Extent and Nature of Circulation		Average No. Copies Each Issue During Preceding 12 Months	No. Copies of Single Issue Published Nearest to Filing Date
a. Total Number of Copies *(Net press run)*		24758	33769
b. Paid Circulation *(By Mail and Outside the Mail)*	(1) Mailed Outside-County Paid Subscriptions Stated on PS Form 3541 (Include paid distribution above nominal rate, advertiser's proof copies, and exchange copies)	23302	33013
	(2) Mailed In-County Paid Subscriptions Stated on PS Form 3541 *(Include paid distribution above nominal rate, advertiser's proof copies, and exchange copies)*	76	88
	(3) Paid Distribution Outside the Mails Including Sales Through Dealers and Carriers, Street Vendors, Counter Sales, and Other Paid Distribution Outside USPS®	97	123
	(4) Paid Distribution by Other Classes of Mail Through the USPS (e.g., First-Class Mail®)	0	0
c. Total Paid Distribution *[Sum of 15b (1), (2), (3), and (4)]*		23475	33224
d. Free or Nominal Rate Distribution *(By Mail and Outside the Mail)*	(1) Free or Nominal Rate Outside-County Copies included on PS Form 3541	54	54
	(2) Free or Nominal Rate In-County Copies Included on PS Form 3541	5	5
	(3) Free or Nominal Rate Copies Mailed at Other Classes Through the USPS (e.g., First-Class Mail)	0	0
	(4) Free or Nominal Rate Distribution Outside the Mail *(Carriers or other means)*	2500	0
e. Total Free or Nominal Rate Distribution *(Sum of 15d (1), (2), (3) and (4))*		2559	59
f. Total Distribution *(Sum of 15c and 15e)*		26034	33283
g. Copies not Distributed *(See Instructions to Publishers #4 (page #3))*		510	510
h. Total *(Sum of 15f and g)*		26544	33793
i. Percent Paid *(15c divided by 15f times 100)*		90.1	99.8

16. Electronic Copy Circulation	Average No. Copies Each Issue During Preceding 12 Months	No. Copies of Single Issue Published Nearest to Filing Date
a. Paid Electronic Copies	0	0
b. Total Paid Print Copies (Line 15c) + Paid Electronic Copies (Line 16a)	23475	0
c. Total Print Distribution (Line 15f) + Paid Electronic Copies (Line 16a)	26034	33283
d. Percent Paid (Both Print & Electronic Copies) (16b divided by 16c × 100)	90.1	99.8

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17. Publication of Statement of Ownership
☑ If the publication is a general publication, publication of this statement is required. Will be printed in the 10/1/24 issue of this publication.
☐ Publication not required.

18. Signature and Title of Editor, Publisher, Business Manager, or Owner
Date: 08/12/2024

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EARTH

Dancing Swifties make seismic waves

Earthquake sensors measured 'concert tremors' during Eras Tour last year

Taylor Swift fans really know how to "Shake It Off" — and shake the ground. Scientists studied how the stadium and ground trembled during Swift's Eras Tour concerts last summer. They found that dancing fans generated vibrations in the ground — seismic waves that matched the beat of each song.

The ground moves in different ways during quakes and concerts. Earthquakes happen when huge slabs of Earth's crust, called tectonic plates, shift around. Those motions permanently change the ground. The shaking caused by crowds doesn't usually deform the Earth. Earthquakes also usually last only a few seconds. A "concert tremor," in contrast, can last several minutes.

A concert tremor "is more like splashing on a puddle of water," explains Gabrielle Tepp. She's a seismologist at the California Institute of Technology in Pasadena. "You see the ripples coming out, but then once you're done splashing, it just goes back to normal."

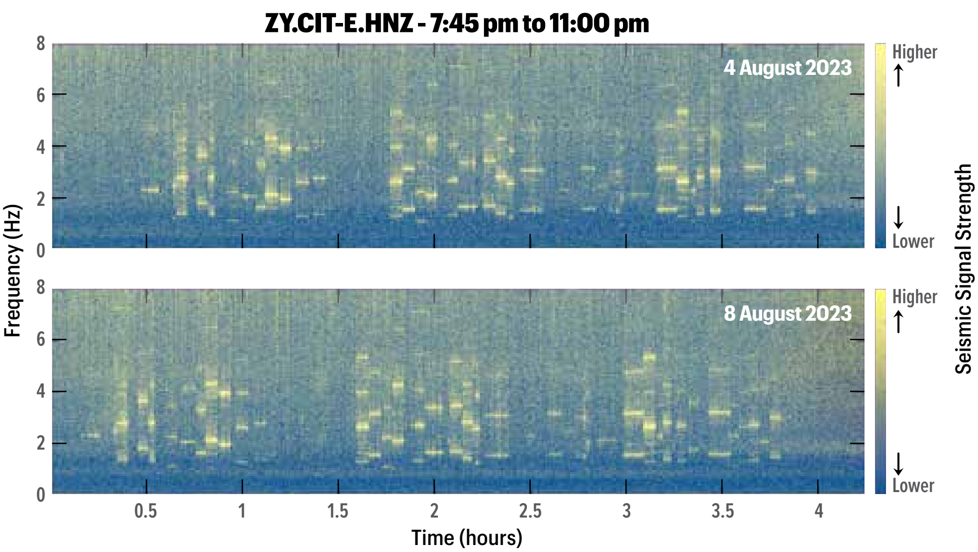
Seismologists use similar instruments to detect earthquakes and concert tremors. In the new study, Tepp's team set up motion sensors in and around SoFi Stadium in Inglewood, Calif. They did this right before Swift's first Eras Tour performance there on August 4, 2023. Some 70,000 people attended that show.

For many of the songs performed that night, the frequency of the vibrations lined up with the beat of the song. The researchers could identify almost every song that Swift performed using the frequencies and durations of the vibrations.

The stadium shook most during Swift's performance of "Shake It Off." During that song, the stands released about as much energy as a magnitude 0.85 earthquake. That's not quite strong enough to be felt by humans, but it releases as much energy as blowing up a few ounces of TNT.

That energy was released over the full length of the song. An earthquake of similar energy (or a TNT explosion) usually releases all of its energy in a second or less.

The difference between an earthquake and a concert tremor is like "the difference between a firework explosion and a jet engine roaring," says Tepp. "The explosion is happening very quickly. It's all at once. Whereas a jet engine [releases energy] over a longer amount of time."



Taylor Swift fans made seismic waves with their dance moves on two nights in August 2023 at a stadium in Inglewood, Calif. Shown here as yellow bars, seismic wave patterns were similar on August 4 (shown on top) and August 8 (shown on bottom). The August 8 concert started earlier, so the signals did too.

G. TEPP; ADAPTED BY L. STEENBLIK HWANG; KEVIN WINTER/STAFF/GETTY IMAGES ENTERTAINMENT

Tepp and her colleagues wanted to identify what was causing the Swift concert tremor. Was it jumping fans, the sound system or the instruments?

To find out, the team set up a portable speaker next to a motion sensor in their lab and turned the speaker volume all the way up. Then Tepp plugged in her bass guitar and played a simple beat over the speakers. They also blasted Swift's "Love Story" at the speakers' highest volume. Tepp even jumped around near the sensor while grooving to the last chorus.

The sensor picked up vibrations that matched those from the concert only when Tepp was jumping around. That suggests that the vibrations measured on August 4 came from fans jumping and dancing, too.

The findings tell scientists about more than just concert tremors. Understanding how a stadium shakes in response to a large crowd could help make buildings safer, says Eva Golos. She's a seismologist at the University of Wisconsin–Madison.

— *Skyler Ware*

CAMPCRAZY PHOTOGRAPHY/SHUTTERSTOCK

ANIMALS

Why belugas wiggle their forehead fat like Jell-O

These whales may warp their 'melons' in different ways to communicate

Every beluga (*Delphinapterus leucas*) has a big bulge on its forehead called its "melon." This fat-filled bump helps aim the sound waves a beluga makes for echolocation. But this squishy organ might also be used for visual communication. Now, researchers have cataloged the expressions that belugas in captivity seem to make with this wobbly forehead fat.

Belugas mold their melon using muscles and connective tissue. They can extend the melon forward until it juts over their mouths — like the brim of a baseball cap. Or lift it upward to create a fleshy top hat. They mush it flat against their skull, too. They can even shake it with enough force that it jiggles like Jell-O.

"If that doesn't scream 'pay attention to me,' I don't know what does," says Justin Richard. "It's like watching a peacock spread their feathers." He studies animal behavior at the University of Rhode Island in Kingston.

Richard and his team first recorded interactions between four belugas at Mystic Aquarium in Connecticut. This footage revealed the belugas make five distinct melon shapes — flat, lift, press, push and shake.

Then, the team observed 51 captive whales at MarineLand Canada in Niagara Falls. These whales made the same melon shapes as the first group.

When interacting socially, the first group of whales sported an average of nearly two shapes per minute. They made 93 percent of the shapes when another beluga could see them.

Whether the whales make the shapes consciously remains unclear. But Richard suspects they're likely purposeful signals. "There must be important information that is transmitted," Richard says. "There's got to be a reason they spend so much time doing it."

— *Elizabeth Anne Brown*

Belugas can lift, press, push, shake and flatten their squishy melons.

Watch beluga whales shake their melons here!

SPACE

The universe could have a complex shape like a doughnut

Scientists have yet to rule out many complicated shapes for the cosmos

Ancient light called the cosmic microwave background could offer clues about whether the universe might loop back on itself in a complex shape similar to that of a doughnut (shown in this artist's conception).

J. LAW/ESO

The universe may have something in common with a doughnut: the complexity of its shape. In a universe with such a complex shape, you could travel across the cosmos and end up back where you started. Past research seemed to rule out that our universe is like this. But not so fast, a group of physicists now says. The shape of the universe might still be as complex as that of a doughnut.

Glenn Starkman and his colleagues shared this idea in *Physical Review Letters*. Starkman is a physicist at Case Western Reserve University in Cleveland, Ohio.

Understanding the contours of our universe is important, Starkman says. One reason is that this could help to explain previous hints that the universe isn't the same in all directions.

Some objects have simple, or "trivial" shapes. On objects like this, any closed loop can be shrunk down to a single point. Take the Earth, which is roughly a sphere. If you travel all the way around the world along the equator, that's a closed loop. But if you shift your trip up to the North Pole, you can squish that loop down to a single point.

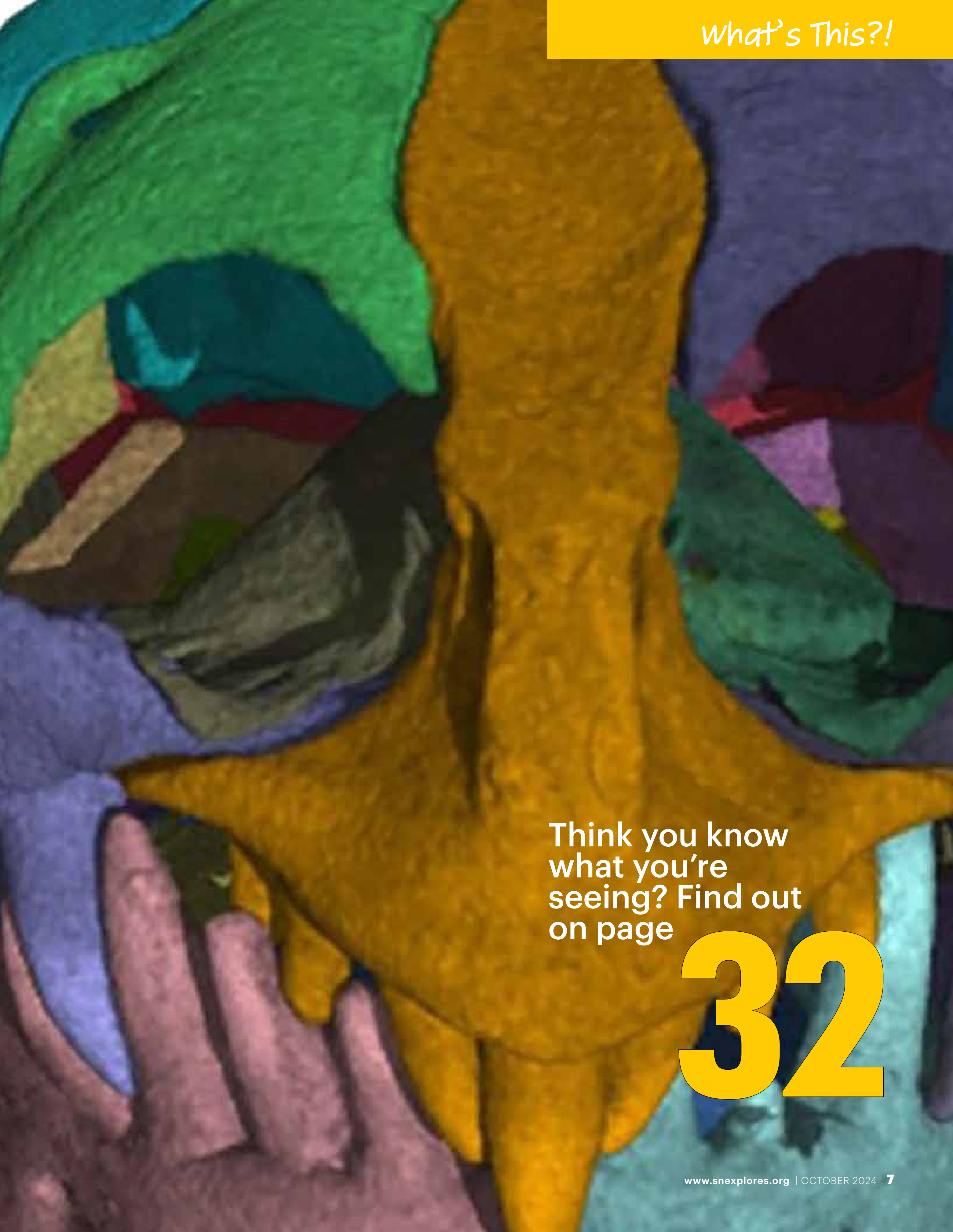
On objects with a "nontrivial" shape, such as a doughnut, some closed loops can't be squished to single points. The loop around a doughnut's hole can't be shrunk to a point. The hole gets in the way.

The universe is generally thought to have a simple shape — more like a sphere than a doughnut. But scientists have wanted to test if that's true.

The new study looked at 17 possible complex shapes for the cosmos. Most of them haven't yet been ruled out, the researchers found. And features in ancient light spread throughout the cosmos — called the cosmic microwave background — could help tease out which of these shapes, if any, our universe has.

"I find it fascinating," says Dragan Huterer of the results. This cosmologist works at the University of Michigan in Ann Arbor. He was not involved with the study. Huterer is not just intrigued by the idea that the cosmos might have a complex shape. What's really cool, he says, is that "we might be able to measure it."

— *Emily Conover*



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

Giant kelp form large forests in coastal waters around the world. Like trees, these algae can pull carbon out of the environment. As such, they make promising climate-change warriors.

MADELEIN WOLFAARDT/SHUTTERSTOCK

By **Rina Diane Caballar**

RESTORING GIANT UNDERWATER FORESTS, ONE BLADE AT A TIME

In New Zealand, rebuilding these kelp ecosystems is a community effort

A cold, damp lab in Wellington, New Zealand, houses a nursery of sprouting seaweeds. These babies are brown dots about the size of crushed peppercorns. Growing on rocks, they're submerged in big basins of seawater that smell of fish and salt. Water filters hum in the background as the babies gently sway in basins that tilt from side to side. Tipping buckets splash them with waves of water. Designed to mimic conditions at sea, this nursery aims to ready the babies for the ocean they will one day call home.

Big hopes abound for these little ones.

These babies will grow into massive brown macroalgae called giant kelp. Much like trees on land, this species forms large forests in deep waters. Their towering stemlike stipes and long leaflike blades spread out to create dense, floating canopies.

Those canopies provide food and an "immense, three-dimensional habitat that's extremely important for many marine vertebrates and invertebrates," says Christopher Cornwall. A marine botanist, he works at the Victoria University of Wellington.

Giant kelp anchor their ecosystem. They're culturally important too. For Māori, the Indigenous people of New Zealand, seaweeds continue to be a sustainable food source. In the past, baskets of dried seaweed were traded for preserved birds. Today, bowls of seaweed are served during gatherings. Māori also use kelp to create bags for preserving and transporting food. The skill of making these traditional bags is passed down through generations.

But climate change has put the giant kelp at risk. Already, their numbers are dwindling. That's where the seaweed nursery comes in. Located at the National Institute of Water and Atmospheric Research (NIWA), it's part of the Love Rimurimu project. "Rimurimu" means seaweed in the Māori language.

Love Rimurimu aims to restore giant kelp in the coastal waters off Wellington, the capital of New Zealand. Along with scientists, the team is finding ways to cultivate seaweed babies in the lab and to plant them at sea. But they're also engaging the community to monitor kelp health.

Much like the seaweeds that moor their ocean ecosystem, the project anchors a whole community. Together, these "kelpers" are working to rebuild underwater algal forests.

Promising climate-change warriors

Giant kelp (*Macrocystis pyrifera*) are one of the fastest-growing organisms on Earth. They can grow as much as 60 centimeters (24 inches) per day and reach heights of 60 meters (200 feet).

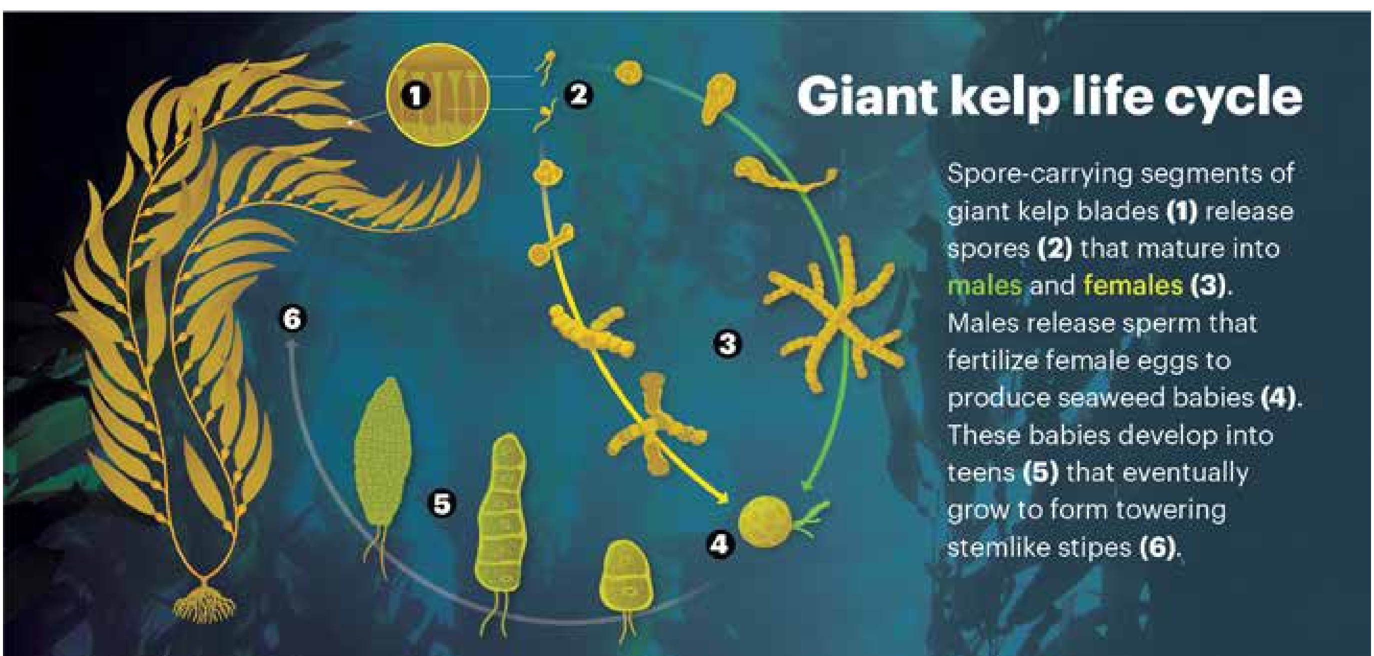
Their gigantic size and rapid growth allow them to absorb huge amounts of carbon dioxide (CO_2) through photosynthesis. Researchers estimate that seaweeds around the world could sequester, or lock up, as much as 173 million metric tons of CO_2 each year. That's nearly as much as the entire emissions of the state of New York!

Given their impressive growth rate and ability to act as natural carbon sinks, seaweeds have the potential to help fight climate change. They might even help counter some of its harmful effects. For example, seaweeds "can make seawater more alkaline," Cornwall says. "And that could protect some organisms from ocean acidification."

But giant kelp are dying off. Wellington is "one of the last places left where the species is still alive" in northern New Zealand, says Siddharth Ravishankar. He's a marine aquaculturist. He's part of the Love Rimurimu team. The kelp's decline stems from a triple threat.

The first is warming oceans. Marine heat waves can harm seaweeds. Extreme heat stresses giant kelp, especially. Prolonged heat could kill it.

At the seaweed nursery (top), Siddharth Ravishankar uses an underwater camera to measure the blade lengths of giant kelp. He then tracks growth of planted giant kelp in Mahanga Bay in Wellington, New Zealand (bottom).



STEVE MCCRACKEN

An influx of sediments poses the second peril. Sediments can be bits of rock, sand and other matter that wash into the sea. Farming, building near a coast and other human activities can foster erosion. So can the more intense rains and storms driven by climate change. Both wash more sediment into the sea.

When suspended or swirling in coastal waters, these sediments will blunt how much sunlight gets through. Scientists call this "coastal darkening." Without enough light, seaweeds can't perform photosynthesis at peak rates. That limits their food supply and stunts their growth.

Overgrazing by sea urchins strikes the third blow. Sea urchins bite a chunk off the seaweed's rootlike anchor. That allows the rest to detach from a rock and float away, explains Ravishankar. Normally, fish help keep urchin populations in check. But overfishing has allowed urchin numbers to rise.

Overgrazing turns seaweed forests into barrens, Cornwall says. They leave behind no fleshy seaweeds — just the pink algae that grow on the rocks.

Stressed-out seaweeds

To help offset these negative effects, the Love Rimurimu team is racing to return kelp forests to the coasts. The babies growing in their nursery will be replanted in the ocean. Once those little kelp sprout from their rocks, they'll be moved from their big basins to the open seas.

The team starts by collecting adult seaweeds in the wild. The kelp's blades have darker patches containing spores. Once they mature, they'll produce sperm and eggs.

These spores number in the "thousands or millions," says Yun Yi Kok. A former marine biologist on the Love Rimurimu team, she studied the early growth of macroalgae, such as kelp.

Kok cuts the kelp patches into smaller pieces, then dries them on paper towels. Later, she dunks them again into jars of seawater. This triggers the plant to release its spores into the water. Kok moves the "spore soup" into petri dishes where they can mature. Male spores release sperm that fertilize female eggs and lead to baby seaweeds.

Ravishankar nurtures these babies in the lab. He seeds them onto rocks and allows them to attach. This technique is called "green gravel."

Once the kelp blades reach at least two centimeters (or three-quarters of an inch) tall, they'll be planted in the sea.

NIWA's seaweed nursery houses around 350 rocks, each with about 50 attached kelp blades. Before bringing them to the sea, the researchers separate the blades and tie each to its own rock with a string. This increases each baby's chance of survival.

"When you get too many individuals on a single rock, eventually … a few of them will outcompete the rest," explains Ravishankar. During planting, the babies' rocks will be tucked into cracks and crevices in the ocean floor. As the kelp blades grow, they'll anchor themselves to the underlying reef.

Yun Yi Kok (far right) submerges spore-carrying segments of giant-kelp blades into jars of seawater. "We're trying to stress them," she explains. Later, when they're put back in the water, "they'll be like, 'Oh, I almost died! I should reproduce now and try to release all my spores.'"

From teeny to tall

Baby giant kelp are seeded onto rocks to grow in the lab (left). This technique is called "green gravel." After one week (middle), the seaweed babies are starting to grow leaflike blades. They're about the size of crushed peppercorns. Next (right), seaweed blades will be tied to individual rocks with a string. These rocks will then be tucked into cracks and crevices at the ocean floor. As the blades grow, they'll outgrow the rock and anchor themselves to the underlying reef.

S. RAVISHANKAR; JOE WARMINGTON; LOVE RIMURIMU

Dressed in SCUBA gear, Christopher Cornwall (left) surveys giant kelp growing off the coast near Wellington, New Zealand.

Baby giant kelp are tiny! This baby (above inset), viewed through a microscope, is in its early stages of growth. It's only about 800 micrometers (0.03 inch) long.

VALERIO MICARONI; Y.Y. KOK

Fighting underwater deforestation

The green-gravel technique is already being tested elsewhere. Projects across Australia, Europe, North America and South America are using it to bring seaweed forests back to life.

In Norway, for example, kelp-bearing rocks grew well at a small site of degraded reef. Trials with golden kelp (*Laminaria ochroleuca*) took hold along Portugal's coast. So did others with giant kelp in the Baja California region of Mexico.

In 2022, the Love Rimurimu team planted giant kelp at a pilot site at Mahanga Bay in Wellington. The two-centimeter (0.8-inch) seaweed babies successfully grew into two-meter (6.6-foot) seaweed teens within a span of six months. In 2023, though, the team got fewer spores. And they grew slowly in the lab.

Under good conditions, blades can emerge in as little as seven days, Ravishankar says. But that year, "it took months."

That delayed how quickly scientists could move the seaweeds to sea. The team had planned to do it during New Zealand's winter months of July and August. Instead, they planted them in spring, during early September.

Coastal conditions also affect the success of regrowing underwater forests. Both Kok and Ravishankar suspect that hotter temperatures might be partly to blame.

Maybe the seaweeds were too stressed with the heat waves during the summer, Kok says. "Ocean warming can really affect their growth and the quality of the spores."

These long-term climate-change impacts are what scientists at the Victoria University of Wellington are studying. These partners of Love Rimurimu hope to learn how sedimentation, heat waves and ocean acidification affect kelp growth.

At the university's Coastal Ecology Lab, Cornwall and his students expose giant kelp to high temperatures to mimic heat waves. They're testing the impacts of how long, how strong, how often and how fast a heat wave comes on. Then they gauge how well the algae adapt to these conditions.

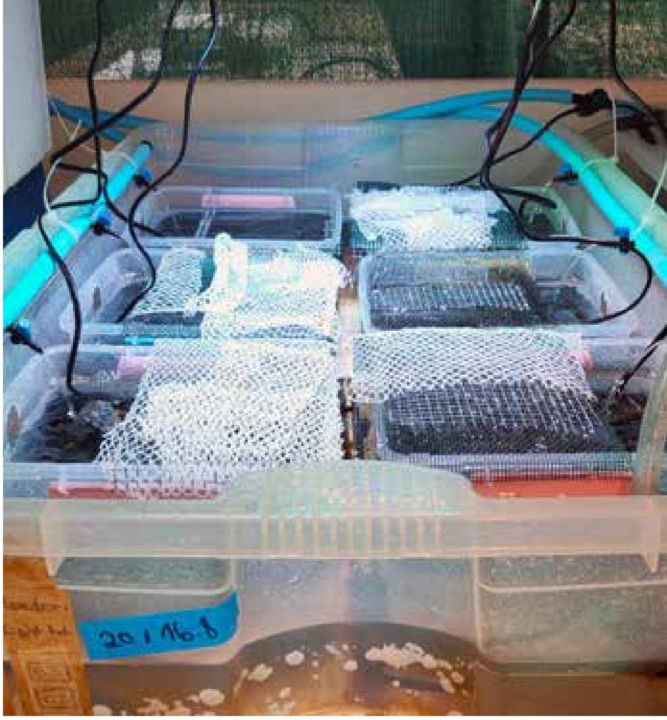
Those studies are still underway. But so far, it looks like longer heat waves cause more harm to the kelp.

"We want to know … how these giant kelp will be impacted," Cornwall says. Some may survive better than others. These could be "individuals we could take and selectively breed in the future." For example, kelp able to tolerate higher temps and low light might help anchor hardier underwater forests.

Community 'kelpers'

Akin to the seaweeds it's trying to save, Love Rimurimu is tethering an ecological community — one that includes people. More than just science, restoration projects need to have people at their core, says Zoe Studd. She leads the Love Rimurimu project. People drive social change to improve the environment or take action, she notes.

Her team has partnered with Taranaki Whānui. This Māori tribe is the traditional guardian of Wellington's lands and coasts. Lee Rauhina-August represents the tribe and serves as Love Rimurimu's Māori adviser.



These tanks at Victoria University of Wellington's Coastal Ecology Lab hold adult giant kelp. These experiments aim to identify how heat waves and ocean acidification can affect the algae's growth.

The scientists consult with her and the tribe about possible culturally important restoration sites. For example, such sites could have traditional names that point to where seafood was abundant. Or, they might have been favorite fishing grounds of the tribe's ancestors. Love Rimurimu also is working with Rauhina-August and the tribe to consider traditional methods for planting seaweeds. For example, Māori use a lunar calendar that guides when they fish or plant.

For help, Love Rimurimu turns to its "kelpers." These trained volunteer divers track the growth and health of planted giant kelp. The original "kelpers" were kids and teens from Love Rimurimu's partner schools. Earlier stages of the project had focused on ocean studies. A yearlong program taught students about seaweeds. Here, they learned how to identify different species, why they're important and threats to their survival.

That focus on kelp forests was intentional. The Love Rimurimu team felt that kelp deserved as much awareness as fish and the other sea species. We "put our attention on the forest, not on all the creatures," says Studd.

An annual version of the sea-studies program continues today. Students take part in a range of tasks. They create maps of restoration sites and present them to Taranaki Whānui. They weave harakeke baskets for transporting seaweed babies from the lab to planting sites. Harakeke is a native New Zealand flax plant of great cultural significance to Māori. The students learn how to monitor planted seaweeds. They can even take snorkeling trips to gather seaweeds and cooking classes to turn their harvest into food. Sometimes it's "really cold, slimy work," Studd admits. But the kids have fun and are engaged in the kelp restoration.

"Students are very much at the heart of the journey," she adds. And once they graduate, Studd hopes they will think about marine science as a possible career. "Perhaps some of them will be out helping us in the aquaculture lab in due course."

With such a "kelping" hand from scientists, kids, teens and the community, the future of seaweed restoration here looks bright.

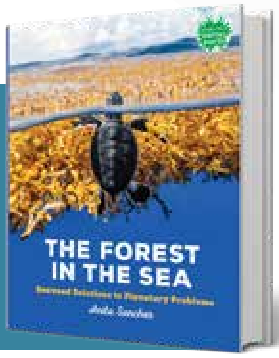
To transport seaweed babies from the lab to planting sites, volunteers weave the fibrous harakeke plant (above) into baskets (such as the ones at left).

READ MORE

The Forest in the Sea: Seaweed Solutions to Planetary Problems

By Anita Sanchez

Seaweed plays an important role in marine ecosystems. Threats from climate change to pollution harm this ocean resource. This eye-catching guide outlines ways to protect underwater forests and details the mysteries still puzzling seaweed experts.



C. CORNWALL; CHAMELEONSEYE, ALEKSANDRA SHMAKOVA/SHUTTERSTOCK; HOLIDAY HOUSE

This biologist gets help from the public to track seadragons

Nerida Wilson uses machine learning to better understand mysterious Australian fish

Along the southern coasts of Australia, flashy fish called seadragons sport leaflike lobes that help them blend into kelp and seagrass. Seadragons "are like the marine version of a koala or kangaroo," says Nerida Wilson. "They're just that iconic."

Wilson is a biodiversity scientist at the Commonwealth Scientific and Industrial Research Organization in Canberra, the capital of Australia. She's helping create a library of DNA sequences of Australia's wildlife. In her spare time, Wilson runs SeadragonSearch.

SeadragonSearch uses machine learning tools to identify seadragons in photos taken by citizen scientists. The program analyzes each seadragon's unique markings to match it with previous photos of the same animal. This helps scientists track individual seadragons over time and learn more about their mysterious lives. That includes how seadragon numbers may be affected by ocean changes.

Though seadragons have been known for a long while, there's still much to learn about them, says Wilson. In 2015, Wilson helped describe a bright red ruby seadragon. One of only three seadragon species, it was the first found in 150 years. In this interview, Wilson shares her experiences and advice with *Science News Explores*. (This interview has been edited for content and readability.) — *Aaron Tremper*

Q How did the SeadragonSearch project come about?

A I started diving with seadragons around the areas where I learned to dive in high school. I read research to see whether anyone looked at seadragon genetics before. Could this reveal anything about their populations or where they are traveling? There wasn't any work in that space. I thought that was outrageous. These are such iconic Australian animals. I thought I'd better try and find out.

We faced a practical problem in the field, though. While underwater, we'd have to photograph the seadragon. Then, we'd take our sample, a little snippet from the leafy appendages. Then we'd let the dragon go. But we needed to make sure that we didn't resample the same individual seadragon. That would ruin the statistics.

We thought maybe the spot patterns on the face were unique. If we couldn't identify them underwater, this would let us do so afterward. Once we realized that worked and got funding, we

N. WILSON

Meet Speedy, the world's oldest known seadragon. Scientists estimate that this weedy seadragon has lived at least 16 years — twice as long as expected.

Three species of seadragons call Australia home: weedy, leafy and the recently discovered ruby. Nerida Wilson uses machine learning to study seadragon photos submitted by citizen scientists, keeping tabs on individual fish by analyzing their unique markings.

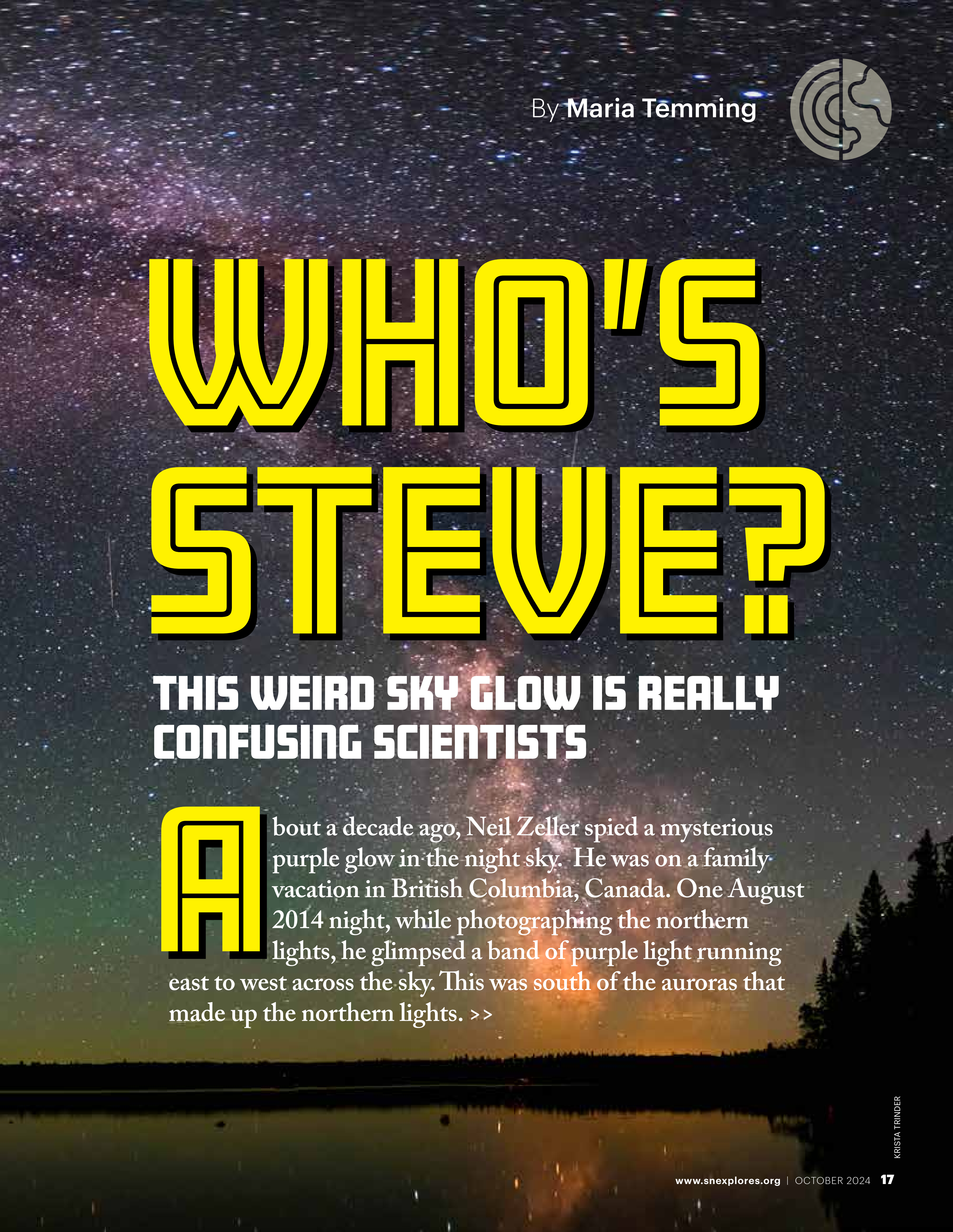
were able to build the SeadragonSearch platform and start rolling it out. Seeing all of the data come in from citizen scientists was very exciting.

Q What piece of advice would you give those interested in this kind of work?

A I knew from age four or five that I wanted to work with animals and be outdoors. I couldn't have explained it properly then, but I knew I was going to make that happen. And I just kept going and refining my goals. Of course, everyone has times of doubt. But if someone really wants to do this, I say just do it. It is important to be motivated by what you do. There's great joy and rewards in doing things that you care about.

Q What is a particularly memorable experience you had while working on this project?

A It was really nice to see Speedy the seadragon in Tasmania [off the coast of southern Australia]. He was the oldest seadragon known. [Speedy lived at least 16 years.] That was special. But sadly, he was only seen about two more times after that. Then he was never seen again.



KRISTA TRINDER

By Maria Temming

WHO'S STEVE?

THIS WEIRD SKY GLOW IS REALLY CONFUSING SCIENTISTS

About a decade ago, Neil Zeller spied a mysterious purple glow in the night sky. He was on a family vacation in British Columbia, Canada. One August 2014 night, while photographing the northern lights, he glimpsed a band of purple light running east to west across the sky. This was south of the auroras that made up the northern lights. >>

The purplish-white streak looked almost like the vapor trail of an airplane — yet not quite. Intrigued, Zeller swiveled his camera toward the strange light.

Later, he found that other aurora chasers online had seen similar purple streaks. They called them proton arcs — known features of the northern and southern lights. But a couple of years later, Zeller and his fellow photographers would learn that they actually had been documenting a natural light show that was yet unknown to science.

The revelation took place in a pub in Calgary, Canada. A group of aurora chasers were hanging out with researchers from the University of Calgary. "I ended up sitting with Dr. Eric Donovan," Zeller says. "And just in casual conversation, we started a tiny bit of an argument."

Zeller said he'd seen a proton arc. Donovan replied that this was impossible, because that type of northern light can't be seen with the unaided eye. So to prove what he'd seen, Zeller pulled out a photo of the purple streak.

"I don't know what that is," Zeller recalls Donovan saying. "But it's not a proton arc." In fact, it didn't look like any aurora Donovan or his colleagues had ever seen.

Since no one had a clue what this ribbon of purple could be, aurora chasers started calling it Steve. Scientists later turned that name into an acronym. It's now short for "Strong Thermal Emission Velocity Enhancement." But to this day, researchers are still struggling to understand STEVE.

One puzzle is what makes STEVE's purple light. Another is what causes the "picket fence" of green stripes that sometimes glimmers in the sky below STEVE. And recent photos have raised questions about how STEVE might be related to another non-aurora light show.

"STEVE and the picket fence are arguably the biggest mystery in space physics right now," says Claire Gasque. She's a space physicist at the University of California, Berkeley.

Conditions in Earth's atmosphere where STEVE appears can affect satellite signals, she notes. So explaining what causes STEVE could have uses beyond understanding a pretty sky light.

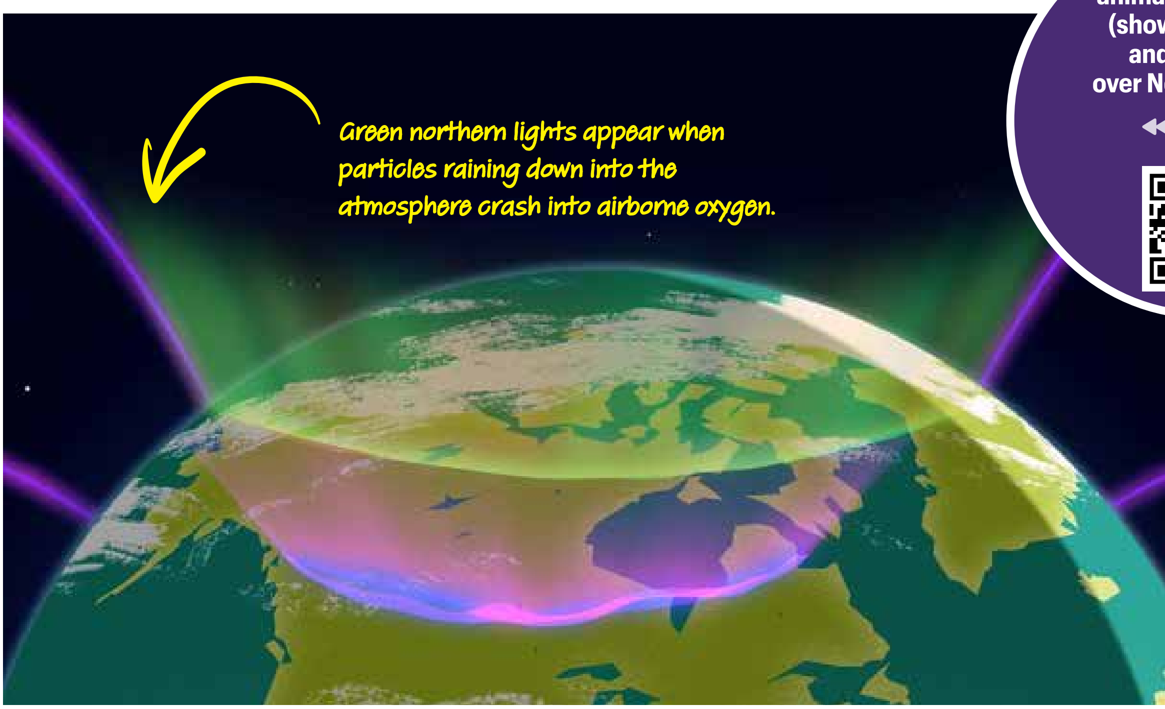
STEVE's perplexing purple

The auroras that make up the northern and southern lights drape the sky with green, blue and red hues. They form when charged particles rain down into the atmosphere from the magnetic bubble, or magnetosphere, around Earth.

Those particles crash into airborne oxygen and nitrogen atoms near Earth's North and South Poles. This causes those oxygen and nitrogen atoms to glow green, red and blue.

STEVE, meanwhile, paints the sky with a brush of purple, and it shows up closer to the equator.

Watch an animation of STEVE (shown in purple) and an aurora over North America!



STEVE's purple arc appears in the night sky farther south than normal auroral lights, as shown in this illustration of North America.

NASA GSFC/CIL/KRYSTOFER KIM

Satellite data have shown that STEVE is likely powered by a river of charged particles rushing through the atmosphere at several kilometers (miles) per second. That plasma stream is thought to energize the air about 200 kilometers (125 miles) off the ground so that it glows.

But what molecules give STEVE its signature purple hue remain unclear. Scientists thought nitric oxide might be responsible. But a new video of STEVE has thrown a wrench into that idea.

Citizen scientist Alan Dyer took the video in his backyard in Alberta, Canada. He and other photographers normally try to take photos of STEVE that are as bright and colorful as possible. To achieve that, they often let their cameras collect light for seconds at a time.

Such long-exposure shots smear STEVE's finer details. So Dyer tried a different approach when a STEVE stretched over his house one night in August 2022. He zoomed in on the sky glow and took a high-speed video.

This video captured structures in STEVE's light as small as 90 meters (some 300 feet) across. That's pretty small for an airglow that can span thousands of kilometers. The footage was made up of 24 snapshots per second.

Instead of a largely smooth drift of purple, Dyer's video exposed STEVE as a quickly flickering torrent of purplish white fuzz. In case the video might be scientifically useful, Dyer sent it to Toshi Nishimura. This space physicist studies STEVE at Boston University in Massachusetts.

"I said, 'Oh my God, no one has ever seen this before,'" Nishimura recalls. His team inspected STEVE's nitty-gritty details and found they didn't seem to match what scientists thought they knew about the airglow. "This fine-scale structure gave us a huge headache," Nishimura says.

Dyer's video showed a speckled stream of light with variations in brightness as small as a few kilometers across. Some of those features popped in and out of view within seconds.

A high-speed video of STEVE taken in August 2022 revealed small structures in the purple streak that scientists couldn't see in still photos.

Watch STEVE emerge from another aurora-like glow!

"The leading theory of the STEVE emission is that there's nitric oxide that is excited by the fast plasma stream," Nishimura says. Excited nitric oxide can glow for an hour. That's about how long STEVE lasts. But nitric oxide can't explain bursts of brightness that last mere seconds.

Nishimura's team shared its assessment last December in *JGR Space Physics*.

Launching a rocket loaded with scientific sensors through STEVE could help identify the molecules behind the airglow. "But the challenge is that we need to know when and where STEVE is going to happen," Nishimura says. "That's extremely difficult."

One thing that might help researchers refine their STEVE predictions is better understanding STEVE's relationship to another type of non-auroral airglow. It's called a stable auroral red arc, or SAR arc. Citizen-scientist photos have recently shown SAR arcs morphing into STEVEs.

STEVE and SAR arcs

In March 2015, Ian Griffin set out to photograph a dazzling auroral display near Dunedin, New Zealand. But just north of these southern lights, the citizen scientist spotted something even more spectacular. A wide, red sky glow morphed into the purple strand of STEVE. Griffin caught this whole transformation on camera, offering researchers their first glimpse of a STEVE blooming out of a SAR arc.

Carlos Martinis and his colleagues described it in 2022 in *Geophysical Research Letters*. Martinis is a space physicist at Boston University in Massachusetts.

Scientists have studied SAR arcs for decades, Martinis says. Like STEVE, these airglows stretch east-to-west across the sky closer to the equator than the northern and southern lights. But while STEVE lasts roughly an hour, SAR arcs can stain the sky for hours to days at a time. These red glows are usually too dim to see with the unaided eye but are visible to cameras.

SAR arcs appear due to disturbances in Earth's magnetosphere. Those disturbances can cause collisions between charged particles thousands of kilometers out in space. Such collisions create heat that seeps down into the ionosphere — the layer of the atmosphere that's home to STEVE. There, the heat energizes electrons, which excite oxygen atoms to shed the red light.

SAR arcs normally are about a tenth as bright as auroras. But the red arc that Griffin saw was bright enough to rival red southern lights.

"It was just stunning," says Megan Gillies, who studies auroras at the University of Calgary. Griffin's footage inspired her to hunt for other cases of STEVE emerging from SAR arcs. Her team found one in Canada in April 2022 that appeared over Lucky Lake, Saskatchewan. The group reported it in *Geophysical Research Letters*.

In this event, STEVE's bright purple streak emerged from a SAR arc's red glow. It hung around for about half an hour, then gave way to more red. "It's like watching a fire smoldering," Gillies says. "You throw more wood on it, and then it blazes up." Later, it dies down again.

"There's something that happens that triggers a STEVE," Gillies says. But not all SAR arcs mutate into STEVE, so it's not clear why some do.

It might have something to do with the plasma torrent that powers STEVE. SAR arcs have also been linked to plasma flowing westward in the

Citizen science videos have revealed that stable auroral red (SAR) arcs (top) can sometimes morph into purple arcs of STEVE (bottom).

C. MARTINIS *ET AL*/*GEOPHYSICAL RESEARCH LETTERS* 2022 atmosphere. The plasma linked to SAR arcs just flows more slowly than the plasma that powers STEVE. Maybe as the slower, wider plasma flow linked to a SAR arc quickens and narrows, it becomes strong enough to power a STEVE. But what would trigger that switch is still an open question, Martinis adds.

"This is where modeling comes in," Gillies says. Scientists can use computers to test whether the physics they think is happening produces light patterns that look like STEVE. Computer models are already helping piece together another STEVE-related puzzle: What causes STEVE's occasional sidekick, the picket fence?

Building the picket fence

The picket fence is a row of green stripes that may light up the sky below STEVE's purple arc. At first, researchers thought this green light might be a plain old aurora. After all, the picket fence's hue is similar to some normal green northern lights. But the specific wavelengths of light emitted by the picket fence hint that it might be something else.

True auroras get their energy from charged particles way out in the magnetosphere. "When [those particles] collide with the atmosphere, they're going to create a pretty wide spectrum of colors," Gasque says. These include the green light emitted by oxygen, plus red and blue light from nitrogen.

"That blue is kind of the smoking gun that we didn't see with the picket fence," Gasque says. Its absence hints that the picket fence's green spires don't come from the same process as auroras. Gasque and her colleagues think the picket fence may instead arise from electric fields in the atmosphere.

Those electric fields could energize electrons in Earth's atmosphere — rather than relying on particles raining down from the magnetosphere above it. Electrons energized by electric fields could tickle oxygen into glowing green and coax nitrogen into giving off a bit of red. But they wouldn't cause nitrogen to emit any blue light.

Gasque and her team tested this idea with a computer model of Earth's atmosphere. The model energized the electrons with electric fields. The team then compared the light produced inside the model atmosphere to the light of a picket fence seen at Lucky Lake in April 2018.

The model did indeed produce the green light and the smidge of red seen in the real-life picket fence, but no tinge of blue. This supports the idea that atmospheric electric fields could construct the picket fence.

The researchers shared their findings last November in *Geophysical Research Letters*. But scientists now need to confirm that such electric fields actually exist in the atmosphere. A rocket mission could help.

In the meantime, STEVE's paparazzi of citizen scientists will continue snapping photos of the sky glow from the ground.

"We're out specifically looking for STEVE," Dyer says, because there's scientific interest in it. "Prior to the era of STEVE … you might have thought, well, there's nothing amateurs can contribute now to aurora research. It's all done with rockets and satellites and the like. But nope! There's a lot we can contribute."

Those contributions will surely turn up plenty of new puzzles for scientists to solve.

R. RAYBELL

STEVE's green sidekick

The picket fence is a row of green stripes that sometimes appears below the purple streak of STEVE. "That can be even more brief than STEVE itself," photographer Alan Dyer says of the picket fence. "STEVE might be there for half an hour, and the picket fence green fingers might be only there for a few minutes."

HUMANS

Full moon illusion

How much bigger does a moon look on the horizon than high in the sky?

By Science Buddies

Have you ever noticed that a full moon at the horizon looks bigger than it does high in the sky? This is thought to happen because our brains perceive the horizon as being farther away than the sky overhead. But just how much bigger does this illusion make the moon seem? Here, we investigate using afterimages — images seen after looking at brightly colored objects, then away. Like the moon, these images maintain constant size but can appear to shrink or grow when viewed overhead or on the horizon.

OBJECTIVE

Determine the moon's perceived size increase at the horizon

EXPERIMENTAL PROCEDURE

1. Glue a 5-centimeter (2-inch) square of blue paper to a piece of yellow paper.

2. Cut out paper squares of a different color with varying sizes — for instance, 2.5, 3.75 and 5 centimeters (1, 1.5 and 2 inches) wide.

3. Under a blue sky, stare at the blue square for 30 seconds, then look at the horizon.

4. Hold the paper squares of varying sizes at arm's length to estimate how big the afterimage appears on the horizon. Record the results in a notebook.

5. Repeat steps 3 and 4, but look directly overhead instead of at the horizon.

6. Perform additional trials until you settle on a stable measurement for afterimage sizes on the horizon and overhead.

7. Based on your data, how much larger does an image of constant size — such as an afterimage or the disk of a full moon — appear on the horizon than overhead?

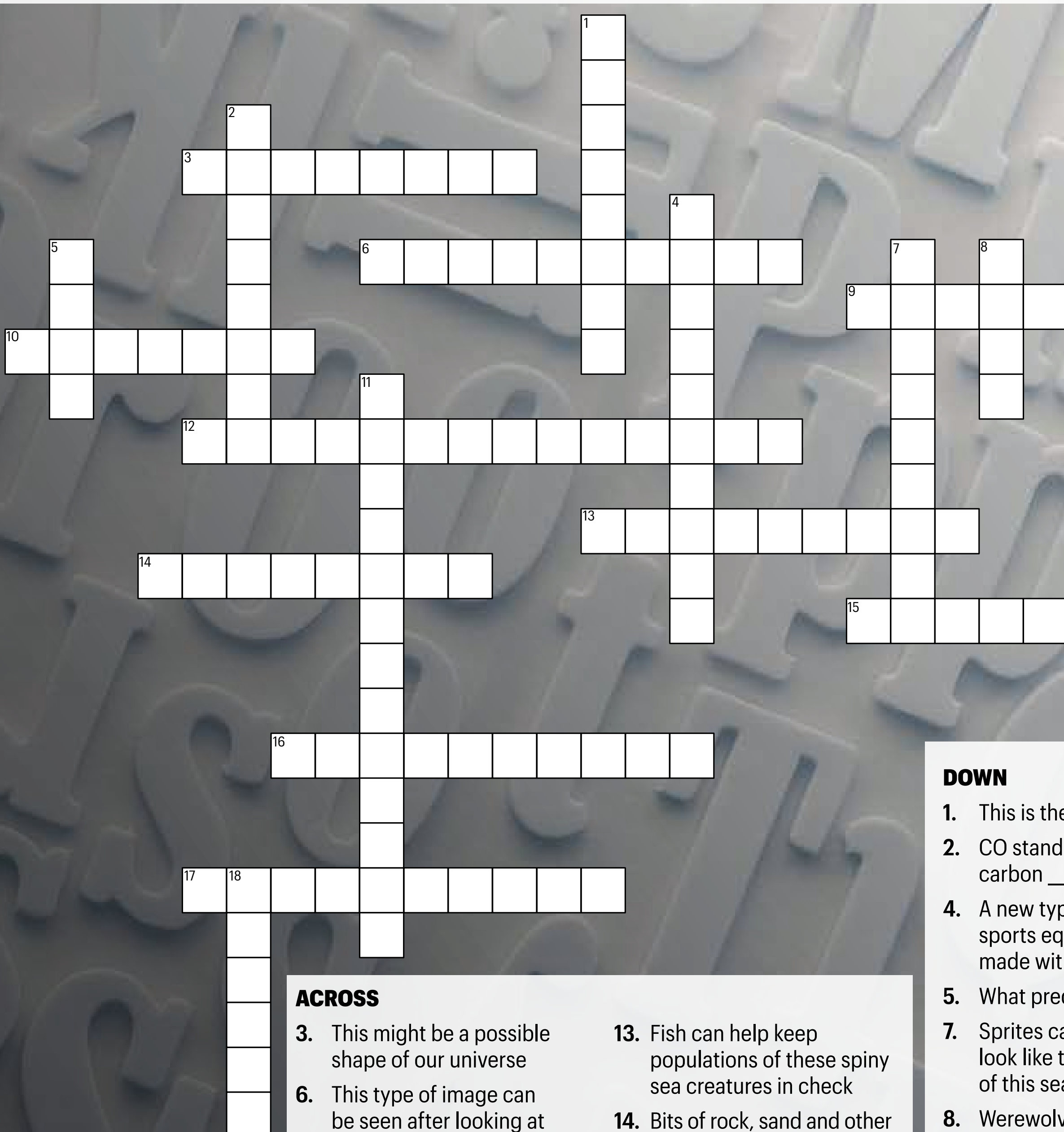
Find the full activity, including how to calculate your answers, at snexplores.org/moonillusion. This activity is brought to you in partnership with Science Buddies.

SCIENCE BUDDIES

BEAUTIFUL LANDSCAPE, CATTALINA, ERFINDA DWIRK, HELEN STEBAKOV/SHUTTERSTOCK

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

3. This might be a possible shape of our universe
6. This type of image can be seen after looking at brightly colored objects
9. The big bulge on a beluga's forehead, or a type of fruit
10. These types of waves carry energy from earth movements
12. Huge slabs of Earth's crust and mantle
13. Fish can help keep populations of these spiny sea creatures in check
14. Bits of rock, sand and other matter that wash into the sea
15. A phantom green glow high in the sky
16. A simpler name for an amphisbaenian
17. Giant kelp are an example of this

DOWN

1. This is the "V" in STEVE
2. CO stands for carbon ______
4. A new type of this sports equipment is made with a 3-D printer
5. What predators hunt
7. Sprites can sometimes look like the tentacles of this sea creature
8. Werewolves and other creatures are affected by this object
11. The Eras Tour caused this type of earth motion
18. Another name for the northern or southern lights

BART SADOWSKI PL/SHUTTERSTOCK

MATERIALS

Holey basketballs! 3-D printing could be a game changer

An 'airless' design makes Wilson's new basketball quieter and puncture-proof

Wilson's limited-edition Airless Gen 1, now sold out, came in three colors — and with a hefty $2,500 price tag. Each ball shipped in a special case and with a display stand.

WILSON SPORTING GOODS

Basketballs have been dribbled across courts and shot through the air for nearly 150 years. In all that time, the look and feel of those balls has remained almost the same: Leather or rubber-based panels hold in pressurized air that gives the ball its bounce.

Now Wilson Sporting Goods — the company that makes the NBA's official game balls — has created a new type of ball. It uses no pressurized air. In fact, this ball is designed for air to flow through it. That means that it won't puncture or deflate like an ordinary basketball.

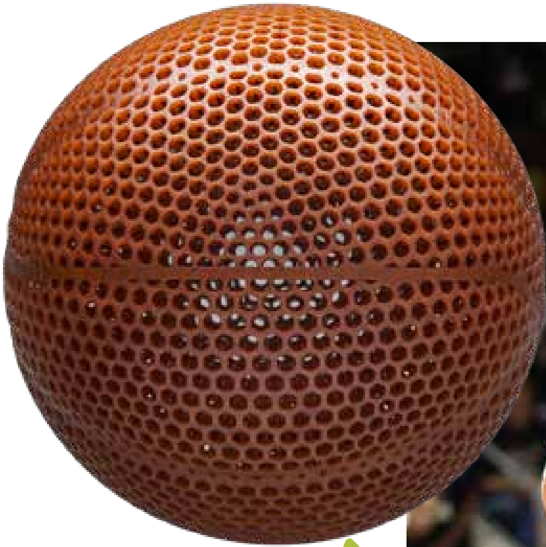
Called the Airless Gen 1, the new ball is 3-D printed from an elastic polymer material. Its surface is a lattice of small, hexagonal holes. The end product is roughly the same size and weight as a standard basketball.

But the most dramatic feature of this limited-edition ball is its cost. At $2,500, it's more than 100 times more expensive than Wilson's cheapest ball. That leaves players to decide: Is it worth it?

THE SCIENCE OF BOUNCE

This Airless Gen 1 is the brainchild of Nadine Lippa. She's an innovation manager and materials engineer at Wilson, based in Schiller Park, Ill., and holds a Ph.D. in sports and high-performance materials. The new ball is "designed to be used without an air pump or needle," she says. "Players can just pick it up and play with no preparation."

A traditional basketball loses its bounce over time. Dribble a new or newly inflated basketball and it immediately springs back from the



The 3-D printed lattice pattern helps store and release energy to give the ball its bounce.

Will professional teams, such as Caitlin Clark's Indiana Fever (seen here playing against the Dallas Wings), someday swap out conventional balls for Wilson's Airless alternative?

WILSON SPORTING GOODS; GREGORY SHAMUS/STAFF/GETTY IMAGES SPORT

ground. The bounce of an old or somewhat deflated ball, however, may not return high enough to reach your hand.

The bounce comes from the air pressure inside these balls. As some air starts to seep out over time, that pressure will fall. Now, no matter how much force you apply, the ball cannot bounce as high.

The new basketball's 3-D printed polymer lattice helps solve that problem, says Monique McClain. She's a mechanical engineer at Purdue University in West Lafayette, Ind., who works on 3-D printed materials. The bounce in Airless Gen 1, she says, comes in part from the ball's structure.

"The advantage of a lattice is that it can deform," she says. "When you're deforming the lattice, there's some storage of energy in there — kind of like springs." Later, the release of that energy allows the ball to bounce back up.

The material used also likely plays a big role in the new ball's bounce and durability. Wilson has not revealed exactly what it's made from.

A SLAM DUNK, OR AIR(LESS) BALL?

With its innovative design, the Airless Gen 1 may handle differently from a traditional ball. People have said online that it feels very different in their hands.

And the holey surface may change its wind resistance, says Patrick Cavanaugh. He's a research engineer at Purdue University's Ray Ewry Sports Engineering Center. With different aerodynamics, "shooting that ball is going to result in a different flight path," he says. That's "going to require [someone] to relearn how to make that shot."

The new ball's bounce is much quieter than that of a traditional basketball. Online reviews describe a soft "whoosh" as air flows through the ball. This feature could be useful for players who don't want to disturb the neighbors as they dribble in their driveway at night.

But it could change the experience of the game, says materials engineer Jan-Anders Mansson. He directs Purdue's Ewry Center. "Sound is extremely important in many sports," he says. Imagine hitting a tennis ball without the *thwack* of a racket, or a home run with no *crack* of the bat. It would be a big adjustment for basketball players — and fans — as they dribble a virtually silent ball down the court.

Even though this design has some kinks to work out, Mansson says he "totally loves the concept" of an airless ball. "It's opened up a whole new area of possibilities." For example, embedding sensors in this ball. One day, they might monitor stats, like acceleration, he says.

"Many people don't realize how much engineering goes into sports products," Lippa says. "We are excited to see how the next generation will use this budding technology to solve problems and have fun."

Most people don't have thousands of dollars for a designer ball. Makers have already begun 3-D printing their own attempts. But so far, none perform like the real thing — which took five years to develop and went through rigorous testing at Wilson's NBA test facility in Ada, Ohio.

— *Sarah Wells*

ANIMALS

Moonlight can affect both predator and prey

Werewolves aren't the only creatures affected by the full moon

As the full moon rises, a mythical werewolf howls and heads out on the hunt. But is this the best time for a werewolf to find a meal? In some stories, this transformation can happen at any time of the month or even during the day. And science suggests that a smaller, weaker werewolf might want to schedule their change a little differently — or face becoming the hunted.

The moon affects our world in several ways. As it orbits Earth, the moon pushes and pulls at the oceans to make tides. These tides can, in turn, influence the behavior of ocean creatures. And moonlight — a reflection of the sun — can also have power over the behavior of animals on both land and in the sea.

If a werewolf is all big, scary predator, the full moon might be a blessing. But if the animal could face predators itself, it might want to save its transformation for a much darker night.

TRANSFORMATIONAL TIMING

The dark depths of an ocean or stream might not seem like the obvious place for animals affected by the moon. But "it is something that we see pretty commonly among aquatic critters," says Heidi Ballew. She's a marine ecologist at Texas A&M University in Corpus Christi.

Ballew studies the ʻOʻopu nakea (*Awaous stamineus*), a goby native to Hawaii. The hardy little fish are born in freshwater streams in the hills. From there, goby

A common werewolf myth has a person turn into a werewolf during a full moon. The moon doesn't really affect people this way, but it can influence animals in other ways.

LOSW/SHUTTERSTOCK

lives can take two very different paths depending on when they are born.

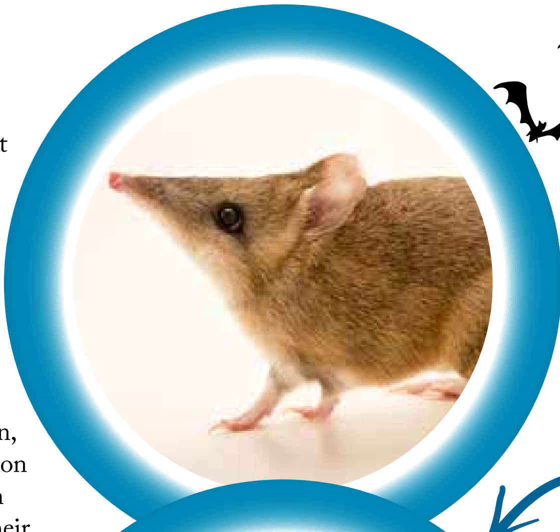
During the full moon, the sun, Earth and moon are lined up. This produces higher tides. Some gobies hatch during that full moon. The higher tides sweep their tiny bodies out to sea. When they are grown, higher tides during the new moon (when the sun, moon and Earth line up again) help them find their way back to their home streams. Special fins on their bellies, modified into suckers, help them climb waterfalls back to their birthplace. There, they mate and make more gobies.

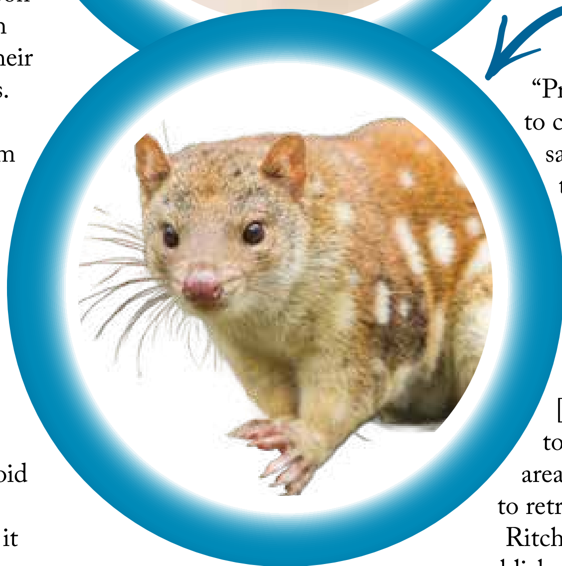
But not all gobies go out to see the world. Gobies born during the dark of a new moon stay home and never leave the stream where they are born.

Baby gobies are trying to avoid predation, Ballew says. “A full moon provides a high tide. But it also produces a lot of light — even underwater.” Night-hunting fish can better see tiny, defenseless gobies. So if a fish is going to stay put, hatching at the new moon is a safer bet.

The moon matters even as they grow into adults. A big, well-fed baby goby may become an adult during the full moon. But a smaller goby might become an adult at the new moon instead. The darkness hides these still-small new adult gobies, keeping them safe from predators. Ballew and her colleagues published their fishy findings in the journal *Ecology of Freshwater Fish*.

So there are pros and cons to lots of moonlight. A full moon lights up the night and makes it easy to spot dinner. But if a werewolf is as likely to become prey as it is to go hunting, a new moon might help it hide.





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Bandicoots (top) and quolls (bottom) are Australian marsupials. A key feature of marsupials is the pouch in which females raise their young.

PREDATORS AND PREY

The bright night of a full moon also presents Australian mammals with a problem, says Euan Ritchie. He’s a wildlife ecologist at Deakin University in Melbourne, Australia.

In one study, Ritchie and his colleagues took photos of animals in southeastern Australia at different phases of the moon. Prey species such as possums and rabbit-sized bandicoots were more active when nights were cloudy. The extra darkness provided cover to hide from predators.

But predators such as quolls were also more active when it was darker — when the moon was new or half. Each species was trying to find a balance between getting more food and becoming someone else’s dinner.

“Predators often use ambush to capture their prey,” Ritchie says. “The lighter it is, the harder it might be [for predators] to avoid detection.” While the prey might be able to spot a predator more easily, they, too, may be more detectable. “They [might] be more hesitant to be active, especially in areas without much cover to retreat to.”

Ritchie and his colleagues published their findings in the journal *Australian Mammalogy*.

Werewolves also need to find that balance between predator and prey. If a werewolf wanted to hunt as much as possible, “they would hunt humans by day and night,” Ritchie says. But being a werewolf isn’t without risk. “Many prey, including humans, are often far from harmless.”

In that case, Ballew says, a werewolf might be advised to vary its strategy. A big, strong werewolf could find good hunting during the full moon. But if a werewolf is small, young or weak? “Maybe you would want to utilize the new moon so that your predators are less likely to find you.” It’s a lesson a werewolf could learn from the gobies that stayed home.

— *Bethany Brookshire*

Nocturnal animals often have to make choices between finding food and finding safety. And like Australian bandicoots and quolls (above), werewolves, too, might want to be choosy about when they are most active.

EARTH

The four types of seismic waves

Earth's rocks can roll and shimmy with different types of shakes

Seismic waves transfer energy through the Earth in four main ways. Each type typically travels at a different rate of speed, which helps scientists tell them apart.

Seismic waves are vibrations in the ground. They can be caused by a variety of phenomena, such as earthquakes, underground explosions, landslides — or even concerts. Energy rippling away from these sources creates the vibrations.

There are four major types of seismic waves. Each typically travels at a different speed. That helps scientists tell them apart.

Studying the different types of waves and how they move can not only help pinpoint where an earthquake or explosion occurred but also shed light on the inner structure of our planet.

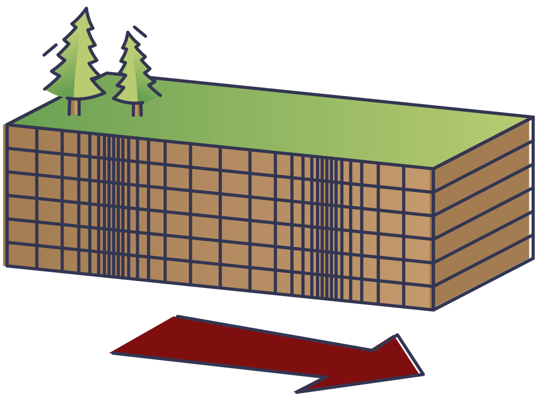
— *Sid Perkins*

As the energy released by earthquakes travels through the ground, it can leave behind visible damage like this surface fault.

VASTRAM/SHUTTERSTOCK

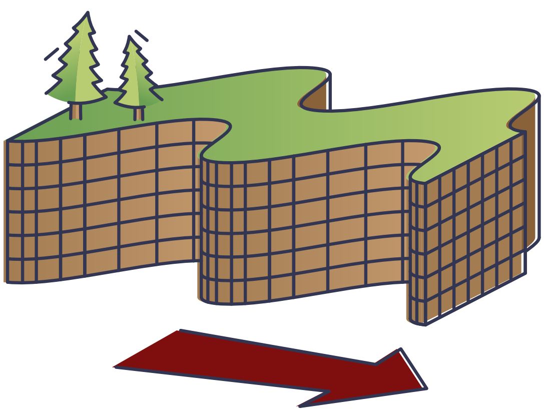
Body Waves

Because P waves and S waves travel through Earth — not just along its surface — they are known as body waves.



P WAVES

P, or "primary," waves are the fastest seismic waves. They travel about 5 to 8 kilometers per second (roughly 3 to 5 miles per second) across Earth's surface. But in deeper, denser material, they can travel more than 13 km/s (8 mi/s). P waves travel through rock as pressure waves, similar to the way sound waves move through air. The material moves forward, then back, along the same path that the wave is traveling. Unlike other seismic waves, P waves can travel through liquids and gases as well as solids.

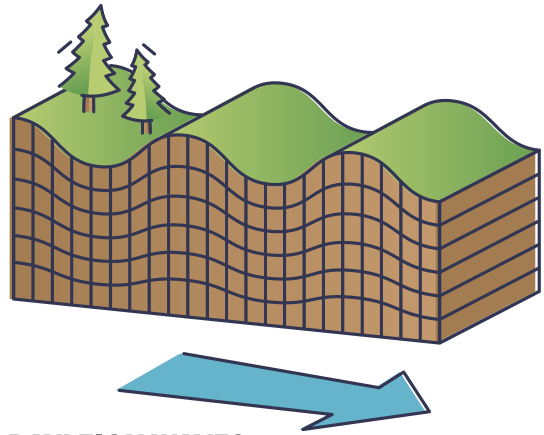


S WAVES

S, or "secondary," waves travel about 60 percent as fast as P waves. At the surface, they move about 3 to 5 km/s (2 to 3 mi/s). Unlike a P wave, though, an S wave moves material from side to side or up and down as it passes. And these waves can only move through solids, not through liquid or gas.

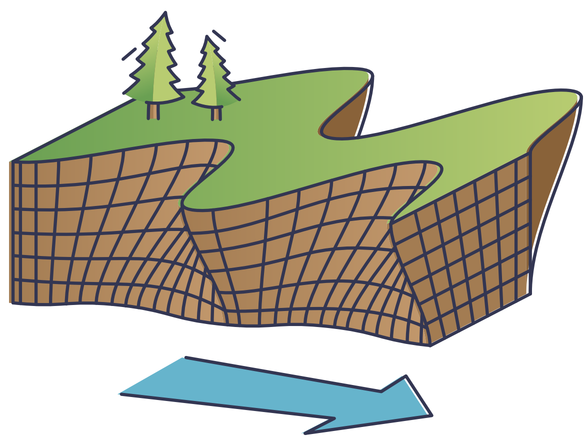
Surface Waves

Energy can also spread across the Earth's surface as either Rayleigh or Love waves. Surface waves are typically larger and cause much more damage than body waves.



RAYLEIGH WAVES

Rayleigh waves cause ground movements in two directions at once. One motion is up and down, much like waves on the ocean's surface. The other is a push-pull movement along the same path that the wave is traveling. Together, those motions generate a rolling action that can cause extreme damage to buildings and other structures. They travel about 3.5 km/s (2 mi/s).



LOVE WAVES

Like S waves, Love waves shake the ground from side to side compared to the direction they're headed. They travel a little bit faster than Rayleigh waves, about 4.5 km/s (3 mi/s).

EARTH

Green 'ghosts' haunt the upper atmosphere

Oxygen and space dust give atmospheric ghosts their eerie hues

Spooky red sprites (pictured) are sometimes visible above powerful storm clouds from 100 to 200 kilometers (60 to 120 miles) away.

Subtle greenish gleams called ghosts can appear above storm-sparked lights known as sprites. But ghosts are much harder to capture on camera than sprites' red glows.

Spooky glows haunt the air above powerful thunderstorms. These include vibrant red lights called sprites, sometimes followed by eerie green ghosts. But these light shows are not paranormal. They arise naturally from the electricity of strong storms. And now, scientists have unveiled exactly what is behind ghosts' green hue.

To create sprites and ghosts, you need a massive thunderstorm that holds a lot of electrical charge, says Oscar van der Velde. He's a meteorologist at the Polytechnic University of Catalonia in Terrassa, Spain. Strong storms can spark intense lightning that moves a lot of electrical charge around, kicking off a process that causes molecules in the air to briefly glow red. This creates sprites, which can look like jellyfish tentacles. After a sprite, a subtle greenish gleam — a ghost — sometimes appears near the sprite's top.

Sprite hunters noticed such glimmers of green in videos they had taken since 2019. Scientists suspected that oxygen high in the atmosphere was responsible for throwing off this green light. But van der Velde's team wanted to take a closer look.

Using a camera and an instrument that could pick out the specific wavelengths in light, the team waited for a green phantom glow to appear. One did over the Mediterranean Sea on September 21, 2019. It was difficult to capture the green gleam in the narrow slit of the instrument, van der Velde says. It can be challenging to predict exactly where a ghost will appear. But ultimately, he says, "we captured a ghost."

The researchers plotted the wavelengths of light in the ghost's gleam. Then, they compared the spectral features to the wavelengths of light known to be given off by specific chemical elements. "It's like a fingerprint," van der Velde says. This confirmed that oxygen was involved in producing the green hue. But the team saw that other elements they didn't expect — iron and nickel — were involved, too. These metals likely come from meteors burning up high in the atmosphere. The researchers reported their results in *Nature Communications*.

— *Carolyn Wilke*

O. VAN DER VELDE; ZDENEK BARDON/EUROPEAN SOUTHERN OBSERVATORY/SCIENCE PHOTO LIBRARY

ATMOSPHERIC GHOSTBUSTING

Outside of van der Velde's home, the team set up an instrument called GRASSP that analyzes light. On September 21, 2019, GRASSP caught sight of a sprite that gave way to a ghost (at the location in the Mediterranean Sea marked by a white plus sign). Black dots clustered to the right of the white plus sign show locations of nearby lightning strikes picked up by a lightning detection network.

The GRASSP instrument identified wavelengths of light that contributed to the color of the ghost spotted on September 21, 2019. The spread of wavelengths analyzed include green, yellow and orange light. Colors found in the ghost's glow show up as peaks on the graph, which is called a spectrum. (The two bottom panels zoom on specific parts of the spectrum in the top panel.) The taller the peak, the brighter the light at that wavelength is. Peaks are labeled with the chemical element responsible for making that light wavelength. The researchers can tell if a peak is worth considering if it meets certain brightness levels, rising higher than the gray area and dashed lines.

FIGURE A

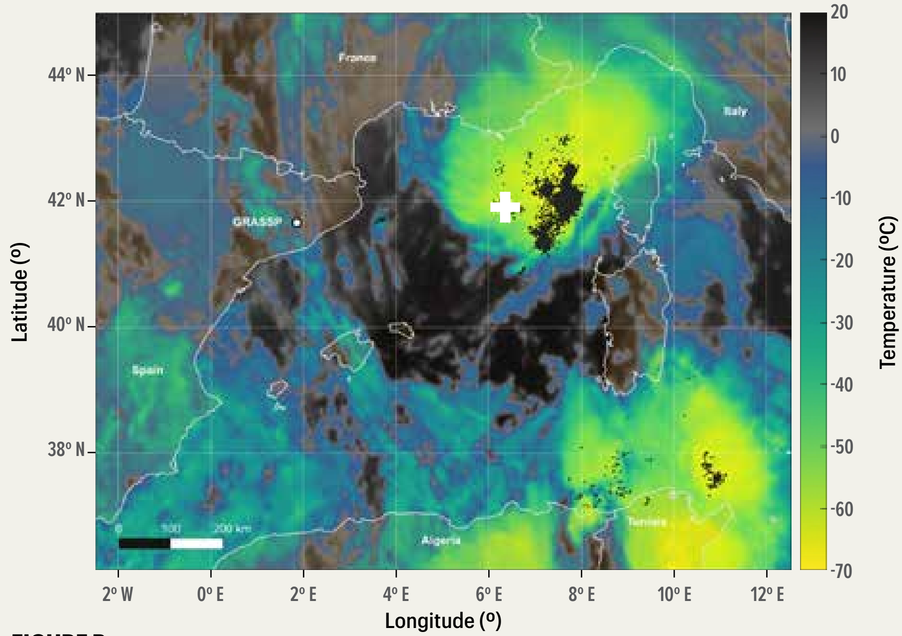
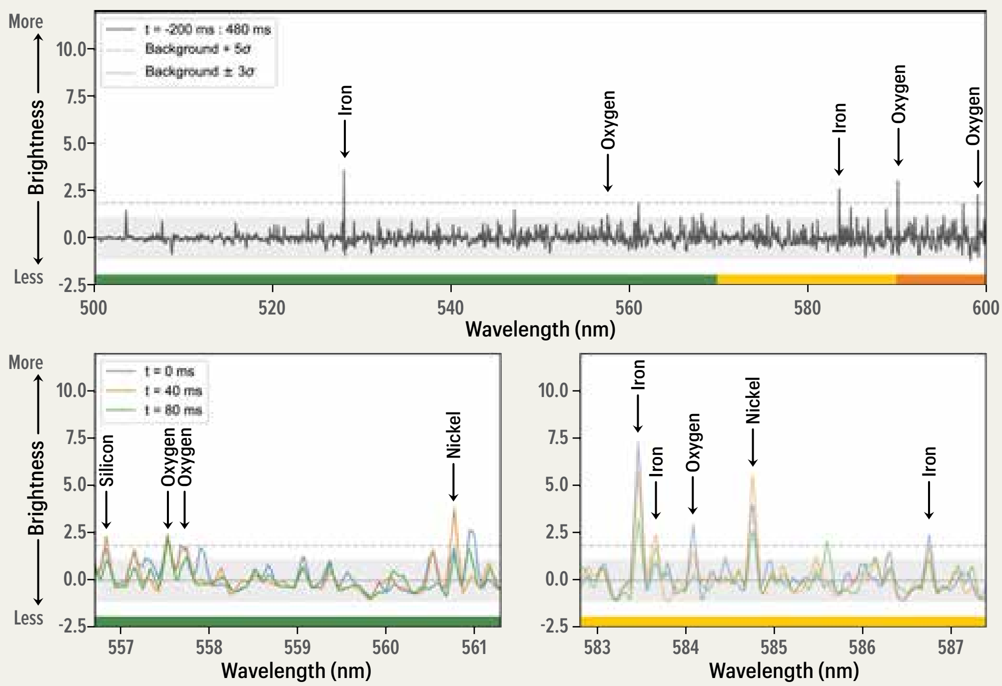


FIGURE B



DATA DIVE

1. Look at Figure A. Where is the GRASSP instrument located? How far is it from the ghost (white plus sign)? (See the scale bar in the bottom left corner.)

2. Where was the highest density of lightning on the evening the ghost was observed? How far was that from the ghost?

3. Look at the top panel of Figure B. What is the range — or spread — of wavelengths that the instrument analyzed?

4. Now look at all three panels. Which elements make green light? Which elements make yellow light? Which elements make orange light?

5. Which elements create the brightest peaks?

ANDREY PROKOPENKO/SHUTTERSTOCK; M. PASSAS-VARO *ET AL*/*NATURE COMMUNICATIONS* 2023

ANSWER

Elusive worm-lizards sport weird, spooky skulls

CT scans reveal bizarre features of the reptiles' anatomy

Worm-lizards have pink or brown scaly skin, black beady eyes and sometimes a coy smile. But behind that grin hides a powerful jaw and one giant middle tooth. New views of the skulls of these tiny beasts show how their noggins may help them burrow through the ground.

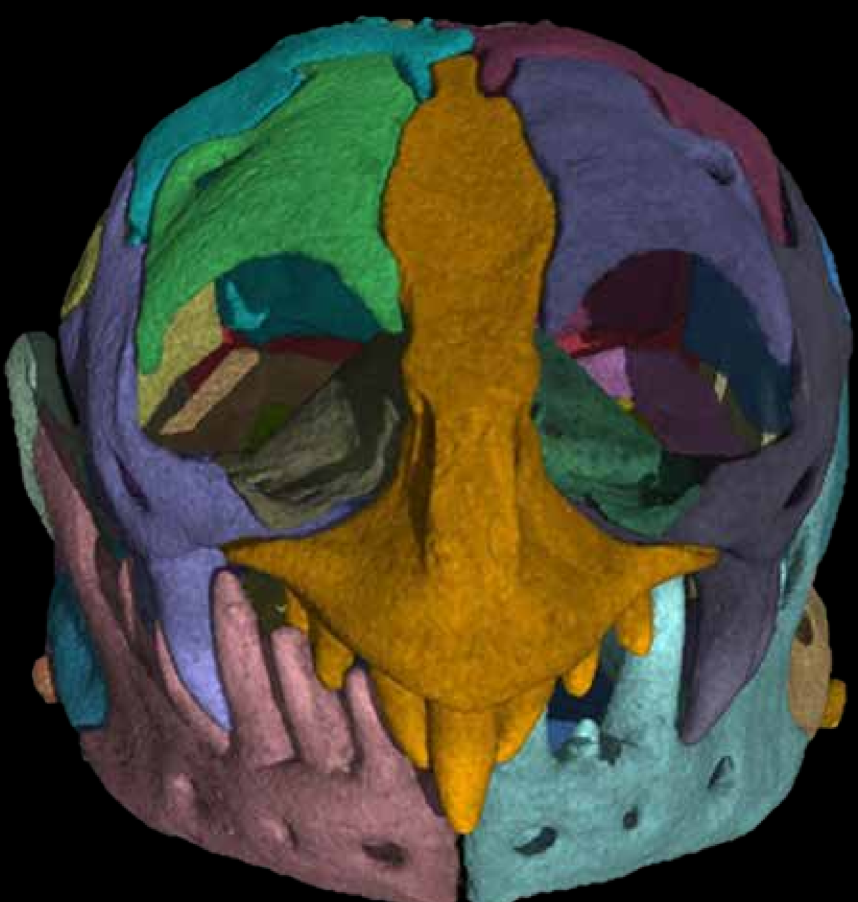
These amphisbaenians are reptiles, not worms. They have no limbs and could fit in a person's hand.

Worm-lizards live throughout much of the tropical world. But since they spend most of their time underground, researchers have known little about them. For the most common genus, *Zygaspis*, scientists had only studied the animals' outer appearance. In two new papers in *The Anatomical Record*, researchers now describe these creatures' odd skulls, bone-by-bone.

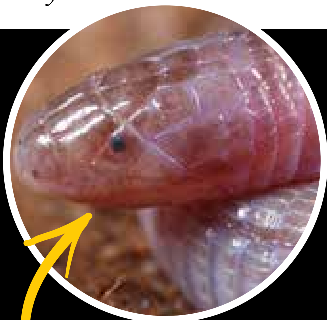
The researchers studied specimens of round-headed worm-lizards from Botswana. Technicians at the University of Texas at Austin imaged the animals' skulls with CT scans.

Their skull bones "are really, really weird," notes anatomist Adam Hartstone-Rose. He works at North Carolina State University in Raleigh and was not part of the new study.

There's that big central canine, for one thing. The CT scans also revealed a mysterious, barely visible bone at the bottom of the skull. And strange "zig-zaggy connections" between some bones may help keep the animals' skulls from breaking as they push through tough soil.
— *Andrea Tamayo*



This CT scan of a worm-lizard skull shows its bones in different colors. It has large nostril holes and a large, sharp central tooth.



Worm-lizards hide their toothy jaws behind a mild smile.

PATRICK LEWIS; JOHAN MARAIS

INSIDE THE MIND OF A SCIENCE AWARD WINNER

A Regeneron International Science and Engineering Fair winner answers three questions about her science

Science competitions can be fun and rewarding. But what goes on in the mind of a winner? Ishita Mukadam, a winner at the 2024 Regeneron International Science and Engineering Fair (ISEF), shares her experience.

Q What inspired your project?

A "A few years ago, I was in India at my grandparents' house, and I fell and scraped my knee," Ishita says. "My traditional grandmother, she sprinkled turmeric on my knee wound." Turmeric is a golden-yellow cooking spice. It is used in some cultures for medicinal purposes. Ishita designed a color-changing bandage that uses turmeric. "It hasn't been researched too much in terms of wound healing," she adds. "Because I eat turmeric, I was curious to know why food was in my wounds."

Q What resources helped you complete your project?

A "A couple years ago, I did research on the antibacterial properties of turmeric. And I found that it [kills] some bacteria," Ishita says. Turmeric can also be used as a pH indicator. It changes color in contact with substances of a certain pH level. "I am using the pH-sensing qualities of turmeric to be able to detect wound infections early, before they spread throughout the body."

Q Did you encounter any challenges?

A "Turmeric is a powder. And it can get quite messy in a wound environment, so it needs a covering," Ishita says. She didn't want to use commercial bandages because they are are made of latex and plastics. Those substances can be harmful to the environment. "I wanted to … go more eco-friendly," she says, "as well as use a natural and sustainable approach to wound healing."

Regeneron International Science and Engineering Fair Special Award Winner

Ishita Mukadam

Ishita, 18, designed a color-changing bandage that uses turmeric to detect infection. Turmeric naturally changes hue in new pH environments. The spice also has natural antibacterial properties. Ishita is a graduate of Maharishi School in Fairfield, Iowa.

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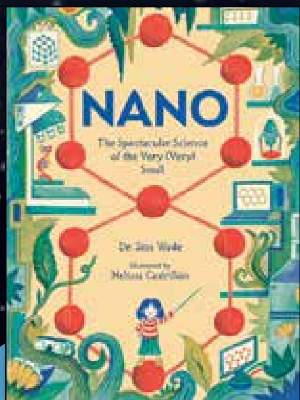

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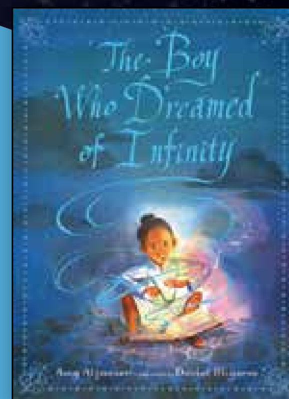

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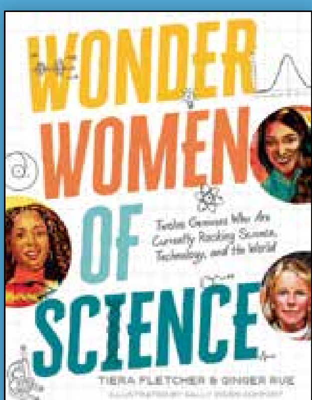

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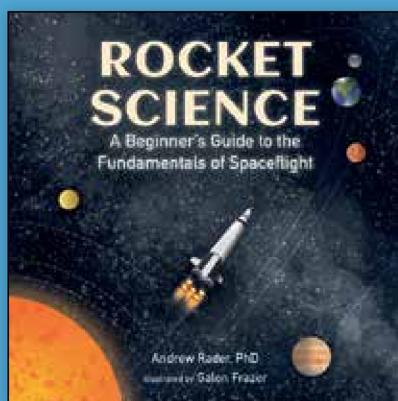

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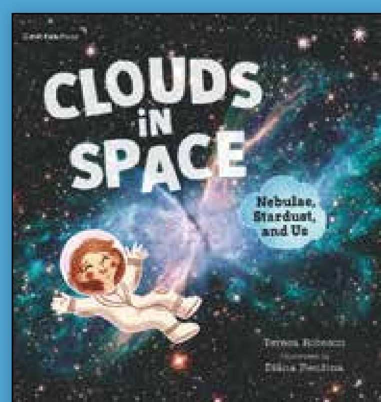

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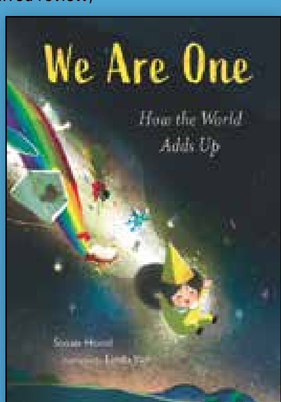

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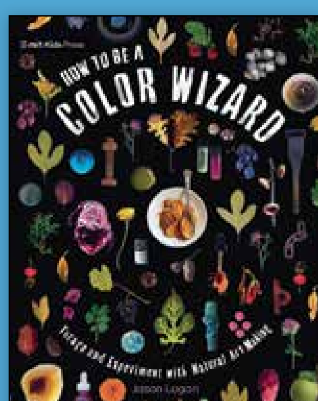

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