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March 2024
SPECIAL EDITION

THE ULTIMATE BLACKOUT

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Table Of Contents

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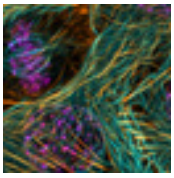
BENJAMIN BOE

Contents

Science News Explores | March 2024 | Vol. 3, No. 3



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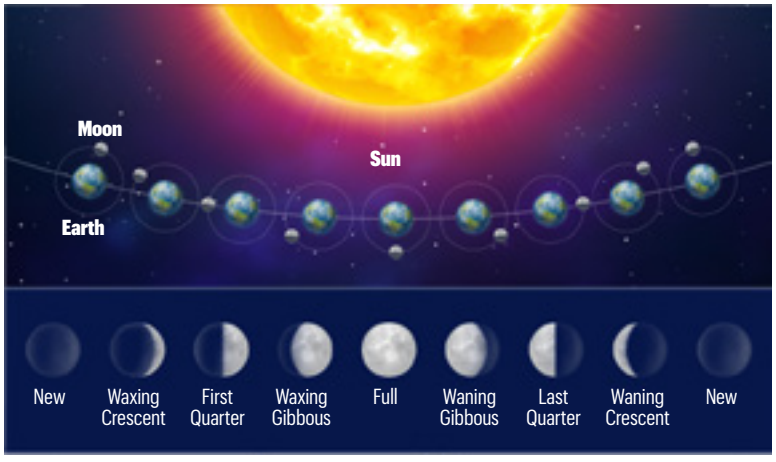
Q How come sometimes you can see the moon during the day and sometimes you can't?

— *Calvin H.*



A As our planet spins, the moon orbits Earth. This affects how much of the bright, lit half of the moon we see, and what time of the day or night we see it. During a full moon, the moon is on the opposite side of Earth from the sun. So we see all of the half of the moon lit up by the sun — but only at night. As the moon's orbit brings it closer to the sun, less of its lit half is visible to Earth. But that bright half starts to become visible during part of the day. About a quarter of the way through the moon's orbit, half of its lit side is in the sky from about midnight to noon. Halfway through the moon's orbit, during the new moon, the moon lies between the Earth and sun. The moon's lit side faces the sun, so it is not visible at any time of day or night to those of us on Earth. As the moon moves away from the sun again, more of its bright side becomes visible. And three-quarters of the way through its orbit, half the moon's lit face is in the sky from noon to midnight.

Q If milk and cream are white, why is butter yellow?

— *Cora B.*

A Milk and cream are mostly water. They get their white color from a protein called casein. Casein clumps with other compounds in milk to form a type of spherical molecule called a micelle. Micelles scatter light, giving milk its light hue. An animal's milk also contains fat. Churning (agitating) milk or cream helps separate that fat, producing butter. This process also exposes a pigment called beta-carotene. It is found in yellow, orange and leafy green plants. The pigment gives vegetables like peppers, carrots and sweet potatoes their warm colors. Beta-carotene from the grass and feed the cows eat gets stored in the animal's fat. When that fat ends up in butter, the beta-carotene gives the spread a yellowish hue.

Q If stomach acid is bad for your esophagus, why doesn't it hurt your stomach?

— *Jyothi J.*

A Though an empty stomach is only about the size of a fist, it can pack quite the punch. Cells lining the stomach produce a watery, clear fluid we call stomach acid or gastric juice. This liquid contains hydrochloric acid, which breaks down food and kills germs. Other cells secrete mucus and a chemical called bicarbonate to stop this acid from digesting the stomach lining. Mucus blocks the acid from reaching the stomach wall. Bicarbonate weakens the acid. The esophagus doesn't have these same defenses. When gastric juices leak into the esophagus, causing a burning sensation, we call that discomfort acid reflux.

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*

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SUNFLOWERRR/SHUTTERSTOCK

TECH

Cool in summer, warm in winter

A thermal 'cloak' uses no power and makes no CO_2 pollution

If you've ever burned your hands on a scorching hot seat belt buckle, you know how hot the inside of a car can get on a summer day. But a new fabric could one day help cars and other objects stay cooler in the summer — and warmer in the winter.

Kehang Cui is an engineer at Shanghai Jiao Tong University in China. His team made a prototype of the fabric. It acts as a "thermal cloak." That means it limits temperature changes in the space under it.

The cloak has two layers. In the outer layer, white silica fibers and a ceramic coating reflect sunlight and help shed heat. This keeps the area under the cloak from getting hot.

When the environment outside the cloak cools — like at night — the inner layer works like an insulating blanket. Made of aluminum foil, it traps heat under the cloak to keep that space warm.

The material requires no power source. That means it has the potential to cut the energy used for heating and cooling. If so, it could also cut carbon dioxide (CO_2) released by burning fossil fuels to make that energy, says Aaswath Raman. He's an applied physicist at the University of California, Los Angeles, who did not take part in the new study.

The cloak, described in the journal *Device*, even held up through extreme testing. The researchers baked the fabric at 800° Celsius (1,470° Fahrenheit) and dunked it in ultracold liquid nitrogen. They doused it in acid and blasted it with fire from a butane torch. In each case, there was virtually no change in the cloak's structure or performance.

This extreme durability suggests the cloak might be useful in spacecraft, the team says.

— *Skyler Ware*

HUAXU QIAO

Draping the new fabric over one car (left) kept its inside temperatures up to 28 degrees Celsius (50 degrees Fahrenheit) cooler than an uncovered car (right).

EARTH

This lake may mark the start of the Anthropocene

The proposed new epoch points to humans' dominant role in altering Earth

Scientists are one step closer to defining a new chapter in geology. They're calling it the Anthropocene. This name refers to humans having become the biggest force shaping Earth's environment and climate. And a lake in Canada may mark its official beginning.

Scientists first started describing an Anthropocene in the early 2000s. They wanted a term to note how people were now reshaping the planet on a global scale. But the term lacked a formal geologic definition.

The International Commission on Stratigraphy is in charge of defining geologic time. In 2009, it formed a committee to define the Anthropocene. It also asked the group to decide if such a time deserved its own spot in the geologic time scale.

Scientists suspected the new epoch started at some point in the early 1950s. So the committee set about looking for some place that might show when it emerged. They started from a list of 12 sites around the world. Each one recorded detailed effects of human activity. In 2023, they announced their choice: Crawford Lake in Milton, Ontario, Canada.

This lake's muddy layers trapped one of the most precise histories of how human activity has altered Earth, the group decided. Each summer, the lake's pH and warm temperatures trigger mineral crystals to form near the top of the water. Those crystals later fall like snow to the lake floor. There, they build up undisturbed.

"You get these lovely stripes," says Simon Turner, a member of the committee. An earth scientist, he works in England at University College London. Like looking at tree rings, he says, you can figure out what year each layer is from. You do it "pretty much by counting backwards from the [top]."

Starting in the early 1950s, those layers show a sharp rise in signs of human activity. These changes include upticks in radioactivity due to tests of nuclear weapons. There's ash from the burning of fossil fuels and heavy metals, such as lead. Microplastics show up in more recent layers.

Not all scientists agree that the Anthropocene began just 70 years ago. Some question if it should be officially defined at all. "Any time you draw a hard line in the geologic record," says Jacquelyn Gill, "there's a before and there's an after." And, she points out, "We know human impacts began well before 1950." A paleoecologist, she works at the University of Maine in Orono.

Still, trying to define human effects in geologic terms underscores our dramatic — and rapid — impact on Earth. Turner says, "we've become a geological force."

The Anthropocene isn't an official epoch yet. More committees must approve it before it can be added to the official geologic time scale. But doing so would end the nearly 12,000-year-long Holocene. Marking the end of the last ice age, that epoch covered the rise of humans as Earth's defining species. — *McKenzie Prillaman*

Mud at the bottom of Canada's Crawford Lake (pictured) holds an extremely precise record of humans' impacts on our planet. Some scientists think the layers here might mark the start of a new geologic time period called the Anthropocene.

SF PHOTO/SHUTTERSTOCK

PLANTS

Young corn leaves can 'smell' danger

As they mature, these leaves lose their ability to detect threatening scents

Plants can often tell when they're in danger — by smell. But not all leaves sniff out threats equally well. In corn plants, baby leaves do this best, new data show.

"They sense this — like OK, danger is at the corner, we better prepare," says Lei Wang. He's a plant biologist at the University of Bern in Switzerland. He and his colleagues shared the new findings in *Current Biology*.

Many plants beef up their chemical defenses when they're about to get chomped on by insects. One way plants sense such threats is through scent. They can detect odor molecules floating through the air. Such odors may waft off an insect's saliva or from nearby injured plants.

But scientists don't know which parts of plants sniff out danger. (Obviously, plants don't have noses.) And they know even less about what goes on inside plants for them to process: *danger*!

Wang and his team set out to study this warning system in corn plants. But they ran into a problem. When exposed to "threat" scents, adult leaves didn't respond much at all.

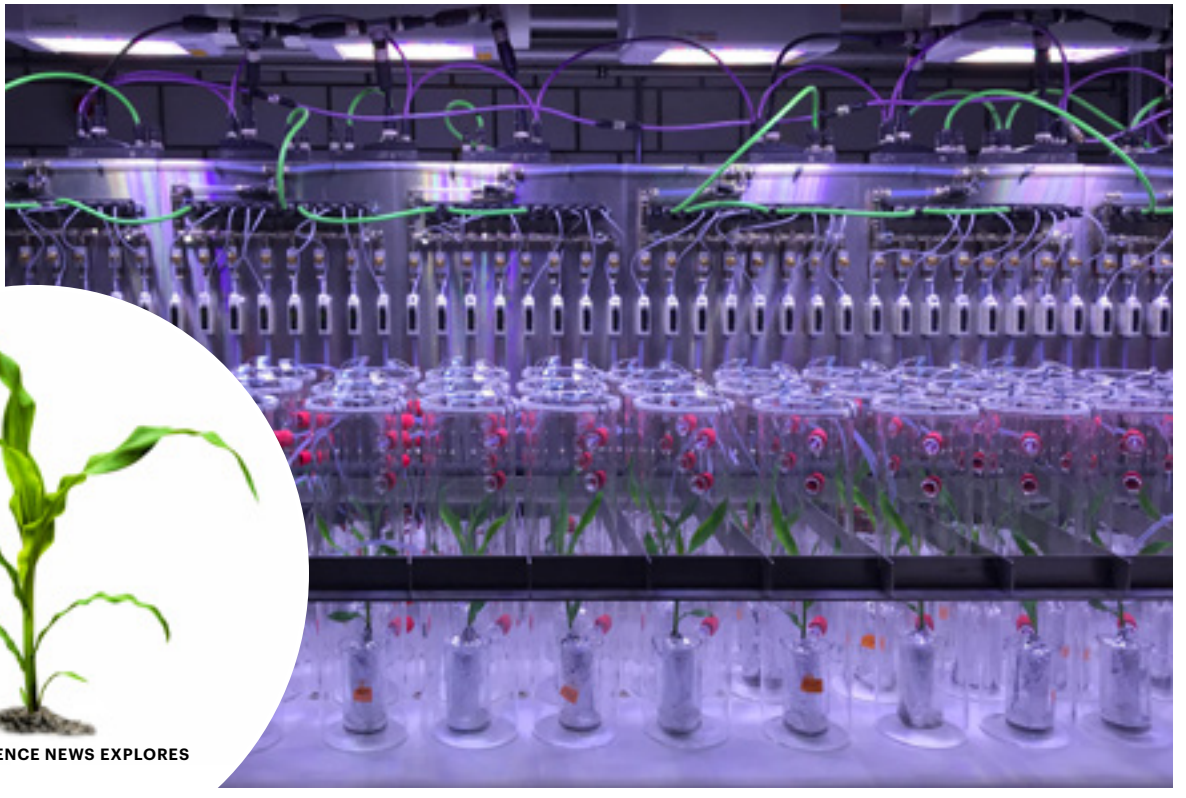
The researchers turned to baby leaves instead. In the lab, young corn leaves seemed better able to sniff out danger than older ones. They responded more strongly to a common danger-signaling scent. (It smells like freshly cut grass.)

It's not clear why young corn leaves smell trouble better than older ones do. Maybe it helps protect these more vulnerable leaves. Or, since young leaves often grow at the top of a plant, they might better detect scents blowing from long distances. These questions will need more study.

Wang hopes his research may lead to the breeding of smarter crops — ones more resistant to insects. In the long run, that should reduce the need for toxic pesticides.

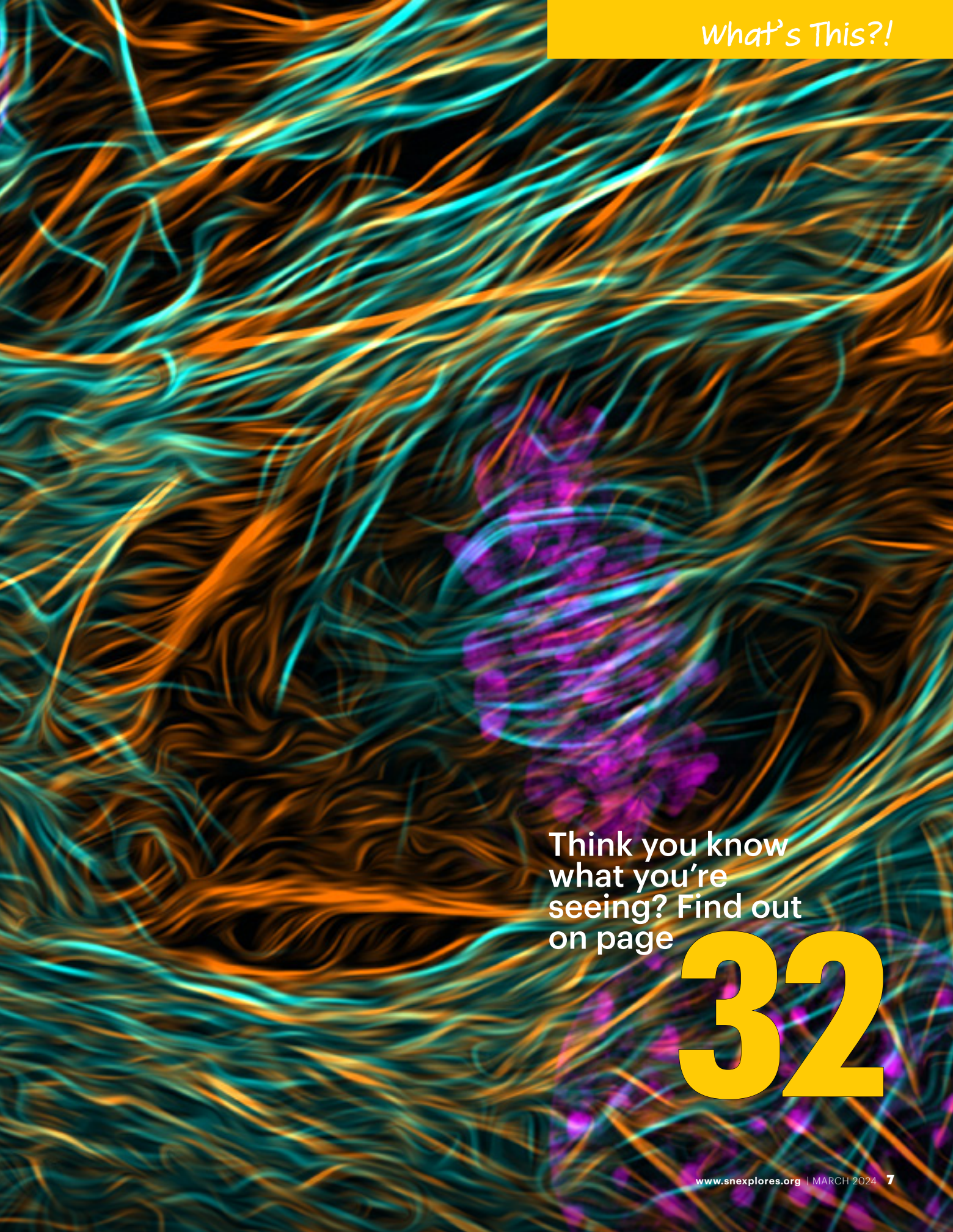
"My parents are farmers," Wang says. So this research is "not just to satisfy my curiosity. I really want to solve some urgent questions in agriculture."

— *Nora Bradford*



A system in a lab measures airborne chemicals emitted by individual corn plants. Young corn leaves (inset) seem able to sniff out "danger" signals better than older leaves do.

FOTOLDEE/SHUTTERSTOCK; LEI WANG/*CURRENT BIOLOGY* 2023



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


WHALE

By **Kathryn Hulick**

TALK

How artificial intelligence could help us talk to animals

A sperm whale surfaces, exhaling a cloud of misty air. Its calf comes in close to drink milk. When the baby has had its fill, mom flicks her tail. Then, the pair dive down deep. Gašper Beguš watches from a boat nearby. "You get this sense of how vast and different their world is when they dive," he says. "But in some ways, they are so similar to us."

AMANDA COTTON

Artificial intelligence (AI) could help translate the clicks that sperm whales use to communicate into words we can understand.

AMANDA COTTON

Sperm whales have families and other social relationships. They use loud clicking sounds to communicate. It seems as if they might be talking to each other.

Beguš is a linguist at the University of California, Berkeley. He got the chance to observe sperm whales off the coast of the Caribbean island nation of Dominica. With him were marine biologists and roboticists. There were also cryptographers and experts in other fields. All have been working together to listen to sperm whales and figure out what they might be saying.

This is Project CETI. That's short for Cetacean Translation Initiative (because sperm whales are a type of cetacean).

At each of three listening stations, a cable hangs deep in the water from a buoy at the surface. Along the cable, several dozen underwater microphones record whale sounds. From the air, drones record video and sounds. Soft, fishlike robots do the same underwater. Suction-cup tags on the whales capture even more data.

But just collecting all these data isn't enough. The team needs some way to make sense of it all. That's where artificial intelligence, or AI, comes in.

A type of AI known as machine learning can sift through vast amounts of data to find patterns. Thanks to machine learning, you can open an app and use it to help you talk to someone who speaks Japanese or French. One day, the same tech might translate the sounds of whales and other animals.

What is language?

Long before AI came into the picture, scientists and others worked toward understanding animal communication. They learned that elephants communicate in rumbles too low for human ears to hear. Bats chatter in squeaks too high for our hearing. Hyenas spread scents to share information. Bees communicate through dance.

Whether these communication systems count as language is a controversial question. No one really agrees on how to define language, says Beguš.

Human language has many important features. It's something we must learn. It allows us to talk about things that aren't in the here and now. It allows us to do lots more, too, such as invent new words. So a better question, Beguš says, is "what aspects of language do other species have?"

AI could help find hidden patterns in animal communication that aren't obvious to people. "Humans are biased," says Beguš. "We hear what is meaningful to us." But the way we use sound in our languages may not be anything like how animals use sound to communicate.

To build words and sentences, human languages use groups of letters called phonemes. Meaning comes from the order of these phonemes. In English, swapping the phoneme "d" for "fr" makes the difference between "dog" and "frog." In tonal languages, such as Chinese, using a high or low voice can also change the meaning of words.

Animal languages could use any aspect of sound to carry meaning. Before Project CETI began, researchers had already collected and studied lots of sperm whale clicks. They call a group of clicks a "coda." Researchers suspected that the number and timing of the clicks in codas carried meaning.

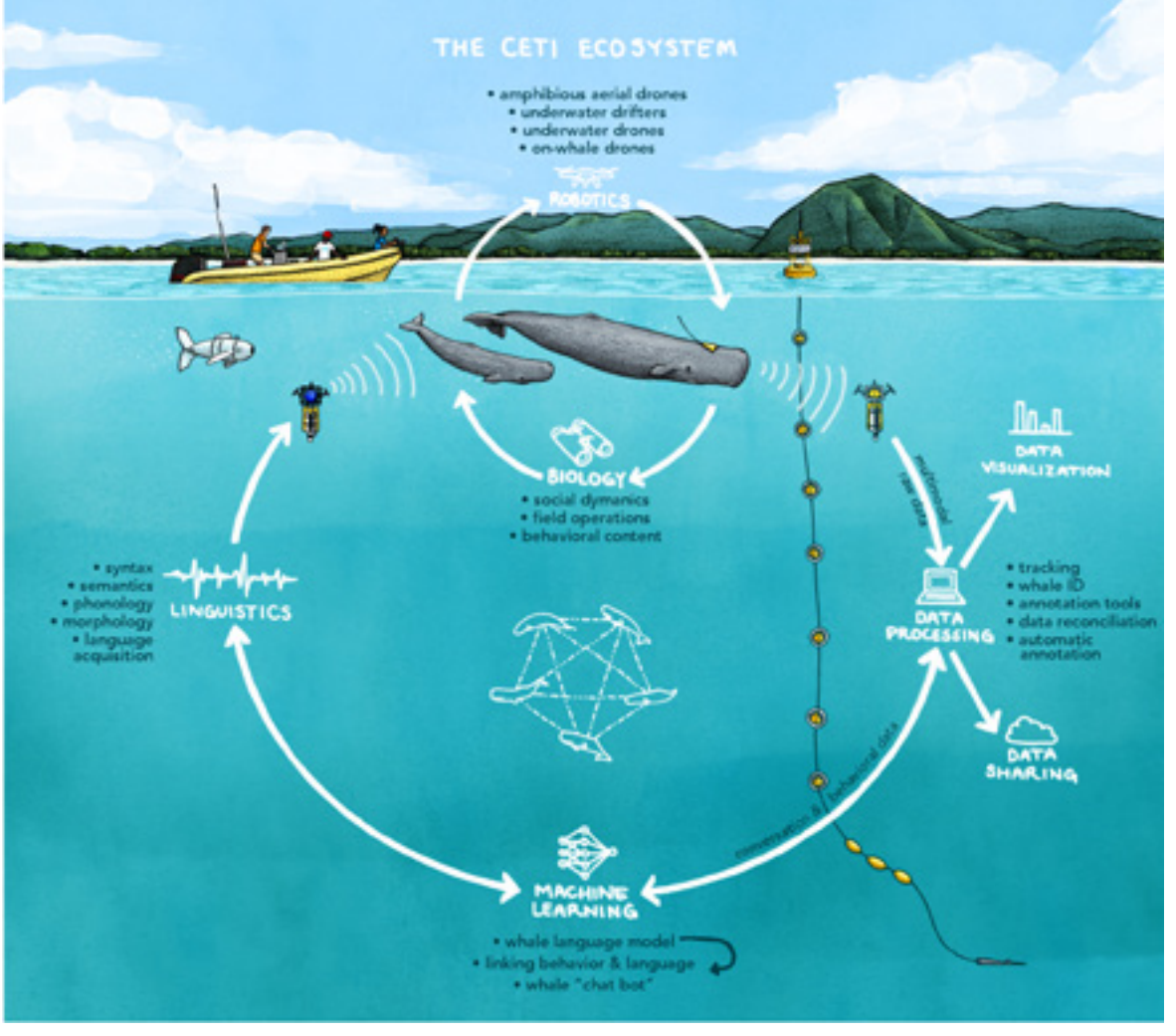
Beguš built an AI model to test this.

Finding meaning

The computer model contained two parts. The first learned to recognize sperm whale codas. It worked from a collection of sounds recorded in the wild. The second part of the model never got to hear these sounds. It trained by making random clicks. The first part then gave feedback on whether these clicks sounded like a real coda.

Over time, the second part of the model learned to create brand-new codas that sounded very real. These new codas might sound like nonsense to whales. But that doesn't matter. What Beguš really wanted to know was: How did the model create realistic codas?

The number and timing of clicks mattered, just as the researchers had suspected. But the model revealed new patterns that the experts hadn't noticed. One has to do with how each click sounds. It seems important that some frequencies are louder than others.



ALEX BOERSMA

Project CETI is using drones and other technology to collect data on whale communication. Machine learning models could crunch that data to reveal if whales use language and perhaps what their sounds mean.

Beguš and his colleagues shared their findings at arXiv.org. (Studies posted on that site have not yet been vetted by other scientists.)

Once researchers know which features of sperm whale sounds are most important, they can begin to guess at their meaning.

For that, scientists need context. That's why Project CETI is tracking everything from water temperatures around the whales to whether there are dangerous orcas or tasty squid nearby. "We are trying to have a really good representation of their world and what is important to them," Beguš explains.

This gets at a tricky aspect of animal translation — one that has nothing to do with technology. It's a philosophical question. To translate what whale sounds mean, we need to figure out what they talk about. But how can we understand a whale's world?

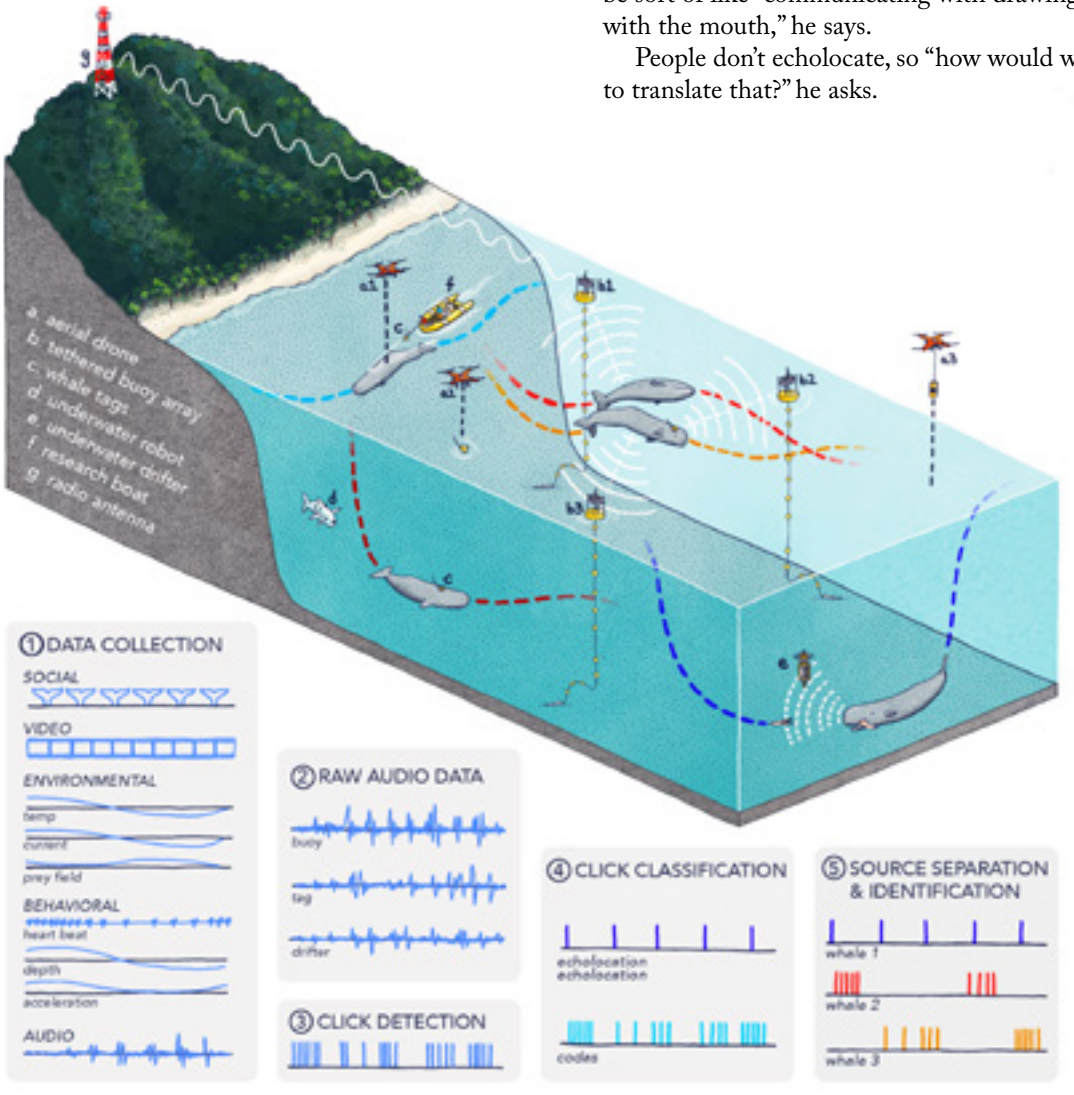
In 1974, the philosopher Thomas Nagel published a famous essay: "What is it like to be a bat?" No matter how much we learn about bats, he argued, we'll never understand what it feels like to be one. We can imagine flying or sleeping upside-down, of course. But, he noted, "it tells me only what it would be like for me to behave as a bat behaves."

Imagining life as any other species poses the same problem. Marcelo Magnasco is a physicist at the Rockefeller University in New York City who studies dolphin communication. He notes that linguists have made lists of words common to all human languages. Many of these words — such as sit, drink, fire — would make no sense to a dolphin, he says. "Dolphins don't sit," he notes. "They don't drink. They get all their water from the fish they eat."

Similarly, dolphins likely have concepts for things that we never talk about. To get around, they make pulses of sound that bounce off certain types of objects nearby. This is called echolocation.

In water, sound waves pass through some objects. When a dolphin echolocates off a person or fish, it "sees" right through to the bones! What's more, Magnasco notes, dolphins might be able to repeat the perceived echoes to other dolphins. This would be sort of like "communicating with drawings made with the mouth," he says.

People don't echolocate, so "how would we be able to translate that?" he asks.



Do these animals have a language of their own?

Listen to them online, and judge for yourself.

ALEX BOERSMA

Chatting with dolphins

Yet dolphins do share some experiences with people. "We're social. We have families. We eat," notes marine biologist Denise Herzing. She is the founder and research director of the Wild Dolphin Project in Jupiter, Fla. For almost 40 years, she has studied a group of wild Atlantic spotted dolphins. Her goal has been to find meaning in what they're saying to each other.

This is very slow work. She points out, for instance, "We don't know if they have a language — and if so, what it is."

One thing researchers do know is that dolphins identify themselves using a signature whistle. It's a bit like a name.

Early on, Herzing gave herself a signature whistle. She also records the whistles of the dolphins she works with. She uses a machine called CHAT box to play these whistles back to dolphins. "If they show up, we can say, 'Hi, how are you?'" she explains.

Today, CHAT box runs on a smartphone. It contains more than just signature whistles. Herzing and her team invented whistle-words to identify things dolphins like to play with, including a rope toy. When the researchers and dolphins play with these items, the people use CHAT box to say the whistle-words. Some dolphins may have figured out what they mean. In a 2013 TED Talk, Herzing shared a video of herself playing the rope sound. A dolphin picked up the rope toy and brought it to her.

The next level would be for a dolphin to use one of these invented "words" on its own to ask for a toy. If it does, the CHAT box will decode it and play back the English word to the researchers. It already does this when the researchers play the whistle-words to each other.

Herzing is also using AI to sift through recorded dolphin calls. It then sorts them into different types of sound. Like the Project CETI team, she's also matching sounds with behaviors. If a certain type of sound always comes up when mothers are disciplining calves, for example, that might help reveal structure or meaning. She notes that "the computer is not a magic box." Asking it to interpret all this, she says, is "so much harder than you think."

Much like people introduce themselves by name, dolphins (top, an Atlantic spotted dolphin; bottom, a bottlenose dolphin) identify themselves with signature whistles.

Time will tell

AI has greatly sped up how long it takes to sort, tag and analyze animal sounds — as well as to figure out which aspects of those sounds might carry meaning. Perhaps one day we'll be able to use AI to build a futuristic CHAT box that translates animal sounds into human language, or vice versa.

"AI could eventually get us to the point where we understand animals. But that's tricky and long-term," said Karen Bakker, who passed away in 2023. She was a researcher at the University of British Columbia in Vancouver, Canada, and wrote the book *Sounds of Life*.

Sadly, Bakker said, time is not on our side when it comes to studying wild animals. Across the planet, animals are facing threats from habitat loss, climate change, pollution and more. "Some species could go extinct before we figure out their language," she said.

Plus, she added, the idea of walking around with an animal translator may seem cool. But many animals might not be interested in chatting. "Why would a bat want to speak to you?" she asked. What was interesting to her was what we can learn from how creatures talk with each other. We should listen to nature in order to better protect it, she argued. For example, a system set up to record whales or elephants can also track their locations. This can help us avoid whales with our boats or protect elephants from poachers.

Conservation is one goal driving Project CETI. "If we understand [sperm whales] better, we will be better at understanding what's bothering them," says Beguš. Learning that a species has something akin to language or culture could also inspire people to work harder to protect it.

When you protect an animal that has some version of language or culture, you're not merely conserving nature. You're also saving a way of life. Herzing says that dolphins deserve a healthy environment so their cultures can thrive.

In the future, instead of guessing at what animals might need, we might just be able to ask them.

CAN DANIEL AMIRAK, NICOLAS-SB/SHUTTERSTOCK

Analyzing audio recordings of sperm whales requires picking out groups of clicks from background noise. Scientists may also identify the whales they came from or collect environmental, behavioral and other types of data to help them figure out what the whales might be saying.

MURATART/SHUTTERSTOCK

By **James R. Riordon**

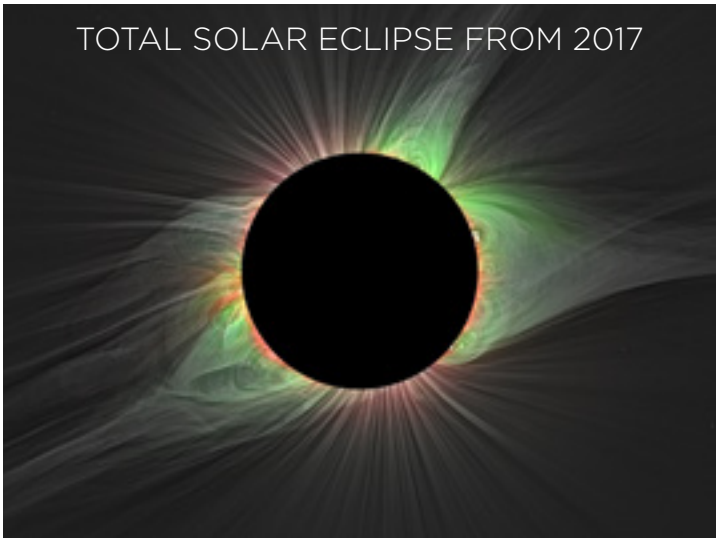
THE ULTIMATE BLACKOUT

A rare total solar eclipse will race across North America on April 8 — are you ready for it? >>

Solar eclipses are dramatic events as a rule. The moon moves between the Earth and the sun and blocks out our star. The world around you goes eerily dark for a few minutes. But the total eclipse coming on April 8 is going to be more special than usual.

The last total eclipse crossed the United States in 2017. It was a spectacular event witnessed by millions. Maybe even you. But this year's total eclipse will last longer. The sky will fall darker. The sun itself will put on a much livelier show. And even more people will be able to step outside their front doors to see one of the most astounding astronomical events of their lives.

It will also be the last major eclipse to cross North America for 20 years. All of that makes for an especially rare opportunity for casual observers and scientists alike. Here are a few things to know about this spectacular event.


TOTAL SOLAR ECLIPSE FROM 2017

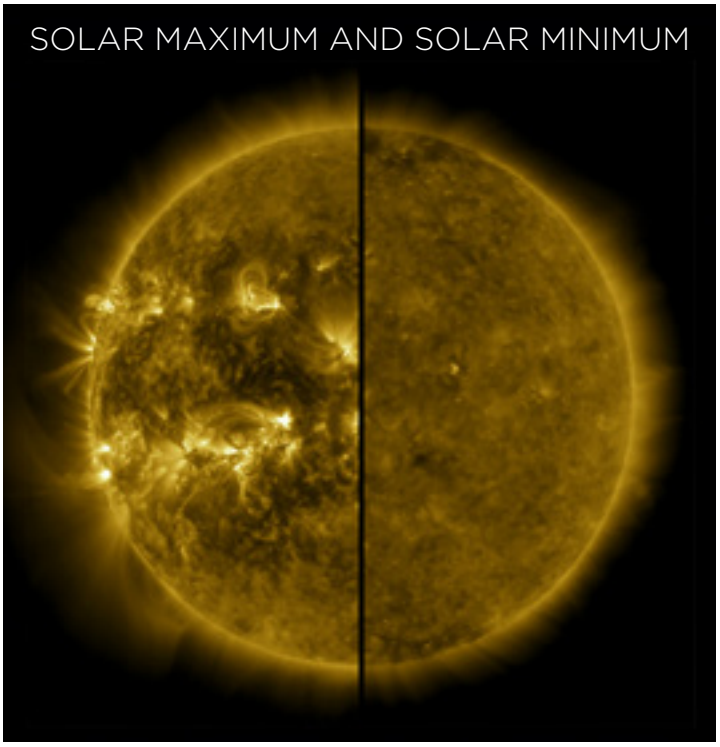

SOLAR MAXIMUM AND SOLAR MINIMUM

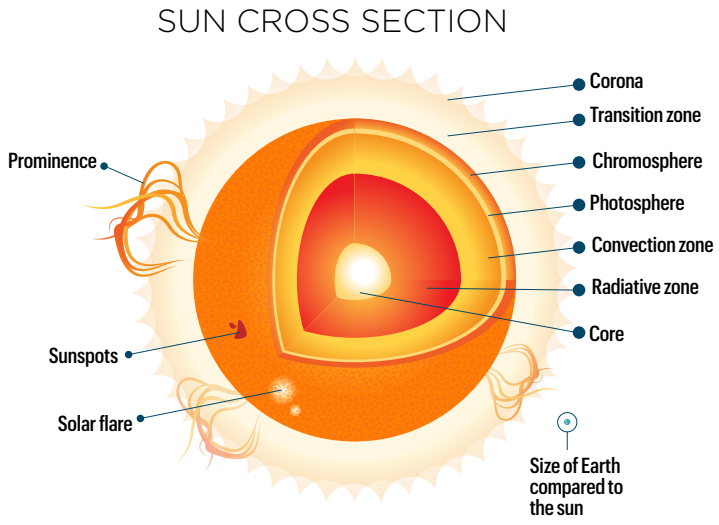
IMAGE PRODUCED BY M. DRUCKMULLER AND PUBLISHED IN HABBAL *ET AL.* 2021; SDO/NASA

Why will this eclipse last longer?

The moon's orbit isn't a circle. It's closer to the Earth at some times than at others. During the April eclipse, the moon will be at a point in its orbit that's comparatively near to the Earth. That will make the moon appear particularly large. This will mean something special for anyone fortunate enough to make it to the path of totality. That's where the moon completely blocks out the sun's disk. For them, this will be an especially dark eclipse. And it will last for nearly 4.5 minutes. That's almost two minutes longer than the Great American Eclipse of 2017.

What's more, the sun will be close to solar maximum in 2024. That's the peak of its roughly 11-year activity cycle. As a result, lots of bright, petal-like streamers of plasma will extend from the solar corona. This is the sun's outer atmosphere. The increase in solar activity also ups the chances of a coronal mass ejection, or CME. This is a large puff of hot gas trapped in a loop of magnetic field that's blasted away from the sun's surface.

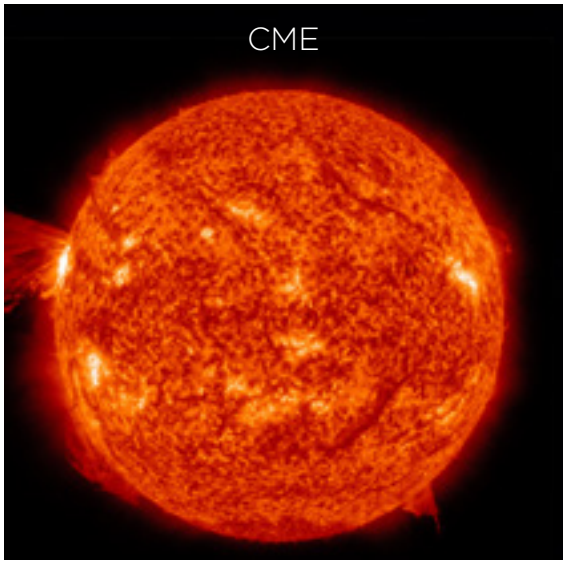
A longer time to observe the eclipse and a more active sun will make a better show. And it will be a boon for scientists. They now have more telescopes, sensors and satellites available to study the sun than ever before. Even non-scientists should be able to see streams of glowing gases flowing from the sun and a CME, if one occurs. (Eclipse glasses are a necessity to safely view the eclipse before and after totality. Your school or local library might give them away for free. Or you can order them online.)



What's different about this eclipse's path?

"Next April," says Michael Zeiler, "there's nearly 32 million people [who will be] inside the path [of totality]." That's about 2.5 times as many as during the 2017 eclipse. And "the major East Coast metros from Baltimore [Md.] to Boston [Mass.] are all about 200 miles [320 kilometers] from the path of totality."

That means that the path of totality is going be very accessible to the bulk of the U.S. population, says Zeiler. He's a cartographer and founder of the website GreatAmericanEclipse.com. The eclipse will be visible to some degree in every U.S. state. And people in portions of northwestern Mexico and southeastern Canada will also be able to see it.



VECTORMINE/SHUTTERSTOCK; SDO/GODDARD SPACE FLIGHT CENTER/NASA

The total solar eclipse in 2017 (left, top, photographed by scientists with a special filter) was spectacular, but this year's eclipse is expected to be better. That's in part because it will occur during solar maximum (left, bottom), when the sun's activity peaks. More sun activity makes it more likely scientists could study a coronal mass ejection (right, shooting off the left side of the sun) during the eclipse.

The 2024 eclipse path will also be helpful for researchers who use radar to study charged particles high in the atmosphere. That's according to space scientist Bharat Kunduri of Virginia Tech in Blacksburg. This eclipse's path passes within the observing range of three radars in the worldwide Super Dual Auroral Radar Network. That wasn't true for the last two North American eclipses.

Those radars monitor a gaslike plasma of positively charged atoms and negatively charged electrons in the Earth's atmosphere. The sun's rays kick electrons off atoms to create this plasma. The plasma makes up a layer around our planet called the ionosphere. It can act like a mirror for radio signals. And it causes those signals to bounce from terrestrial transmitters back down to receivers, instead of letting the signals head out to space. That extends the range that transmitters can reach. The ionosphere also alters the transmission of signals down to Earth from GPS satellites. Taking that effect into account is crucial for ensuring that GPS systems are accurate.

During a solar eclipse, as at nighttime, all the radiation from the sun goes away. The atmosphere becomes a little less dense and less ionized. "And radio waves can behave differently," Kunduri says. Using the instruments in the radar network during an eclipse can help scientists better understand how the sun generates the ionosphere. It can also help them learn how the plasma layer affects transmissions from satellites and radios.

An eclipse "gives you an excellent opportunity to study what happens when there is a sudden change in the upper atmosphere," he says.

What's unique about this chance to spot a CME?

Two satellites will be looking at the sun from the side while the eclipse is happening. These are the European Space Agency's Solar Orbiter and NASA's Parker Solar Probe. Because of the sun's elevated activity this time, the chances are very high that eclipse observers on the ground and those satellites could study a CME at the same time.

Ground-based observers would be able to watch a CME traveling out from the sun. Meanwhile, the satellites would see the event head on, if they happen to lie in the path of an ejection. They might even be able to take samples as the solar material goes blasting past. It's the only time in the lifetimes of the two satellites that they'll be aligned like this during an eclipse at solar maximum.

Two NASA WB-57F jets (one shown) will fly along the path of the eclipse. This will let them collect data for longer than people on the ground and ensure clouds don't obstruct the view.

"If we would be so lucky to have one," says Nour Raouafi, and it's "propagating toward the spacecraft … it will be fascinating to see it during a total solar eclipse." Raouafi is an astrophysicist at Johns Hopkins Applied Physics Laboratory in Laurel, Md.

Scientists want to know more about CMEs because the solar eruptions, when aimed at Earth, can disrupt communications and power grids. They can also threaten satellites or astronauts in orbit around the Earth.

In addition to observing any ejection, the satellites' observations could help confirm the source of very speedy solar winds. These seem to be accelerated by kinks that develop in magnetic fields near the surface of the sun.

Insights into the solar wind, in turn, provide further insights into how CMEs can affect Earth. That's because the ejections, Raouafi says, pile up material in the solar wind. This "will affect the arrival time of these events to Earth. So, knowing the conditions of the solar wind before the [ejections] is extremely important to predict when they are arriving or how important they will be."

How will scientists study this eclipse?

Several experiments planned for 2024 are repeats from past eclipses. Some feature updated instrumentation. Others will benefit from observations gathered while the sun is near its solar maximum. This will let scientists make comparisons to the quieter phase that the sun was in during the 2017 eclipse. All the 2024 experiments should benefit from the increased data quality and quantity that comes with the longer viewing time.

Take the WB-57F jet planes that carried instruments to observe the 2017 eclipse while flying along its path of totality. They will be in the air again in April, says Amir Caspi. He is a physicist at the Southwest Research Institute in Boulder, Colo. "It's a big improvement because we're flying new instruments [that provide] better information. The fact that it's solar maximum will give us a lot more things to look at."

Improved cameras and spectrometers, for example, will offer detailed views of the corona close to the sun's surface. The corona is the outer, bright layer of the sun's atmosphere. It's the only part of the sun that's visible during totality.

"This eclipse is also twice as long as the last one. On the ground, it's 4.5 minutes," Caspi says. "In the air, we're going to get 6.5 minutes per airplane." Planes can't travel fast enough to keep up with the moon's shadow during an eclipse. But they can travel fast enough to extend the time they spend in totality.

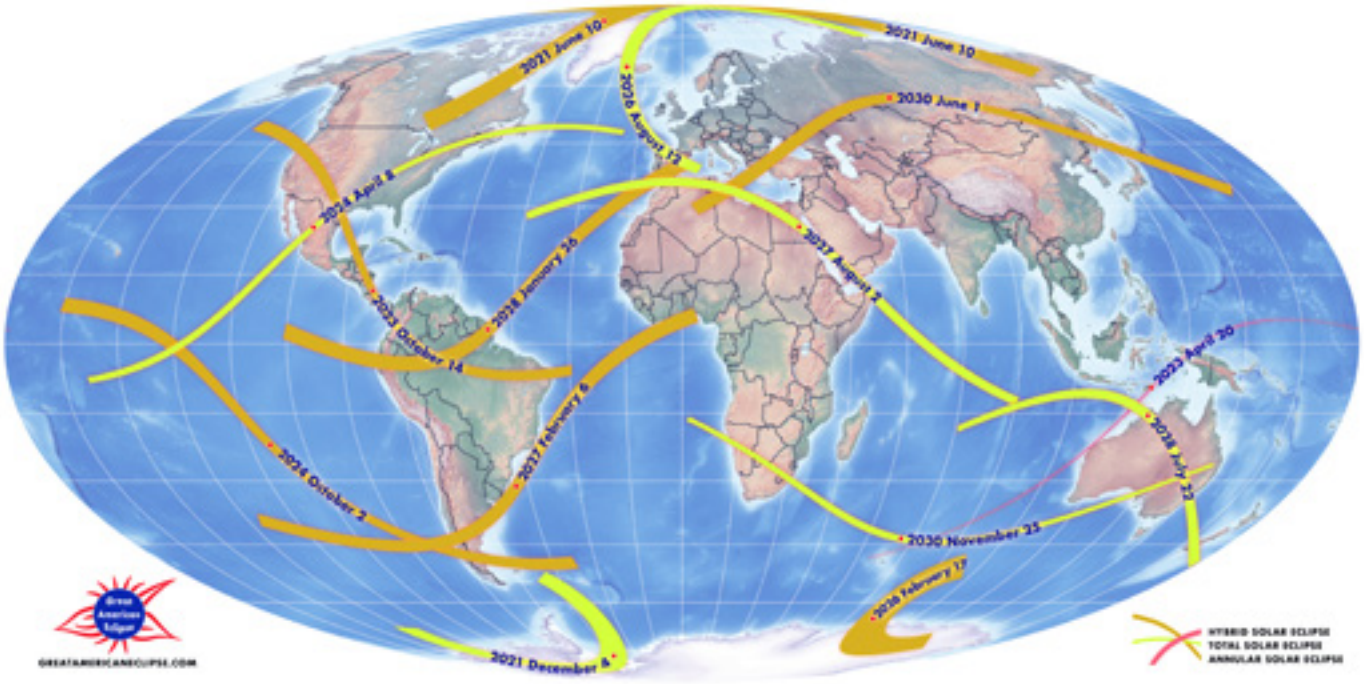
If all goes well, he says, they could also discover some asteroids thought to exist within the orbit of Mercury. Those asteroids are difficult to detect without the moon blocking the sun's glare.

Shadia Habbal is an astronomer at the University of Hawaii in Honolulu. She is leading a team that will fly updated cameras and spectrometers on the jets as well. She's also setting up ground-based observations at sites in Mexico, Texas and Arkansas.

Habbal is even planning to send a spectrometer 4 kilometers (2.5 miles) aloft on a kite from a location near Kerrville, Texas. The kite will get above any clouds that might block the view of the sun. The spectrometer collects light from the sun to determine the composition of material in the corona. "There are changes in the corona that occur on time scales of seconds to minutes to hours," she says. "So the longer duration [of the eclipse] also

NASA

TOTAL AND ANNULAR SOLAR ECLIPSES
2021 TO 2030



Earth will experience six total solar eclipses, seven annular eclipses and one hybrid eclipse from 2021 to 2030. See page 26 for the difference between a total solar eclipse and an annular eclipse. The hybrid eclipse in 2023 started as an annular eclipse, turned into a total solar eclipse and then back into an annular eclipse.

enables us to capture [more] time-variable events and their impact on the corona and solar wind."

Other repeat experiments include weather balloons that will measure waves of pressure in the atmosphere that ripple away from the passing shadow of the eclipse. And a newly redesigned spectrometer will ride aboard a Gulfstream jet chasing the eclipse over Texas.

Looking forward

Alaska has the worst seat in the house, as far as U.S. states go. Only a sliver of the state lies in the range that will see a portion of the sun covered up during the eclipse. And none of it is in totality. But the state will get an exclusive viewing when another total eclipse crosses the western side of Alaska in the spring of 2033. That's it for North America until a total eclipse passes primarily over Canada in 2044. Then another will cross the United States and eastern South America in 2045.

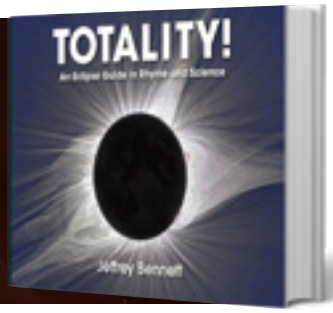
The astronomical event on April 8 will be both livelier and longer than many eclipses. But Habbal says that it doesn't diminish the importance of studying other eclipses. "Every total solar eclipse yields new discoveries."

This one, though, is probably an astronomical event you won't want to miss.

GREAT AMERICAN ECLIPSE; BIG KID SCIENCE

TOTALITY!
An Eclipse Guide in Rhyme and Science
—by Jeffrey Bennett

Most of North America will be treated to a total solar eclipse next month. Brush up on some astronomy with this guide to eclipse science.



YOUR GUIDE TO THE APRIL 8, 2024 SOLAR ECLIPSE

HOW MUCH OF THE ECLIPSE WILL YOU BE ABLE TO SEE?

WHAT TO EXPECT

If you're in the path of totality

Over an hour before totality, the moon will begin to move in front of the sun. At first, it will look like someone has bitten a chunk out of the sun. Then it will turn into a smaller and smaller crescent. Make sure you're wearing your eclipse glasses if you want to see this.

As more and more of the sun is covered, the sky will get darker and darker. But it's a different, and somewhat creepier, darkness than sunset. Then, totality. The sun's bright corona is visible and perhaps the chromosphere (the sun's lower atmosphere), with the sun's disk entirely covered by the moon. For several minutes, you'll be able to remove your glasses and look directly at the eclipse. You might spot stars or other celestial objects in the sky.

Keep an eye on the clock, though. Before totality ends, you'll need to put your glasses back on as the partial eclipse returns, revealing more and more of the sun until the moon entirely separates from the orb.

If you're outside the path of totality

How much of the eclipse you'll be able to see will depend on how far you are from the path of totality. But even a partial eclipse is still amazing to witness. Just make sure you keep your eyes protected the whole time.

Many cities and towns lie in the path of totality for the April 8 eclipse. People outside that zone should be able to see a partial eclipse on that day.

ALEXMX/SHUTTERSTOCK; GREAT AMERICAN ECLIPSE

HOW TO BE SAFE

What's the danger?

Looking directly into the sun, even when it's partially covered by the moon, can damage your eyes and lead to a permanent blind spot in your vision.

How do I protect my eyes?

You'll need glasses certified to meet the ISO 12312-2 international standard. They block out 100 percent of harmful ultraviolet light and 99.999 percent of visible light. Your school or local library may give them away for free. They can also be purchased online (check eclipse.aas.org for sources).

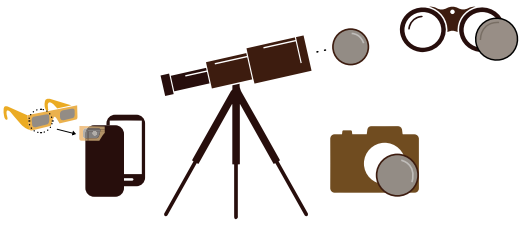
Can I ever look directly at the sun?

Yes, but only in the brief moments of totality during a total solar eclipse when the moon fully blocks out the sun's disk. (Check with an adult before you take off your glasses.)

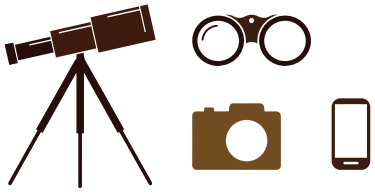
SAFE Use specially designed solar eclipse glasses and viewers to block the sun's harmful rays.

NOT SAFE Ordinary sunglasses are not strong enough to protect your eyes.

SAFE Use only specially designed filters for lenses.



NOT SAFE Wearing solar eclipse glasses to look through a camera, binoculars or a telescope will not protect your eyes.



TRY THIS

During the partial eclipse, take an object with lots of tiny holes, such as a colander or a cracker, and hold it in front of a piece of paper with the sun behind you. You'll be able to see the eclipse in the object's shadow!

AMERICAN ACADEMY OF OPHTHALMOLOGY AND THE AMERICAN ASTRONOMICAL SOCIETY; JOY NG/NASA

This space physicist uses radios to study eclipses

Nathaniel Frissell works with amateur radio operators to learn more about our atmosphere

Next month, Nathaniel Frissell will lead a worldwide effort to collect data during the solar eclipse. Frissell is a space physicist at the University of Scranton in Pennsylvania. He'll be teaming up with amateur radio, or ham radio, operators to collect data through the organization Ham Radio Science Citizen Investigation, or HamSCI, to study the ionosphere.

Ham radio operators are located around the world. They might use their radios to talk to people in their town or in another country. Some help during emergencies. Others participate in science. During the solar eclipse, they'll help Frissell study how the eclipse affects a layer of the atmosphere called the ionosphere. Electrically charged particles in this layer reflect radio waves. During a solar eclipse, less sunlight reaches the ionosphere. This can lead to fewer electrically charged particles and, in turn, disrupt radio signals.

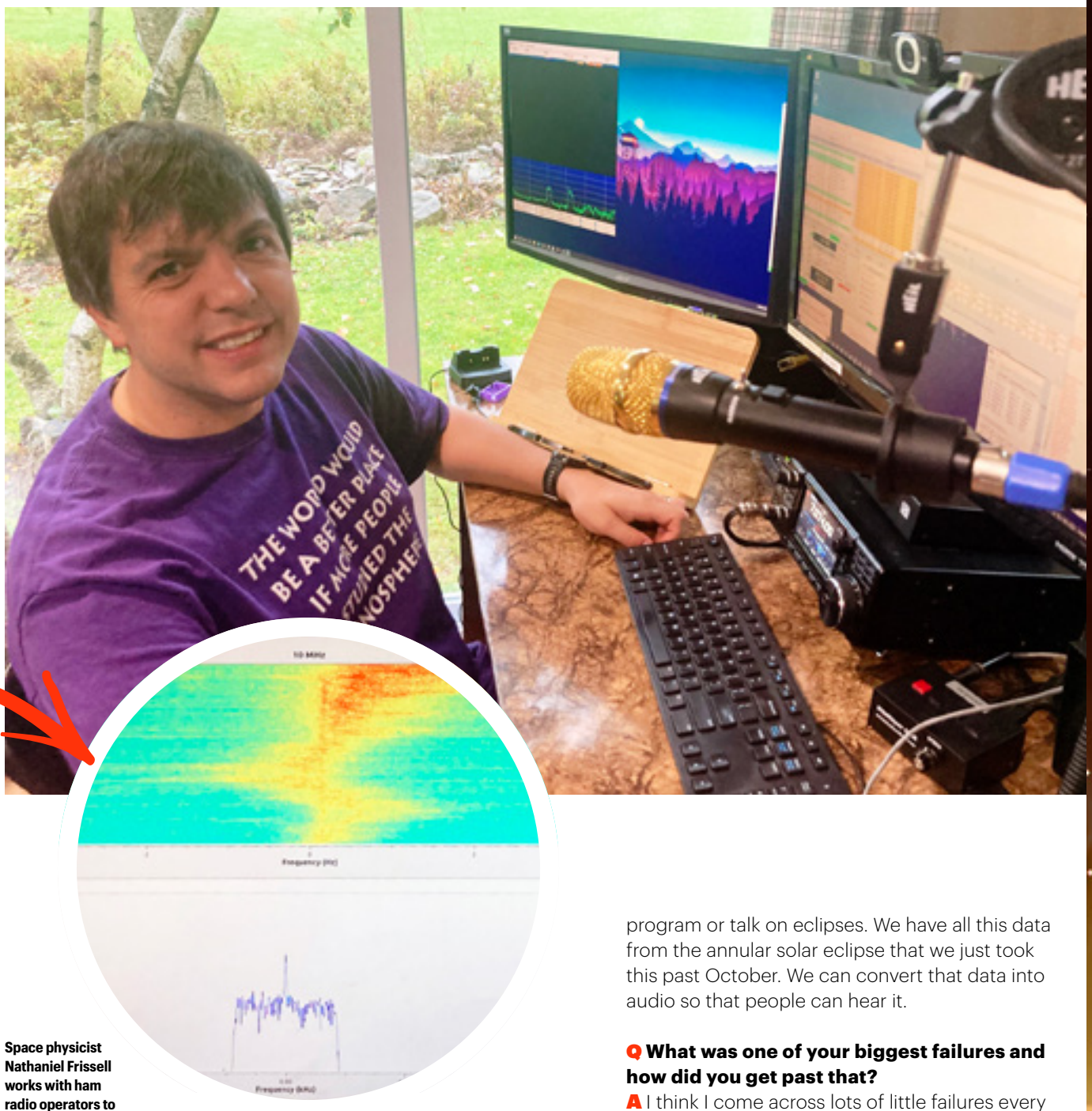
Frissell has been lucky to turn his childhood hobby, amateur radio, into a career. In this interview, he shares his experience and advice with *Science News Explores*. (This interview has been edited for content and readability.) — *Aaron Tremper*

During an eclipse, Frissell and his team try to communicate with as many radio operators as possible. Signals from these communications can help pinpoint where an eclipse is affecting radio waves.

Q What inspired you to pursue your career?
A In middle school, I went on a Boy Scout trip where I met a ham radio operator. He was talking to people all over the world using just a radio setup and a wire. I became fascinated with radios and how the signals get from one place to another. I kept following that passion until I got my Ph.D. in electrical engineering at Virginia Tech in Blacksburg.

Q How did you get to where you are today?
A Virginia Tech had a ham radio club. I started looking for ways to join the ham radio community and the professional community together. I met some people who wanted to study the ionosphere during the 2017 solar eclipse. These eclipses basically serve as controlled experiments that let us study the upper atmosphere in the absence of the sun's light. I suggested that we could do that with ham radio data, too. It was during that project when we developed HamSCI.

Q How do you get your best ideas?
A I'm very collaborative and good at connecting people with others who share interests. For instance, a couple months ago, the Lackawanna Blind Association here in Scranton wanted someone to talk to them about ham radio. Later, I was at a NASA science conference. There, I found copies of a Braille book called *Getting a*



ANN MARIE ROGALCHECK-FRISSELL

Space physicist Nathaniel Frissell works with ham radio operators to study how eclipses affect a layer of the atmosphere called the ionosphere. Here, he sits in front of his personal ham radio setup during last year's annular eclipse.

Feel for Eclipses that explains how solar eclipses work. It had these embossed infographics of solar eclipses that were absolutely gorgeous. I'm going to bring copies of the book to the Lackawanna Blind Association. I'd like to put together a program or talk on eclipses. We have all this data from the annular solar eclipse that we just took this past October. We can convert that data into audio so that people can hear it.

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

A I think I come across lots of little failures every day. It's an important message to have people not get discouraged. My projects don't always work out the way I planned. But I'll learn something different from that work instead. When you come across challenges, try to just stay calm and don't give up.

Gather valuable data during the solar eclipse

Amateur scientists have many chances to assist in research during the U.S. eclipse

During the total solar eclipse on April 8, sky watchers across North America will see the moon pass in front of the sun. This will not only offer a uniquely spectacular view of our star — it will be a prime opportunity for solar science! Here are a couple of ways that amateur scientists like you can gather valuable data during the solar eclipse.

SUNSKETCHER

People in the path of totality — where the moon completely masks the sun from view — can use smartphone cameras and the SunSketcher app to time the appearance of "Baily's beads." These are bright spots that appear when sunlight shines through valleys on the moon. They appear just before and after the moon fully eclipses the sun.

Astronomers can use the timing of Baily's beads to clock exactly how long it takes the moon to pass in front of the sun. They can use that information to calculate how wide the sun is. Scientists want to know the exact shape of the sun because that shape affects the sun's gravitational tug on planets.

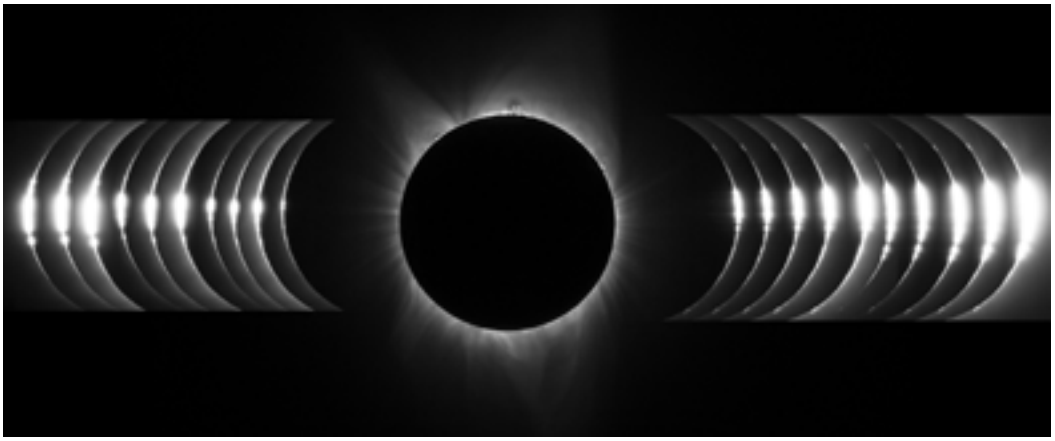
SunSketcher.org

ECLIPSE SOUNDSCAPES

Amateur scientists both in and out of the path of totality can contribute to the Eclipse Soundscapes project. The goal is to record audio during the eclipse that may reveal how this rare, dramatic event affects wildlife on Earth. For instance, sound recordings may capture birds falling quiet or crickets starting to chirp as the moon dims the midday sun.

The Eclipse Soundscapes website (eclipsesoundscapes.org) has instructions to build equipment to record sounds. You can also simply observe the impacts of the eclipse on your local environment. Volunteers will analyze data uploaded to the project's website.

eclipsesoundscapes.org



This composite image collects 10 pictures of Baily's beads taken before and after the total solar eclipse of 2017 (center).

JAMES WEST/FLICKR

Crossword

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

ACROSS

3. This happens when a planet passes in front of its star

5. Spacecraft threatened by coronal mass ejections

6. The moon does this around Earth, and Earth does it around the sun

9. The lunar phase when solar eclipses can happen

11. The only part of the sun visible during totality

12. A kite carrying this tool could study the sun's corona

13. The phase of the solar cycle when our star is most active

15. The upcoming solar eclipse could reveal asteroids around this planet

16. A solar eclipse where the moon completely masks the sun

18. A solar eclipse featuring a "ring of fire"

DOWN

1. These animals may start to chirp during a solar eclipse

2. A solar eclipse where the moon partly masks the sun

4. Citizen scientists can use this app to help measure the sun's shape

7. This layer of plasma surrounds Earth

8. Many people on this continent will see a solar eclipse on April 8

10. This happens when three celestial bodies line up in space

14. This U.S. state will see a solar eclipse in 2033

17. Tools that make it safe for you to view a solar eclipse

Eclipses come in many forms

Awesome things can happen when one celestial body gets in front of another

To eclipse something means to overshadow it. That's exactly what happens during a solar or lunar eclipse. These celestial events take place when the sun, moon and Earth briefly make a straight (or nearly straight) line in space. Then one of them will be fully or partially shrouded by another's shadow. Similar events occur when other stars, planets and moons line up in much the same way.

Scientists have a good handle on how planets and moons move through the sky. So eclipses are very predictable. If the weather cooperates, such events easily can be seen with the unaided eye or simple instruments. (But be careful! It's not safe to look at the sun during a solar eclipse without proper eye protection.) Eclipses and related phenomena are fun to watch. They also provide scientists with rare opportunities to make important observations. — *Sid Perkins*

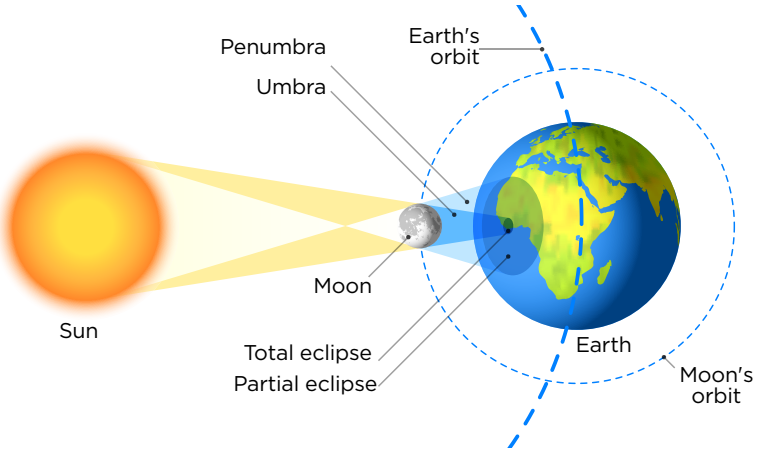
Solar eclipses

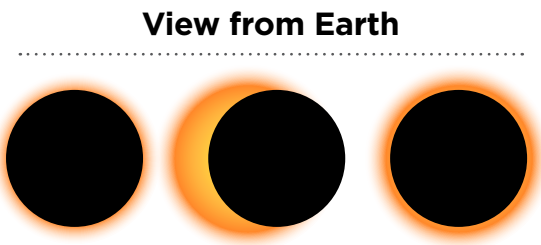
Our moon is, on average, about 3,476 kilometers (2,160 miles) wide. The sun is a whopping 400 times as wide. But because the sun is also about 400 times farther from Earth than the moon is, both the sun and moon appear to be about the same size in the sky. So at some points in its orbit, the moon can entirely block the sun's light from reaching Earth. This is a **total solar eclipse**.

This can happen only during a new moon (see page 3). This is the phase in the moon's orbit where it appears fully dark to us on Earth. A new moon happens about once per month. But the moon's path is slightly tilted compared to Earth's. Most new moons trace a path through the sky that passes near — but not over — the sun.

Some new moons eclipse only part of the sun. This is a partial eclipse. People who are close to but outside the path of the moon's shadow during a total solar eclipse can also see a **partial solar eclipse**.

When the moon is at its farthest point from Earth, it's not quite big enough to block out the entire sun. Instead, a ring of light, called an annulus, surrounds the moon. Scientists call these events **annular eclipses**.

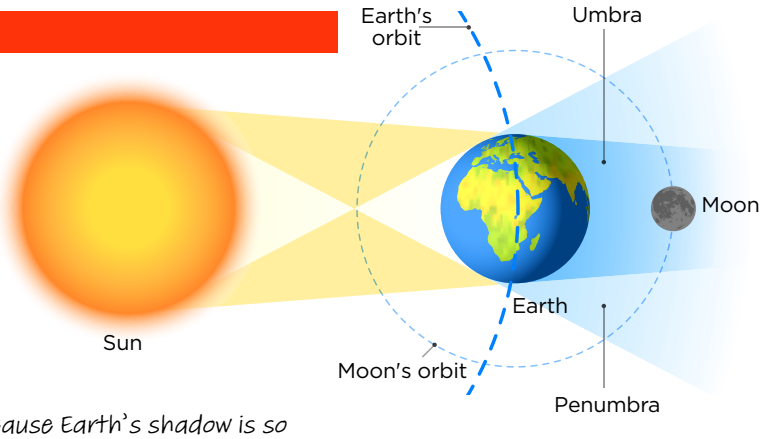




ALHOVIK/SHUTTERSTOCK

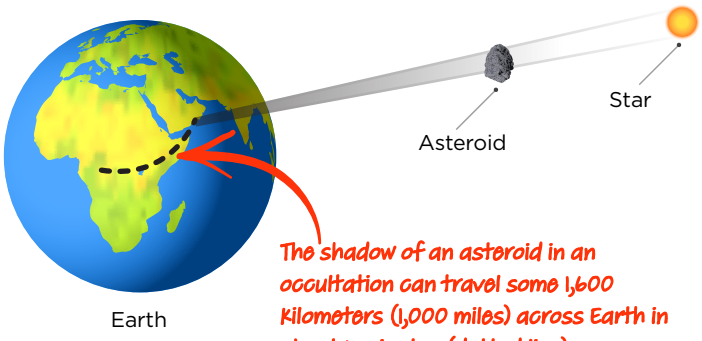
Lunar eclipses

Sometimes the moon falls into Earth's shadow. Such lunar eclipses happen only at full moon, the phase when the moon is opposite the sun in our sky and appears as a completely lit disk. Although total solar eclipses temporarily black out only a narrow path on Earth's surface, a **total lunar eclipse** can be seen from the entire nighttime half of the planet. And because Earth's shadow is so wide, a total lunar eclipse can last up to 107 minutes. Unlike the sun during a total solar eclipse, the moon during a total lunar eclipse remains visible. Sunlight travels through Earth's atmosphere during the whole event, illuminating the moon in a reddish hue.



Occultations

Like an eclipse, an **occultation** occurs when three celestial bodies line up in space. But during occultations, an object that looks large to an observer (usually the moon) moves in front of one that appears much smaller (such as a distant star).

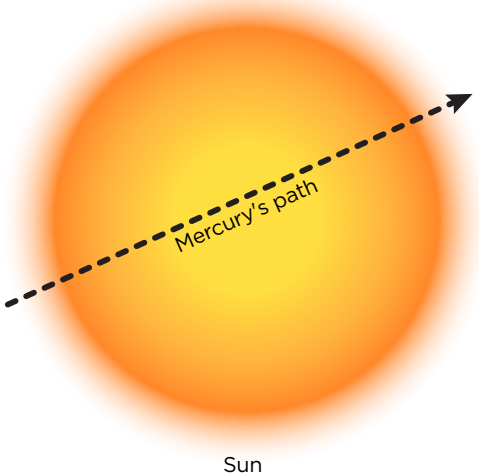


The shadow of an asteroid in an occultation can travel some 1,600 kilometers (1,000 miles) across Earth in about 4 minutes (dotted line).

Transits

A **transit** happens when a small object moves in front of a more distant object that appears much larger. In our solar system, for instance, the planets Mercury and Venus sometimes transit across the sun from Earth's viewpoint. Some asteroids and comets, too, can transit the sun from our point of view.

Scientists have long been interested in transits. In 1639, for instance, astronomers used observations of a transit of Venus — and simple geometry — to come up with their best estimate at that time of the distance between the Earth and the sun.



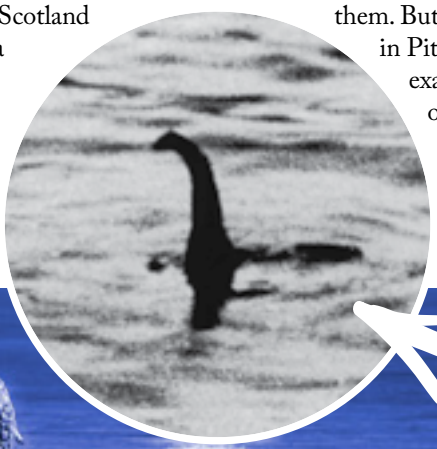
ANIMALS

Seen Bigfoot or the Loch Ness Monster? Probably not

Data science pokes holes into theories that cryptids are real

There were drones, boats and spotters on land. There was a hydrophone listening for suspicious sounds underwater. This past summer, crowds of people had gathered in Scotland to hunt for any sign of a legendary creature: the Loch Ness Monster. This may have been the biggest search of its kind in 50 years.

Nearly 6,000 kilometers (3,700 miles) away, data scientist Floe Foxon emailed the event's organizers. He wished them good luck. "I'm sure it's going to be a fun weekend," he wrote. Foxon wasn't joining them. But from his home office in Pittsburgh, Penn., he has examined Nessie's lore in his own way — with statistics. Last year, Foxon published a study on the probability of finding a



This 1934 photograph of the monster nicknamed Nessie turned out to be a hoax.

FER GREGORY/SHUTTERSTOCK; KEYSTONE/STRINGER/HULTON ARCHIVE/GETTY IMAGES

giant eel in the loch. That's one of many hypotheses for sightings of the storied sea monster. The answer: essentially zero. Even the chances of finding a 1-meter (about a yard) -long eel are low, about 1 in 50,000. Foxon reported this in *JMIRx Bio*. But once you get much longer than that — into monster-sized eel territory — the probability plummets.

But don't call Foxon a myth buster or a debunker. "Absolutely not," he says. "I think you should approach these things with an open mind and let the data influence your decision making."

Though monsters have captured Foxon's imagination, his background is in physics. By day, he's a data analyst for a health consulting firm. In his free time, he flits through far-flung fields of science. They include astronomy, paleontology and cryptology, the study of ciphers. "When you learn data science," Foxon says, "you find that it can be applied to more or less anything." Even monsters.

For his Nessie study, Foxon analyzed the mass distribution of eels caught in Loch Ness and other freshwater bodies in Europe. He converted that data to eel length, then calculated the odds of finding eels of different sizes.

LOOKING FOR MONSTERS WITH MATH

In a separate monster study, Foxon looked at data on Bigfoot sightings and black bear populations across the United States and Canada. The study was posted at bioRxiv.org. As the number of black bears in a region goes up, Bigfoot sightings tend to increase as well, he found. That doesn't tell you whether Bigfoot is real, though, Foxon says. "You can't answer that sort of question without a specimen." Instead, he thinks about it from a probability standpoint. If you think you've seen a sasquatch, he says, it's probably just a bear.

But people claiming glimpses of Bigfoot or other extraordinary beasts probably aren't hoaxers, Foxon says. "Most people are very earnest and honest about having an experience that they personally cannot explain." He thinks scientists should listen to them and take them seriously.

Off the top of his head, Foxon can rattle off the names of supernatural attractions he's visited around the world. There was a museum of curiosities in London, England, and the Flatwoods Monster Museum in Sutton, W.Va. He's even been boating on Loch Ness (though no sign of Nessie).

Foxon considers his study of sea monsters, sasquatches and other mythical beings folk zoology. He describes the field as the intersection between zoology and indigenous knowledge of animals in folklore. Foxon's work has roots in cryptozoology. This field once used the tools of science to investigate mysterious animals. But it has since been "overrun by a lot of pseudoscience," he says.

It's not so much the monsters that pushed the field to the fringe, though. Foxon, for instance, investigates all sorts of cryptic creatures. These include giant snakes and a hypothetical aquatic animal dubbed Champy. It has been reported to live in North America's Lake Champlain. But his quest for answers takes a strictly scientific tack that relies on established mathematical methods.

"It's not what you study, it's how you study it," says Charles Paxton. He's a statistician and fish biologist at the University of St. Andrews in Scotland who has published papers on the Loch Ness Monster. Still, when people find out what Paxton studies, some assume he's a pseudoscientist. "That's quite frustrating, actually," he says. "The methods of science can be more widely used than people might think."

Foxon's latest study was posted at bioRxiv.org. In it, he uses a statistical method to examine eyewitness sightings of a long extinct group of birds, the New Zealand moa (Dinornithiformes). Scientists think the ostrichlike bird went extinct hundreds of years ago. But people have reported seeing moa as recently as the 1990s. The analysis factored in the reliability of 97 separate moa sightings. Foxon estimated that moa probably were extinct by 1770.

"I'm greatly disappointed by all of my findings," Foxon says with a laugh. "I really wish that there was a giant eel in Loch Ness," or a hairy apelike monster in North America's woods or moa living in modern times, he says. But "there seems to be a very, very low probability."

— *Meghan Rosen*

The Loch Ness Monster (left) probably isn't a giant eel, research suggests. And a hairy monster called Bigfoot or Sasquatch (above) is also unlikely to exist.

PIXEL ELITES, SHARON KEATING/SHUTTERSTOCK

ARCHAEOLOGY

Stonehenge's 'Altar Stone' has mysterious origins

The rock's minerals and chemistry don't match suspected sources

Stonehenge is hiding a secret: the source of one of its stones.

Researchers know that the prehistoric circle's outer stones come from nearby areas in England. Other Stonehenge building blocks known as the bluestones came from places far from Stonehenge — some as far as 225 kilometers (140 miles) away. But the source of one bluestone near the center of the monument, called the "Altar Stone," remains shrouded in mystery.

Richard Bevins is an earth scientist at Aberystwyth University in Wales. His team is looking for the source of the Altar Stone. Uncovering the stone's origins could offer insight into the ancient groups that contributed to the monument.

The Altar Stone is a flat, rectangular block nearly 5 meters (16.4 feet) long. "It's a big lump of rock," Bevins says. "It's much bigger than any of the other bluestones." Scientists have been chasing the rock's origins since 1923. An analysis of the Altar Stone's minerals back then suggested it might have come from a set of rocks in Wales near where other bluestones came from. Bevins and his colleagues decided to revisit the rock's riddle with modern techniques.

In 2021, the team analyzed the Altar Stone's chemical makeup using X-rays. The X-ray method revealed that the Altar Stone has high levels of the element barium. But the stone's ingredients didn't seem to match the rocks in Wales.

In the new study, the team collected 58 samples from a wider area in England and Wales. Of the 58 sample stones, four had high barium levels similar to the Altar Stone. The team then compared the overall mineral makeup of those four stones with the Altar Stone. But none were a match. The team shared its findings in the October issue of the *Journal of Archaeological Science: Reports*.

"Maybe we've been looking in the wrong area, and maybe we've possibly been looking at rocks of the wrong age," Bevins says. It's not clear exactly how old the Altar Stone is. So scientists may need to consider stone sources that are younger than the ones they have looked at so far.

— *Carolyn Wilke*

Stonehenge's Altar Stone nestles into the ground, partly buried beneath two other rocks. But where it came from remains a mystery.

NICK PEARCE, ABERYSTWYTH UNIVERSITY

DATA DIVE

1. Look at the seven samples from the Altar Stone. How do the mineral makeups of these samples compare with each other?

2. What is the most common mineral in these samples? What is the range — or spread — of percentages for that mineral?

3. What are some of the other minerals in the Altar Stone?

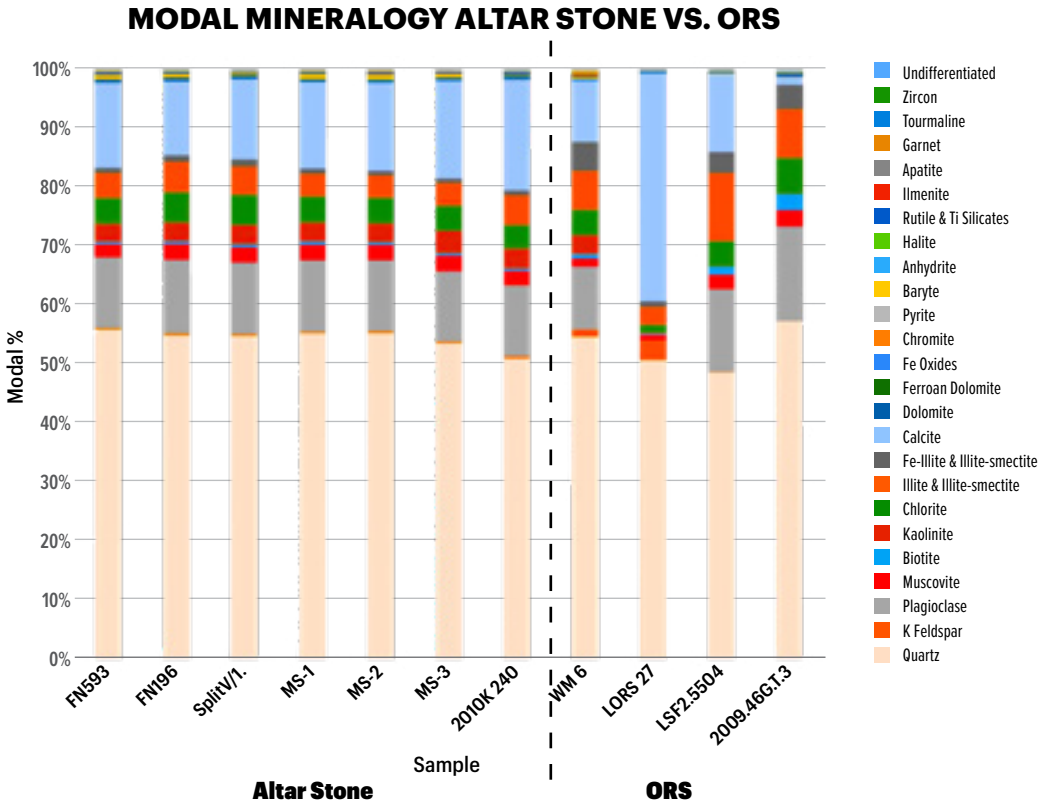
4. How do the four Old Red Sandstone samples compare with those of the Altar Stone?

5. What minerals do these samples have in common with the Altar Stone?

6. Which of the Old Red Sandstone samples looks the most similar to the Altar Stone? Which looks the most different?

Mineral makeups

Of 58 rock sources, researchers found four that had similar levels of the element barium as the Altar Stone. These all came from a type of rock deposit known as Old Red Sandstone (ORS). Researchers studied the mineral makeup of seven Altar Stone samples (left of dashed line) and four ORS samples (right). They used an automated technique that analyzes millions of points on a thin piece of a sample. This provides an estimate for what percentage of each sample is made up of different minerals (the modal %).



GERGELY IVASKO/SHUTTERSTOCK; BEVINS ET AL./JOURNAL OF ARCHAEOLOGICAL SCIENCE: REPORTS 2023

ANSWER

Muscle makers

This picture won a scientific photo contest

These colorful strands are proteins in muscle-building cells. Called myoblasts, the cells kick into high gear when muscle is damaged.

Muscle fibers can't repair themselves after injuries like sprains and cuts. Instead, myoblasts fuse to the fibers to help muscle regenerate.

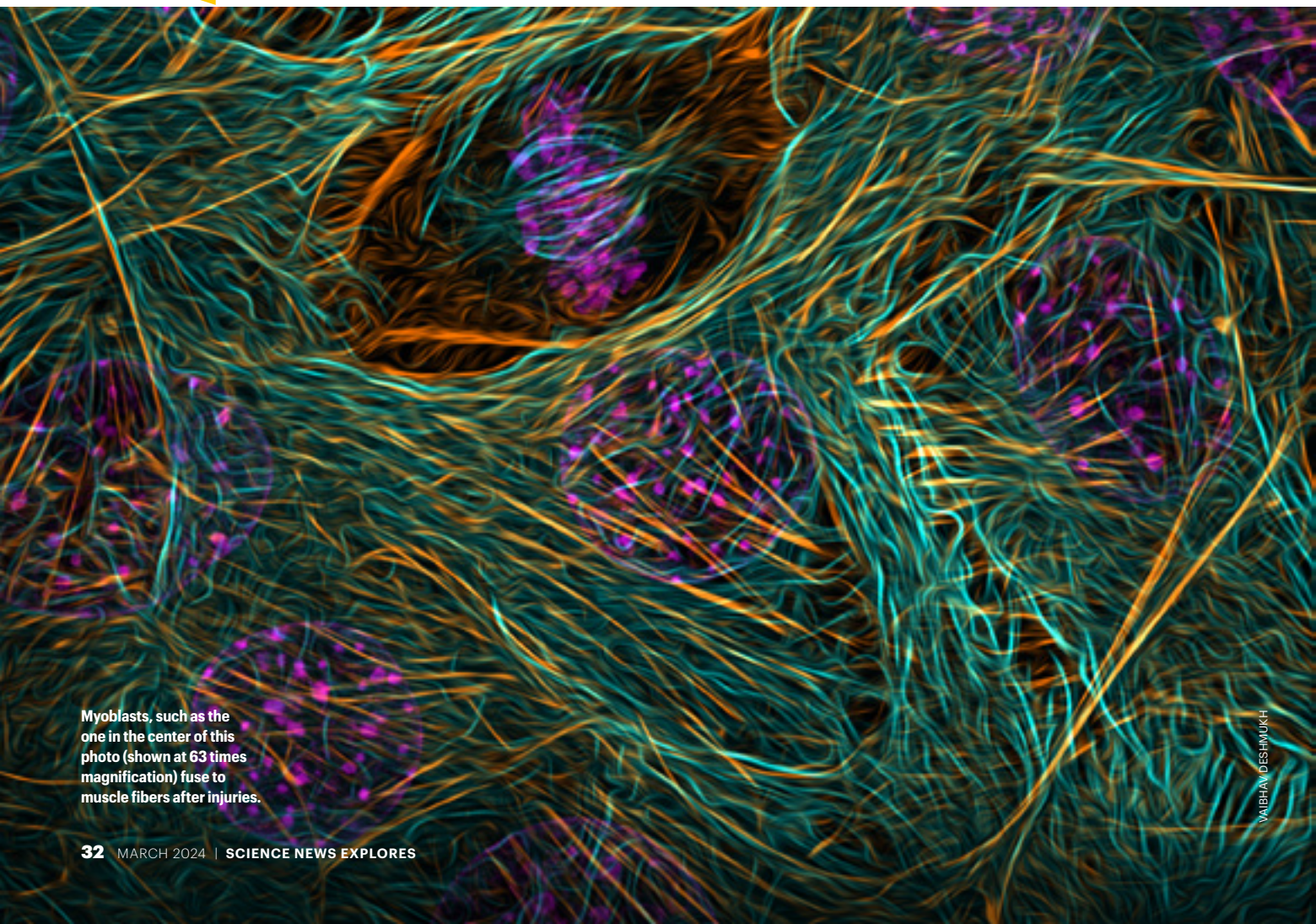
Vaibhav Deshmukh studied heart myoblasts as a graduate student at Baylor College of Medicine in Houston, Texas. For this image, he used dyes and antibodies to label different parts of mouse cells growing in a lab dish. The image placed ninth in the 2023 Nikon Small World photomicrography competition.

Greenish-blue marks a protein that provides structural support for cells. It also pulls genetic material, or DNA, apart when cells divide. Orange marks a protein that helps muscles contract. The nuclei of the cells are magenta.

The myoblast in the center of this photo is dividing in two. It is in metaphase, a stage of the cell cycle when the nucleus dissolves. You can see DNA-carrying chromosomes, in magenta, lined up in the center of the cell. The blue proteins are arranged around them, ready to pull the chromosomes apart before the cell splits in two.

The image shows "how a dividing cell changes its shape and navigates through a crowded space to complete the cell cycle," Deshmukh says.

— *Erin Garcia de Jesús*

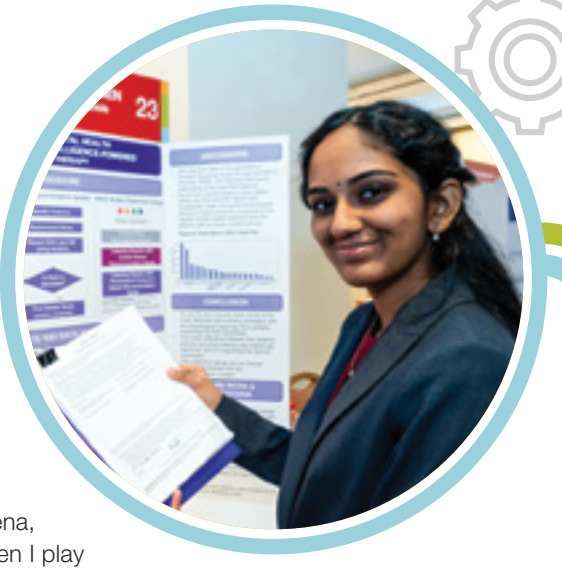


Myoblasts, such as the one in the center of this photo (shown at 63 times magnification) fuse to muscle fibers after injuries.

VAIBHAV DESHMUKH

INSIDE THE MIND OF A YOUNG SCIENTIST

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



Science competitions can be fun and rewarding. But what goes on in the mind of one of these young scientists? Amritha Praveen, a prize winner at the 2023 Thermo Fisher Scientific Junior Innovators Challenge, shares her experience.

Q What inspired your project?
A "I've been a musician for more than half of my life," says Amritha. She plays the viola and the veena, a string instrument that originates from India. "When I play the instruments and when others around me are listening to me playing these instruments, they all face different emotions and relaxation." She set out to find an objective way to measure relaxation when listening to music.

Q What was your favorite part of this project?
A "Finding out what musical features impacted our emotions the most and our relaxation the most," Amritha says. "It was something that I was really curious about." She found that musical key played a role in music's relaxation potential. "That's something there's been a lot of research about," Amritha says. "I also found that timbre was relaxing, which I didn't expect." Timbre is the tone or color of the music.

Q What's next for you?
A "I am interested in continuing to work with this project, because there's still a lot that I've left to uncover," Amritha says. "I'd also like to see if different types of instruments could also influence our physiological responses." And she'd like to use EEG brain waves, in addition to heart rate and sweat, to track how people respond to music. "I think that that could also give a lot of insight into why we feel this way when we're listening to these types of music," Amritha says. "Because obviously it has a lot to do with the brain."

Mathematics Award, Second Place

Amritha Praveen

Amritha, 15, built a system that uses people's responses to music to recommend songs that put them at ease. Her goal? To improve the effectiveness of music therapy for mental health. Amritha's system uses sensors to measure someone's heart rate and sweat while listening to music. Then, the system uses that information to recommend other music that is likely to help the person relax. Amritha is in the eighth grade at Aptakisic Junior High School in Buffalo Grove, Ill.

EXPLORE
OUR SOCIAL MEDIA

What are three reasons lightning bugs glow?
Why are giraffe tongues blue?
Why do we knead bread?