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Explores

June/July 2022

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TEACHING DOGS NEW TRICKS

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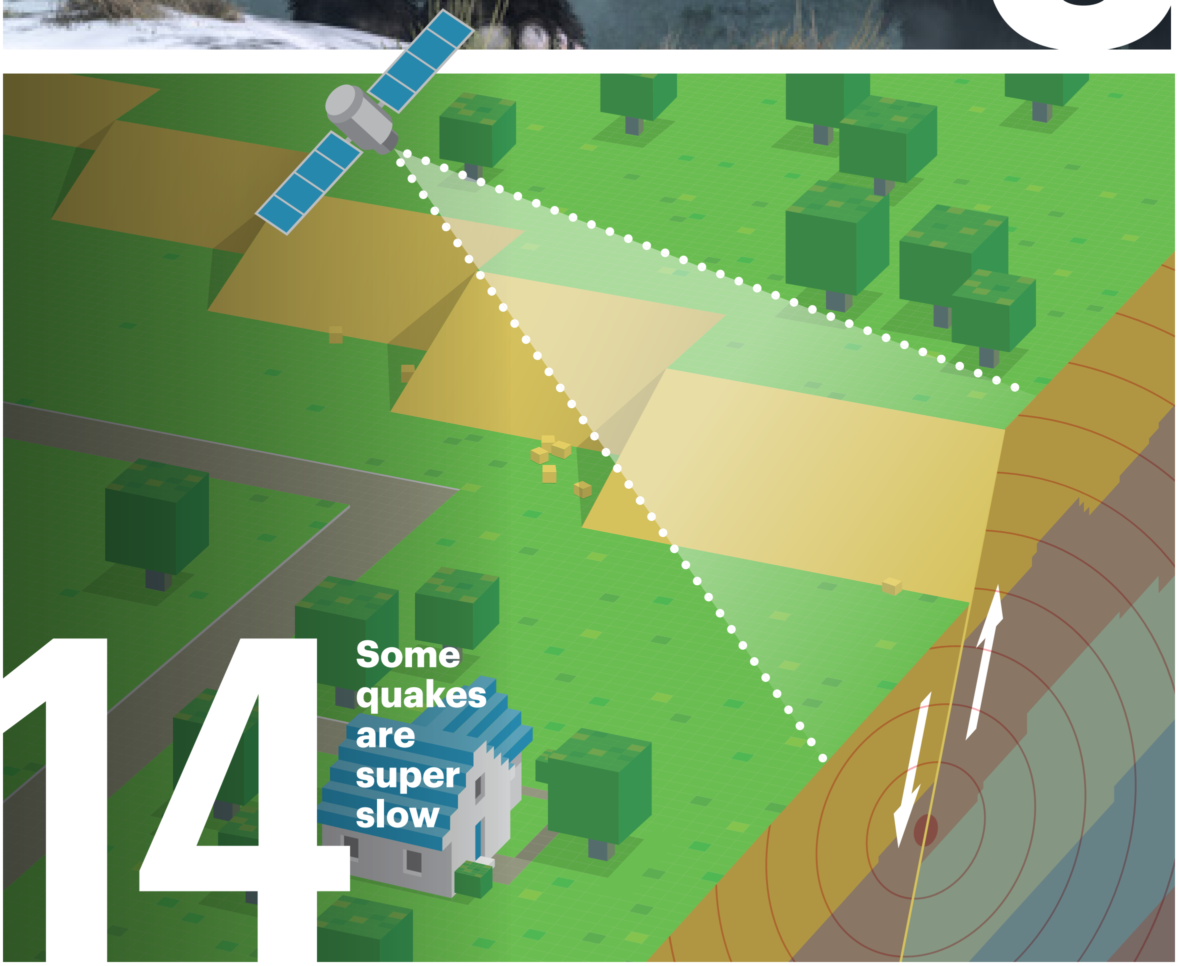

ILLUSTRATION BY STEVE MCCRACKEN

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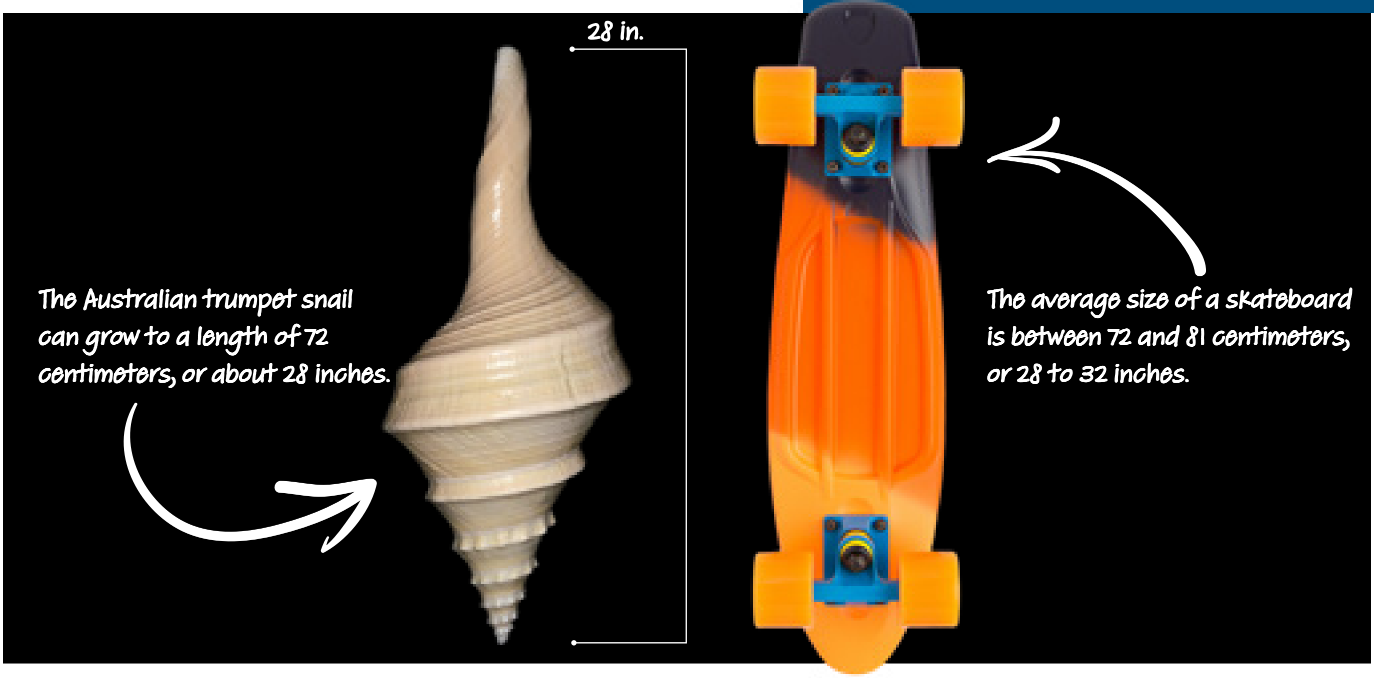


Questions have amazing powers. They help us explore the world around us. And one thing I love about being a science journalist is that if I have a question and can't find the answer in a book or online, I can call a scientist and ask.

If you're a kid or teen, though, getting answers to your questions can be a bit more tricky. If you're lucky, you have a parent, guardian or mentor who makes it easy for you to ask questions. Or maybe you have someone like the seventh-grade science teacher I discovered last year on TikTok. She was making videos about "fishbowl questions" from her classroom. She had put out some fishbowls where students could leave anonymous science questions. About anything. "Why do mammals have babies and birds have eggs?" "Why do you get random nosebleeds?" "How big was the biggest snail?"

But sometimes we have questions for which we can't easily get an answer. Or that we're embarrassed to ask in class. Or that we feel stupid just for not knowing the answer. And what if you don't have a teacher with those fishbowls?

Not to worry. *Science News Explores* is here to help. This page of the magazine needs a purpose. So consider this your page. It's a place where you can ask any question you like, and we'll try to answer it — or find a scientist who can. Just reach out to us on Instagram (**@SN.explores**), or email us at **explores@sciencenews.org**. And we can all explore the answers together, starting with our next issue in August.

And in case you were wondering, the world's largest snail is the Australian trumpet snail. It lives in waters off north Australia as well as southern New Guinea and Indonesia. The mollusk's shell can grow to a length of 72 centimeters, or a little more than two feet. And an extinct snail that lived around 45 million years ago could grow to a whopping 90 centimeters, which is nearly a yard. That was one big snail!

Sarah Zielinski
Editor, *Science News Explores*

GUILLERMO GUERAO SERRA/DZHA33/SHUTTERSTOCK

PHYSICS

Here's why ducklings swim in a row behind mom

It's all about saving energy

There's science to having your ducklings in a row.

Baby ducks are known for paddling in an orderly line behind their mother. Now scientists know why. The babies take a ride on their mom's waves. That boost saves the ducklings energy. Researchers reported the new find in the *Journal of Fluid Mechanics*.

Earlier research studied how much energy ducklings burn while swimming. That showed that the youngsters saved energy when swimming behind mom. But how they saved energy wasn't known. So Zhiming Yuan and his colleagues made computer simulations of waterfowl waves. Yuan, a naval architect, works at the University of Strathclyde. It's in Glasgow, Scotland. The researchers calculated that a duckling in just the right spot behind its mother has an easier swim.

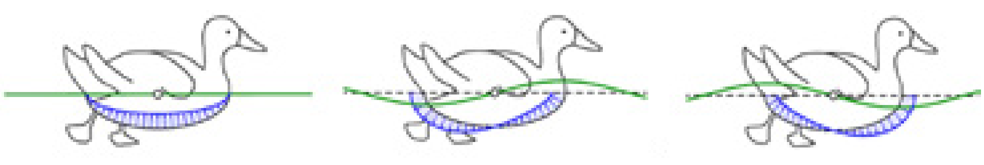
When it swims on its own, a duckling kicks up waves in its wake. Making these waves uses up some energy that would otherwise send it surging ahead. Called wave drag, this resists the duckling's motion. But wave drag is reversed for ducklings in the sweet spot. They feel a push instead of drag.

Like good siblings, the ducklings share with one another. Each duckling in the line passes along waves to those behind. So the whole brood gets a free ride.

But to reap the benefits, the youngsters need to keep up with their mom. If they fall out of position, swimming gets harder. That's fair punishment for ducklings that dawdle.

— *Emily Conover*

Ducklings that trail their mother in a neat line get a boost from the waves that mom stirs up.



To learn about why the babies swim behind mom, the scientists looked at how ducklings swim on calm water (left) and when impeded (center) and propelled (right) by waves.

FROM TOP: ROOM THE AGENCY/ALAMY; © ZHI-MING YUAN, MINGLU CHEN, LAIBING JIA, CHUNYAN JI AND ATILLA INCECIK, 2021. PUBLISHED BY CAMBRIDGE UNIVERSITY PRESS

BRAIN

Will you learn better from reading on screen or on paper?

Don't throw away your books yet

Want to know the current population of India or need a refresher on the phases of the moon? Check the internet. But if you really need to learn something, you're probably better off with print.

Many studies have shown that when people read on-screen, they don't understand what they've read as well as when they read in print. Even worse, many don't realize they're not getting it. Patricia Alexander is a psychologist at the University of Maryland in College Park. She studies how we learn. Much of her research has delved into the differences between reading in print and on-screen. Students often think they learn more from reading online, she says. When tested, though, it turns out that they actually learned less than when reading in print.

Reading is reading, right? Not exactly. Maryanne Wolf is a brain scientist at the University of California, Los Angeles. Reading is not natural, she explains. We learn to talk by listening to those around us. It's pretty automatic. But learning to read takes real work. Wolf notes it's because the brain has no special network of cells just for reading.

To understand text, the brain borrows networks that evolved for other things. For example, the part that evolved to recognize faces is called into action to recognize letters. This is similar to how you might adapt a tool. A coat hanger is great for clothes. But you might straighten out the hanger and use it to rescue a blueberry that rolled under the fridge. You've taken a tool made for one thing and adapted it for something new. That's what the brain does when you read.

And when we read online, the brain creates a different set of connections between cells from the ones it uses for reading in print. It adapts the same tool again for the new task. As a result, the brain might slip into skim mode when you're reading on a screen. It may switch to deep-reading mode when you turn to print.

That doesn't just depend on the device, however. It also depends on what you assume about the text. Naomi Baron calls this your mindset. Baron is a scientist who studies language and reading at American University in Washington, D.C. She wrote *How We Read Now*, a book about digital reading and learning. She says one way mindset works is in anticipating how easy or hard we expect the reading to be. If we think it will be easy, we might not put in much effort.

Much of what we read on-screen tends to be text messages and social-media posts. They're usually easy to understand. So, "when people read on-screen, they read faster," says Alexander.

But when reading fast, we may not absorb all the ideas as well. That fast skimming, she says, can become a habit associated with reading on-screen. Imagine that you turn on your phone to read an assignment for school. Your brain might fire up the networks it uses for skimming quickly through TikTok. That's not helpful if you're trying to understand the themes in that classic book *To Kill a Mockingbird*. It also won't get you far if you're preparing for a test on the periodic table.

— *Avery Elizabeth Hurt*

JEKA/SHUTTERSTOCK

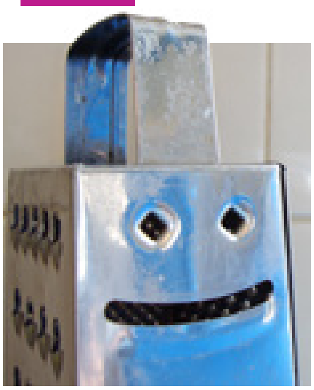
HUMANS

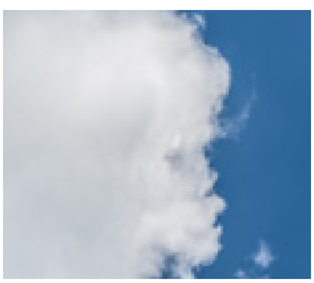
Americans tend to see imaginary faces as male, not female

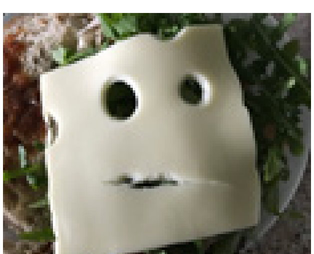
It's not yet clear why this gender bias exists

Have you ever seen the outline of a face in a cloud? Or perhaps in the pattern of your carpet? This phenomenon is called pareidolia. Much is still unknown about how people perceive such imaginary, or "illusory," faces. But one study has uncovered a curious detail. People are more likely to see illusory faces as male than female. Researchers shared that finding in the *Proceedings of the National Academy of Sciences*.

The research was led by Susan Wardle. She is a cognitive neuroscientist at the National Institutes of Health in Bethesda, Md. One day while looking at photos of illusory faces in the lab, she wondered: "Where's all the female faces?" Even though the faces appeared in nonliving objects with no gender, most appeared male to her.







Wardle was curious whether other people shared this bias. So she and her colleagues recruited over 3,800 U.S. adults online. These volunteers viewed about 250 photos of illusory faces. The faces appeared in a variety of objects, from potatoes to suitcases. Participants labeled each one as male, female or neither.

Illusory faces were labeled male about four times as often as they were female. Both male and female participants showed that bias. About 80 percent of people labeled more images male than female. Only 3 percent judged more images to be female than male.

"We had a hunch that there would be a male bias," Wardle says. "But I think we were surprised firstly by how strong it was. And also how robust it is. … [W]e've replicated it in many experiments."

An illusory face is a very basic pattern of a face. Given such a basic pattern, "we're more likely to see it as male," Wardle says. "It requires additional features to see it as female." This makes sense, she adds. Think of female emojis and Lego characters. They are often distinguished from male ones by extra features, such as bigger lips and longer lashes.

It's not yet clear why people assume simple faces are male, Wardle says. But in another study, her team found the same gender bias in kids as young as five. This suggests the bias arises early in life.
— *Maria Temming*

CLOCKWISE FROM TOP LEFT: PAUL DAVID GALVIN/GETTY IMAGES; PRYANETT/SHUTTERSTOCK; CHRIS BAKER; STGRAFIX/SHUTTERSTOCK

K. LI ET AL/SCIENCE ADVANCES 2021

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

WILL THE WOOLLY MAMMOTH RETURN?

Extinction might not spell the end for some species, thanks to genetic engineering >>

DANIEL ESKRIDGE/GETTY IMAGES

By **Kathryn Hulick**

Eriona Hysolli slapped at mosquitoes as she helped feed a baby moose. Not far away, shaggy Yakutian horses grazed on tall grass. It was August 2018. And Hysolli was a long way from Boston, Mass., where she worked as a genetics researcher at Harvard Medical School. She and George Church, the director of her lab, had traveled to northeastern Russia. They'd come to a nature preserve in the vast, remote region known as Siberia.

If Hysolli let her mind wander, she could imagine a much larger animal lumbering into view — one larger than a horse, larger than a moose. This elephant-sized creature had shaggy brown fur and long, curving tusks. It was a woolly mammoth.

During the last ice age, a period known as the Pleistocene, woolly mammoths and many other large plant-eating animals roamed this land. Now, of course, mammoths are extinct. But they might not stay extinct.

"We believe we can attempt to bring them back," says Hysolli.

In 2012, Church and the organization Revive & Restore began working on a Woolly Mammoth Revival project. It aims to use genetic engineering to create an animal very similar to the extinct woolly mammoth. "We call them elemoths, or cold-adapted elephants," explains Hysolli. Others have called them mammophants or neo-elephants.

Whatever the name, bringing back some version of a woolly mammoth sounds like it's coming straight out of Jurassic Park. The nature preserve Hysolli and Church visited even has a fitting name: Pleistocene Park. If they succeed in creating elemoths, the animals could live here. Explained Church in a 2019 interview with PBS, "The hope is that we will have large herds of them — if that's what society wants."

De-extinction engineering

Genetic engineering technology may make it possible to resurrect the traits and behaviors of an extinct animal — as long as it has a living relative. Experts call this de-extinction.

Ben Novak has been thinking about de-extinction since he was 14 and in eighth grade. That was when he won first place in a competition leading up to the North Dakota State Science and Engineering Fair. His project explored the idea of whether it would be possible to re-create the dodo bird.

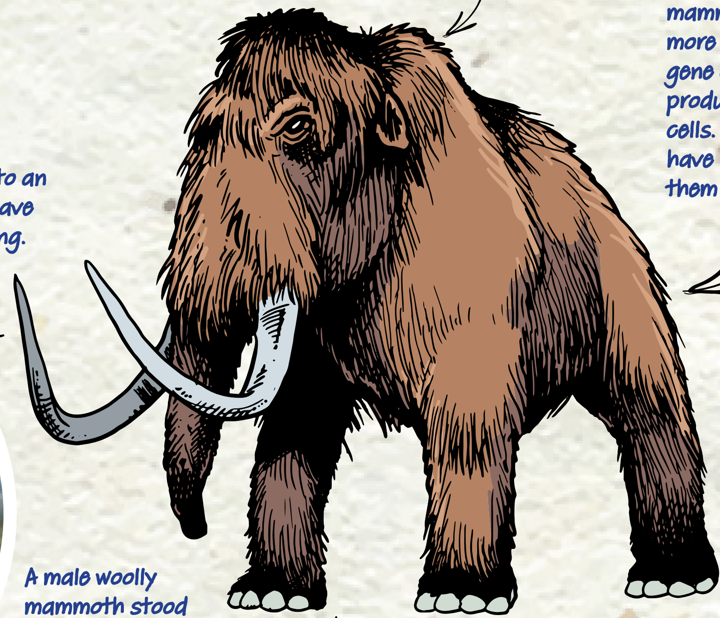
This flightless bird was related to the pigeon. It went extinct in the late 1600s, about a century after Dutch sailors arrived on the only island where the bird lived. Now, Novak works at Revive & Restore, based in Sausalito, Calif. The basic goal of this conservation organization, he says, is to look at a habitat and ask: "Is there something missing here? Can we put it back?"

The woolly mammoth isn't the only animal Novak and his team hope to restore. They are working to bring back passenger pigeons and heath hens. And they support efforts to use genetic engineering or cloning to rescue endangered species, including a type of wild horse, horseshoe crabs, coral and black-footed ferrets. Dinosaurs aren't on their list. "Making dinosaurs is something we can't really do," says Novak.

While in Siberia, Eriona Hysolli collected tissue samples from mammoth remains held in local museums. Here, she is taking a sample from a frozen mammoth's trunk.

BRENDAN HALL/STRUCTURE FILMS LLC

Fun Fact: Although most of the woolly mammoth population died out around 10,000 years ago, a small population of the animals persisted on Wrangel Island, off the coast of Russia, until only 4,000 years ago.



Sorry, *T. rex*. But what genetic engineering can achieve for conservation is astonishing and eye-opening. Many scientists, though, question whether bringing back extinct species is something that should be done at all. Thankfully, we have time to decide whether this is right. The science of bringing back something like a mammoth is still in its very early stages.

Recipe for revival

Woolly mammoths once roamed throughout most of Europe, Northern Asia and North America. Most of the mighty beasts died out around 10,000 years ago, likely due to a warming climate and human hunting. A small population survived until about 4,000 years ago on an island off the coast of Siberia. Across most of the woolly mammoth's former range, remains of most of the animals decomposed.

In Siberia, though, cold temperatures froze and preserved many mammoth bodies. Cells inside these remains are completely dead. Scientists (so far) can't revive and grow them. But they can read any DNA in those cells. This is called DNA sequencing. Scientists have sequenced the DNA of several woolly mammoths. (Scientists can't do this with dinosaurs; they died out too long ago for any DNA to have survived.)

DNA is a lot like a recipe for a living thing. It contains coded instructions that tell cells how to grow and behave. "Once you know the code, you can try to re-create it in a living relative," says Novak.

To try to re-create a mammoth, Church's team turned to its closest living relative — the Asian elephant. The researchers started by comparing mammoth and elephant DNA. They looked for the genes most likely to match specific mammoth traits. They were especially interested in traits that helped mammoths survive in frigid weather. Those include shaggy hair, small ears, a layer of fat under the skin and blood that resists freezing.

The team then used DNA-editing tools to create copies of the mammoth genes. They spliced those genes into the DNA of cells collected from living Asian elephants. Now, the researchers are testing these elephant cells to see if the edits work as planned. They have gone through this process with 50 different target genes, says Hysolli. But the work hasn't yet been published.

One problem, Hysolli explains, is that they only have access to a few types of elephant cell. They don't have blood cells, for example, so it's tough to check if the edit that is supposed to make blood resist freezing actually works.

MORIZ/SHUTTERSTOCK; ILLUSTRATION BY VIVIEN ANDRE/SHUTTERSTOCK

Yakutian horses are Siberian animals that can survive in a region where temperatures can drop below –70° Celsius (–94° Fahrenheit).

Cells with mammoth genes are exciting. But how do you make an entire living, breathing, trumpeting mammoth (or elemoth)? You'd need to make an embryo with the right genes, then find a living mother animal to carry the embryo in her womb. Because Asian elephants are endangered, researchers aren't willing to put them through experimentation and possible harm in an attempt to make baby elemoths.

Instead, Church's team hopes to develop an artificial womb. Right now, they are doing experiments with mice. Scaling up to elemoths is expected to take at least another decade.

A park for mammoths

Back at Pleistocene Park, the Zimov family hopes that Church's team will succeed. But they are too busy to worry about it much. They have goats to check on, fences to mend and grasses to plant.

Sergey Zimov started this park outside of Chersky, Russia, in the 1990s. He had a wild and creative idea — to restore an ancient ecosystem. Today, mosquitoes, trees, mosses, lichens and snow dominate this Siberian landscape. During the Pleistocene, however, this was a vast grassland. Woolly mammoths were just one of the many large animals that roamed here. Animals fed the grass with their droppings. They also broke apart trees and shrubs, making more room for grass.

Nikita Zimov remembers watching his father release Yakutian horses into the park when he was just a little boy. Now, Nikita helps run the park. Around 200 animals live here, including horses, moose, reindeer, bison and yaks. In 2021, Nikita introduced small herds of Bactrian camels and cold-adapted goats to the park.

The park might be a nice tourist attraction, especially if it ever has woolly mammoths or elemoths. But showing off animals is not the Zimovs' main goal. They are trying to save the world.

Beneath the Arctic soil, a layer of ground stays frozen all year long. This is permafrost. Lots of plant matter is trapped inside it. As Earth's climate warms, the permafrost can melt. Then what's trapped inside will rot, releasing greenhouse gases into the air. "It will make climate change quite severe," says Nikita Zimov.

A grassland habitat filled with large animals, though, could change the fate of that permafrost. In most of Siberia today, thick snow covers the ground in winter. That blanket stops cold winter air from reaching deep underground. After the snow melts, the blanket is gone. High summer heat bakes the ground. So the permafrost warms a lot during hot summers, but it doesn't cool very much during cold winters.

Large animals trample and dig through snow to munch on grass trapped underneath. They destroy the blanket. This allows frigid winter air to reach the ground, keeping the permafrost beneath chilly. (As a bonus, during summer thick grass also traps a lot of carbon dioxide, a greenhouse gas, from the air.)

Sergey, Nikita and a team of researchers tested this idea. They took measurements of snow depth and soil temperatures inside and outside of Pleistocene Park. In winter, snow inside the park was half as deep as it was outside. The soil was also colder by about 2 degrees Celsius (3.5 degrees Fahrenheit).

The researchers predict that filling the Arctic with large animals will help keep around 80 percent of the permafrost frozen, at least until the year 2100. Only about half of it would remain frozen if the Arctic's ecosystem doesn't change, their research predicts. (These types of predictions can vary quite a lot based on how researchers assume climate change will progress.)

At just 20 square kilometers (under 8 square miles), Pleistocene Park has a long way to go. To make a difference, millions of animals must roam over millions of square kilometers. It's a lofty goal. But the Zimov family believes in it whole-heartedly. They don't need elemoths to make the idea work. But these animals would speed the process, says Nikita.

Bactrian camels store fat for energy in their two large humps. And they can protect their eyes from blowing ice with their bushy eyebrows and long eyelashes.

FROM TOP: PLEISTOCENE PARK; YERBOLAT SHADRAKHOV/SHUTTERSTOCK

A reindeer herder discovered this well-preserved 42,000-year-old baby woolly mammoth, now named Lyuba, in Siberia in 2007. Extreme cold and lack of oxygen helped to mummify the body. Bacteria made the flesh unappetizing to wild animals.

Considering the consequences

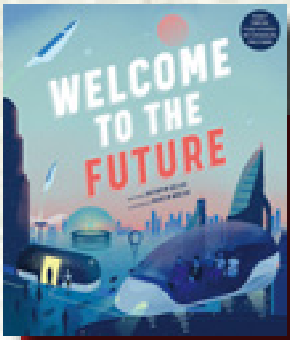
Hysolli wants elemoths in Pleistocene Park not just for the climate but also as a way to improve Earth's biodiversity. "I am an environmentalist and an animal lover at the same time," she says. Humans aren't using most of the space in the Arctic. In many ways, it's a perfect place for elemoths and other cold-adapted animals to live and thrive.

Novak also pursues de-extinction because he believes it will make the world a better place. "We live in a very impoverished world compared to what it used to be," he says. He means that Earth is home to fewer species today than in the past. Habitat destruction, climate change and other human-caused problems threaten or endanger numerous species. Many have already gone extinct.

Not everyone agrees. Restoring any species — mammoth, bird or something else — would take a lot of time, effort and money. And there are already many existing species that need help if they are to be saved from extinction. Many conservation scientists argue that we should help these species first, before turning our attention to ones that are long gone.

Effort and money aren't the only problems. Experts also wonder how the first generation of new animals will be raised. Woolly mammoths were very social. They learned a lot from their parents. If the first elemoth lacks a family, "have you created a poor creature who is lonely and has no role models?" wonders Lynn Rothschild. She is a molecular biologist affiliated with Brown University in Providence, R.I. Rothschild has debated the question of de-extinction. She thinks the idea is incredibly cool but hopes that people will think it through carefully.

As the *Jurassic Park* movies warn, humans may not be able to control the living things they introduce nor predict their behavior. They could end up harming existing ecosystems or species. And there's no guarantee these animals will be able to thrive in the world that exists today.



Welcome to the Future **by Kathryn Hulick, illustrated by Marcin Wolski (Quarto, 2021)**

Have you ever wondered what the future may look like? Will we teleport from place to place, keep dinosaurs as pets, or live on Mars? In this book, you'll explore 10 ways technology could alter our world. The challenge for you is to decide which changes you want for yourself and the world. Just because we can do something doesn't mean we should. How can we build the best possible future for everyone on Earth?

Kathryn Hulick's favorite part of science writing is talking with researchers in many different fields of science.

WHAT DO YOU THINK?

Genetic engineering has given humans incredible power to transform life on Earth. How can we use this technology to make Earth a better place for us as well as for the animals who share this planet?

ITAR-TASS NEWS AGENCY/ALAMY; NAZ-3D/SHUTTERSTOCK

SILENT EART

MAY HOLD CLUES ABOUT THE NEXT BIG ONE

These slowpoke quakes can last days to decades, perhaps prepping faults for a mega slipup >>

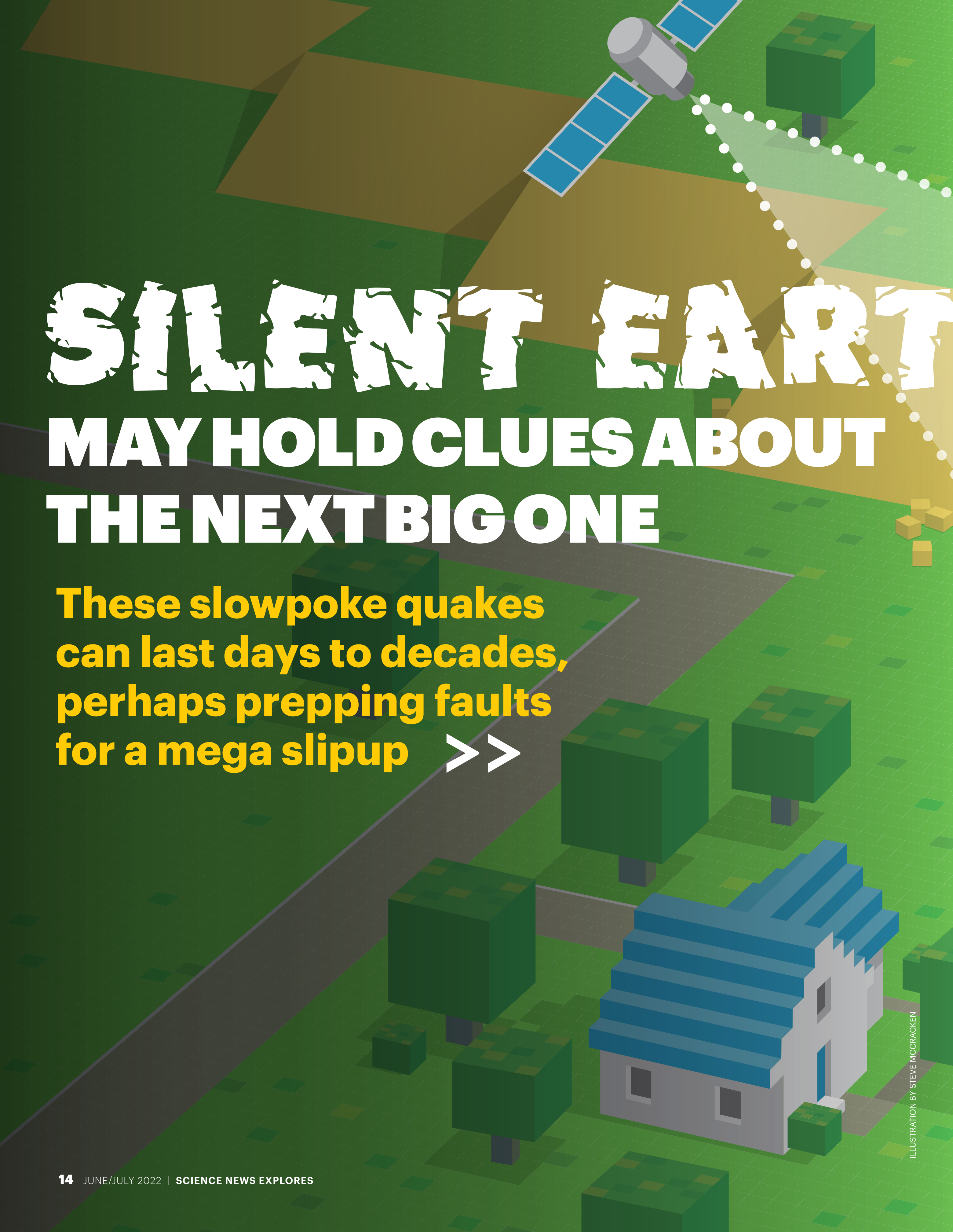


ILLUSTRATION BY STEVE MCCRACKEN

HQUAKES

By **JoAnna Wendel**

On February 16, 1861, a magnitude-8.5 earthquake struck an Indonesian island near Sumatra in the Indian Ocean. The earthquake shook the southeastern side of the island, called Simeulue, triggering a tsunami. That massive wall of rushing water poured onto shore, destroying towns and claiming thousands of lives.

Recently, though, a team of scientists discovered that another earthquake preceded this deadly event. That quake started in 1829 — and didn't stop for 32 years!

Yet no one felt a single shake.

This kind of slow-moving earthquake is called a "slow-slip event." They've also been called "silent earthquakes" because not even instruments such as seismometers can detect them. Scientists have only begun discovering them because of advances some two decades ago in GPS (global positioning system) technology.

Studying earthquakes helps scientists figure out what's going on under Earth's surface. Every earthquake, small or big, can teach scientists something about how much the ground will shake in the future. Unfortunately, no one can predict when an earthquake will hit. Scientists just have to prepare to study any earthquake that strikes.

But slow-slip events like the one near Sumatra change the game for scientists. These silent quakes happen frequently the world over. Sometimes, a slow-slip event happens just before a regular earthquake. This means the two types of Earth movements might be related. By investigating slow-slip events, scientists hope to better understand regular quakes — and possibly how to forecast them.

Silent quakes

Earth's surface is made of a collection of tectonic plates: huge masses of land, like the ground under your feet. These plates lie on top of a deep layer of gooey, hot rock that allows them to slide around. Sometimes the plates run into each other. Other times, they slide away from each other. Sometimes they just slide past each other.

As these plates play a slow-moving game of bumper cars, they sometimes get stuck together. The rocks then push and push against each other, creating stress. When the rocks suddenly unstick, or snap, they release much of that stress as an earthquake. This is similar to what happens when you bend a stick. As you start bending the stick, stress builds in the center. Once there's too much stress, the stick snaps.

When this happens underground, that stress release sends waves of energy, called seismic waves, through the ground. On land, we can see and feel that as the Earth shaking. Seismometers can record those waves — even halfway across the planet.

These quakes are probably the type you think of when you hear the word "earthquake." Framed pictures falling off walls, vases shattering, the ground rumbling. And while these quakes can be scary and even deadly, they typically last less than a minute. Slow-slip events are quite different. They can last days, weeks or longer. As researchers are now figuring out, sometimes these silent earthquakes can last decades.

"We love slow-slip events because they give you all of the excitement of earthquakes, just in slow motion," says Rishav Mallick. He studies geodesy, or the precise three-dimensional shape of land at any given point on Earth. He works at the California Institute of Technology in Pasadena.

In a slow-slip event, the rocks still slide past each other but very slowly, explains Laura Wallace. She's a geodetic scientist who splits her time between two scientific institutions. One is at GNS Science, Te Pū Ao, in New Zealand. It's in a city called Lower Hutt. Her other institution is the University of Texas at Austin. During a slow-slip event, rocks move so slowly that the "energy gets dissipated very, very slowly," she says. "You don't feel the shaking."

Rocks can slip just as far as they would in a regular earthquake. It just takes them far longer. If the rocks slipped the same distance in seconds, such

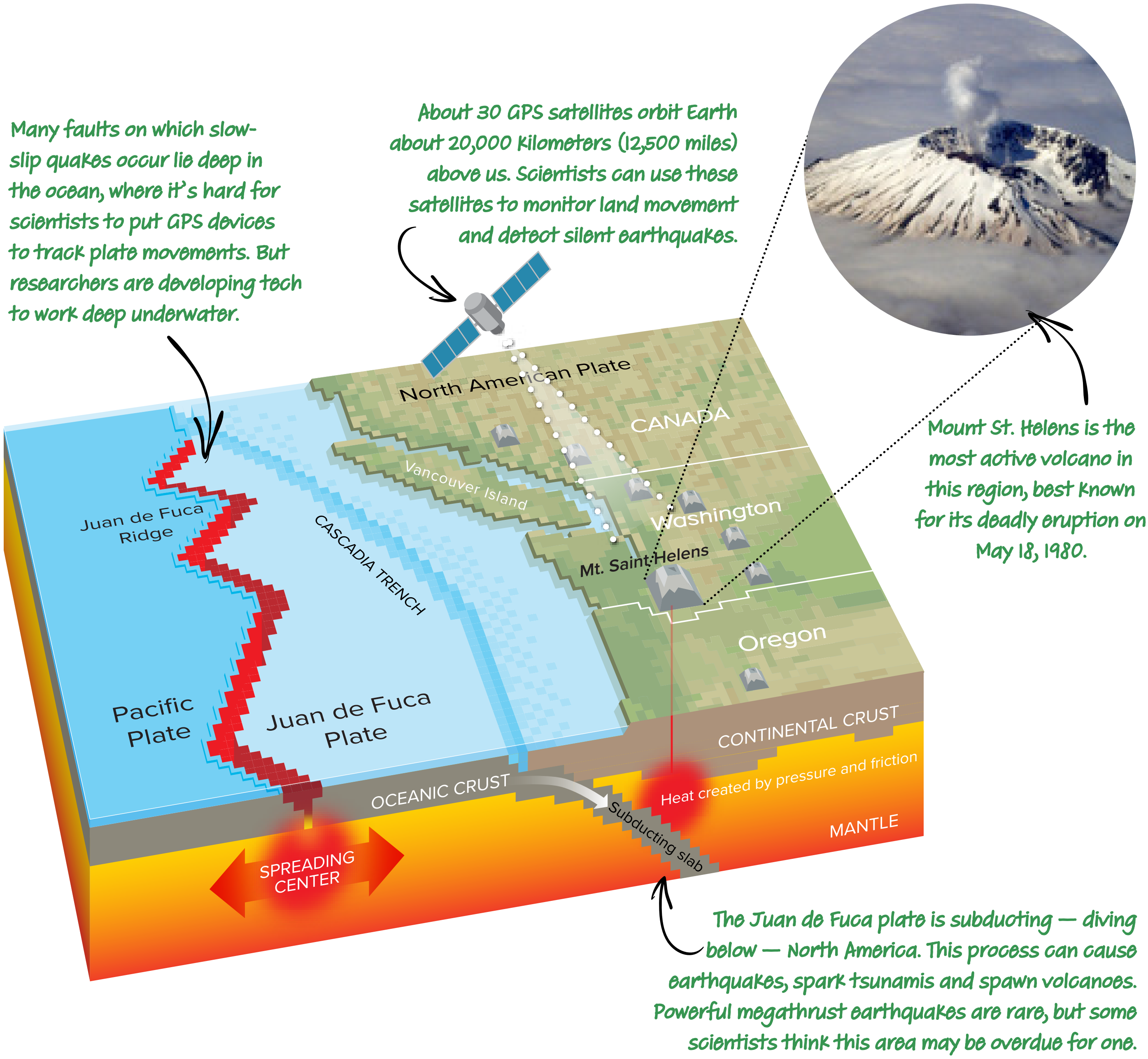


ILLUSTRATION BY STEVE MCCRACKEN; VALERIY POLTORAK/SHUTTERSTOCK

a quake might register as magnitude 7, Wallace says. That would result in some pretty strong shaking. It would be strong enough to damage buildings or even kill unlucky people.

Scientists detect many slow-slip events along structures called subduction zones. In such a zone, an oceanic plate dives beneath a continental plate. Along the U.S. Pacific Northwest coast, the oceanic Juan de Fuca plate dives under the North American plate. This has formed a subduction zone. This tectonic-plate boundary is called the Cascadia Subduction Zone (CSZ). It runs from Vancouver, Canada, to northern California.

Shallow parts of the CSZ fault are currently "locked," Wallace says. Rocks stuck along this fault can't move past each other. Every 400 to 600 years or so, stress builds up so much that the rocks snap and hurtle past each other very quickly. This triggers a "megathrust" earthquake. Megathrust earthquakes are some of the biggest and most destructive natural events on the planet.

But periodically, Wallace says, scientists detect slow-slip events on unlocked spans of the CSZ. And their silent nature and long duration aren't the only features that make them different from regular quakes. Slow-slip events usually occur deeper than regular quakes.

Detecting slow-slip events

Their super-pokey speed allows slow-slip events to evade seismometers. They don't produce the strong seismic waves that can travel across the Earth — and cause all that shaking. This stealthy nature explains why it took scientists so long to even discover them. Fifty years ago, small datasets hinted at slowly moving earthquakes. But technology wasn't good enough to detect them fully. In fact, it wasn't until the last 20 years or so that scientists could even show that these sluggish events were underway, Wallace says. GPS advances helped scientists eventually identify them.

Since the 1980s, scientists have studied the movements of Earth's plates with GPS. This is the same technology that provides your map location and directions on your phone. GPS relies on about 30 satellites. Each orbits Earth twice a day. When your smartphone receives a signal from multiple satellites, it can calculate where on Earth it is, and you are. GPS receivers installed at fault zones can tell scientists how much the land moves between, during and after earthquakes. These devices can measure land movement down to the millimeter (about one twenty-fifth of an inch).

Before slow-slip events were discovered, scientists would visit fault zones periodically with a GPS unit to measure its position. This would allow them to record the land's movement over time. In the late 1990s, scientists started to suspect slow-slip events were underway. So they started placing "continuously operating" GPS units at fault zones. These permanent GPS units provide a constant stream of data.

During a slow-slip event, one of these GPS units might move a few centimeters (about an inch or so) over a couple of weeks. This movement shows a slow-slip event is occurring. For example, as the Juan de Fuca plate dives eastward, it pushes the North American plate eastward as well. GPS signals pick up eastward movement on the North American plate. But, during a slow-slip event, those GPS units will move westward just a bit. This is the North American plate sliding slowly back against the Juan de Fuca plate.

Scientists can detect ancient slow-slip events, too. Here, scientists have to get creative. Mallick and his team, for instance, discovered the 200-year-old slow-slip event near Sumatra by reading the growth patterns in old corals.

Corals grow by building layers of skeleton, one on top of the other. Those different skeletal layers are kind of like tree rings. The different layers — in tree rings or in corals — can tell scientists about the environment in which the layer grew. Corals grow best in shallow water, notes Mallick. Here they can get lots of light as they grow toward the ocean's surface. When there's a rise in sea level, corals grow upward, toward the light. When sea levels drop, corals grow outward to avoid coming in contact with the open air.

In some corals along the coast of the island of Simeulue, near Sumatra, Mallick and his colleagues noticed the corals showed odd growth patterns. It looked like sea levels had risen more than what was usual for that part of the globe. The researchers confirmed that the sea hadn't risen — the land itself had sunk.

To understand the corals' odd growth patterns, Mallick's team looked at data from past research. Previous scientists had measured the age of the corals. They did this by studying the individual layers of coral growth. Each layer holds information about when it formed. The scientists determined that the land had been sinking for 32 years, starting in 1829. Then in 1861, the corals all died. They had been pushed above the ocean surface and exposed to air. The only thing that could have pushed the corals so high was the magnitude-8.5 earthquake that struck near Sumatra that year. The team published its findings in *Nature Geoscience*.

Now researchers are wondering: Could slow-slip events and regular earthquakes be related? If so, how? "That's probably one of the biggest things that we're trying to deal with right now," Wallace says.

A magnitude-6.1 earthquake near the northern border of Thailand on May 5, 2014, created large cracks in some roads.

I LOVE PHOTO/SHUTTERSTOCK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A puzzle to solve

Some of the strongest earthquakes that people experience occur along subduction zones. This also happens to be where scientists also detect many slow-slip events. There's a magnitude-9 earthquake that shook northeastern Japan and caused a tsunami in 2011, for instance. And a magnitude-8.2 earthquake that struck the subduction zone off the coast of northern Chile in 2014.

"There's really good evidence that both of those massive earthquakes were actually preceded by a large slow-slip event," Wallace says. She stresses that it's currently impossible to say whether slow-slip events can trigger an earthquake. Slow-slip events happen often, and sometimes at regular, predictable intervals. Much of the time, big earthquakes do not follow slow-slip events. For instance, she points out, "We've seen hundreds of slow-slip events around the world that didn't lead to really big earthquakes."

Still, there are reasons why scientists suspect they might be related. One is stress, Wallace says. When two plates get stuck together, stress builds along the fault. Slow-slip events can occur on deep parts of the fault, relieving some stress in that area. But that same movement could increase stress on the locked zone above, Wallace says, at some point "triggering a larger earthquake."

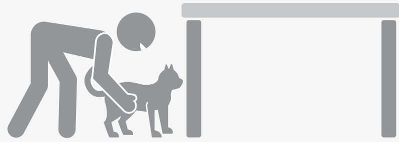
Michael Brudzinski describes a stuck plate as a sleeping dragon. He's a seismologist at Miami University in Oxford, Ohio. If the stuck plate is a dragon sleeping peacefully, then a slow-slip event is a feather tickling its snout. The dragon won't wake up to every tickle. But one tickle too many, and the dragon might roar.

The secret to solving the puzzle of how slow-slip events relate to earthquakes is data, Mallick says. Lots of data. Scientists need to measure many more slow-slip events and many more earthquakes. Unfortunately, many faults on which slow-slip events occur lie deep in the ocean. It's hard for scientists to put GPS devices there to track plate movements. But scientists are now developing tech to operate deep underwater, Mallick notes.

In New Zealand, where Wallace works, earthquakes do indeed occur during slow-slip events along this region's subduction zones. Studying this area will help scientists understand the relationship between the two phenomena.

"I don't think we'll ever be able to predict earthquakes," Wallace says. But, with more data and more research, we just might get close.

WHAT TO DO IN AN EARTHQUAKE



DROP

When the ground starts to shake, don't panic. Drop to the ground, to your hands and knees, to avoid being knocked down and better avoid falling objects. Look for something sturdy to hold onto. If you're in a wheelchair, lock your wheels and stay seated.

COVER

Crawl beneath a desk or table if you can, or get next to an interior wall away from windows. Don't run outside or stand in a doorway. If you're outside, get away from buildings and trees. Stay bent over to protect your internal organs.

HOLD ON!

If you're under a desk or table, grab onto a leg with one hand and be prepared to move along with your shelter. If you don't have shelter or are in a wheelchair, bend over and cover your head with your arms until the shaking stops.

An accident didn't stop this geologist from doing field work

Now Anita Marshall works to help other scientists with disabilities pursue research careers

A career in geology often involves hiking boots or a hard hat. Sometimes both. A geologist may spend at least part of her time in "the field," as opposed to in the lab. That field work is one of the things Anita Marshall loves most about geology. She wanted to hike across mountains and climb rock walls — all while doing science. But that work suddenly got much harder when she was in graduate school. A drunk driver hit her while she was unloading her pickup truck.

Marshall needed six surgeries and used a wheelchair for about a year. Then she had to learn to walk again. She still has nerve damage and other effects. Yet she didn't let that stop her from becoming a geologist. Now, at the University of Florida in Gainesville, she works on ways to help others with physical disabilities learn about geology.

Here Marshall, a member of the Choctaw Nation, shares her experiences and advice. (This interview has been edited for content and readability.) — *Kathiann Kowalski*

Q What's one of your biggest successes?

A Finishing my PhD. It was very difficult. A lot of it had to do with confronting social barriers — people who felt like I didn't belong there. There were people who made it clear to me that I was not welcome, that if I couldn't keep up physically, I was no kind of geologist.

One time I was out in the field and was tired. As I sat on a rock, students walked past. "I don't even know why she bothers," one of them said. That moment was sort of a game changer for me. After that trip, I thought, there's got to be a better way of doing this. We can't keep this up, this idea that if you're not some hale-and-hearty Indiana Jones type, you can't be a geologist. It just doesn't make sense.

Q What do you do in your spare time?

A My first love is photography. There's nothing more relaxing to me than a great photography session, either landscape photography or taking portraits.

COURTESY ANITA MARSHALL

Anita Marshall hasn't let a physical disability keep her from doing field research in geology. Here she is at the crater rim of the Masaya volcano in Nicaragua.

I do a lot of crafts, too. Usually it has to do with figuring out ways to use rocks in something, because you come back from field trips with an awful lot of them.

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

A Find mentors or people you look up to who want to make you the best version of yourself, and not a miniature version of them.

My academic career really took off when I stopped trying to make myself fit that mold that people told me geologists fit into. … I was physically causing myself harm trying to fit in. And I wish somebody had sat down with younger me and said, "Don't do that. No part of this is a good idea." You have to find a way to make your own path.

Also, when we talk about inclusion of people with disabilities in science, this is not a new thing. There are scientists doing great work with all kinds of disabilities. They had to overcome enormous hurdles. My colleagues and I are trying to break down some of those hurdles and make it easier for everybody to do that kind of work. But people with disabilities have been contributing to science for a long time.

CHEMISTRY

Big rock candy science

Every sugar crystal needs to grow from a 'seed'

By **Bethany Brookshire**

Making rock candy at home is a tasty way to show chemistry in action. But the instructions contain a step that seems a bit odd. You're supposed to dip your candy stick or string in sugar at the start of the process. Is that really necessary? This experiment will show you the importance of having something called a nucleation site.

HYPOTHESIS

Using sticks or strings with seed crystals will produce more rock candy than sticks or strings without.

METHOD

1. Dip 9 clean sticks or pieces of string into a cup of clean water, then roll them in a small pile of sugar. Set each aside to dry. Leave 9 other pieces alone. These are your control.

2. Bring 4 cups (946 grams) of water and 12 cups (2.4 kilograms) of sugar to a boil in a pot, stirring. Keep an eye on your mix.

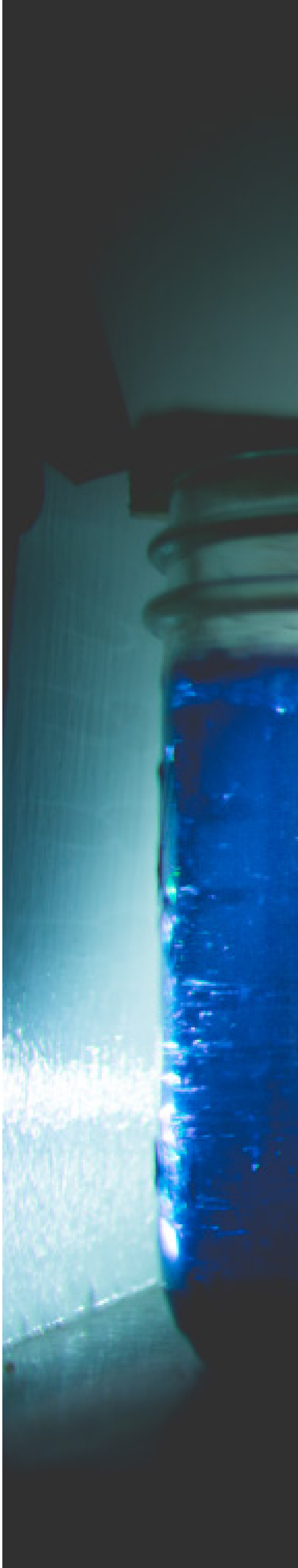
3. Once the solution is clear, add blue food coloring. Pour 250 milliliters (8.4 fluid ounces) of the solution into each of 9 cups.

4. Use a scale to find the mass of each plain stick or piece of string in grams. Then dip the string carefully into a cup of the sugar solution and secure it in place. Make sure the stick or string does not touch the bottom or sides of the cup.

5. Repeat steps 3 and 4 with red food coloring and the sugared sticks or strings.

6. Put all the cups in a cool dry place. Wait at least three days. Carefully crack the sugary film on top of each cup with a spoon. Remove the stick or string and weigh it.

DID YOUR DATA SUPPORT YOUR HYPOTHESIS?
Find out how to analyze your data, and more, at
www.sciencenewsforstudents.org/candy



J_FISHER/SHUTTERSTOCK; ROBERT MACMILLAN/SHUTTERSTOCK

SHUTTERSTOCK/KABARDINS PHOTO

Bye-bye batteries? How to power a phone with fabric

This material turns movements into electricity

Imagine if the swishing threads inside your jeans pocket could charge your cell phone. You might never run out of battery at an inopportune moment again. And this may soon be possible, thanks to scientists working on new piezoelectric materials.

Pressing, squashing or twisting such materials produces an electric charge. Add a circuit to capture and store that charge, and you can convert motion into electricity.

Piezoelectric materials are not new. But getting them to make enough electricity to do useful work is. Today, most such materials produce only a few microwatts of power. For comparison, it takes some 8 million microwatts (8 watts) to power a typical LED light bulb. Most of today's piezoelectric materials also are ceramic. Hard but easily breakable, they may not last very long.

Kamal Asadi wondered how he might create a pocket that could charge a cell phone. Asadi is a physicist at the University of Bath in England. To create such a charging pocket, he'd need a soft and stretchy piezoelectric material. That eliminates ceramic ones. But nylon might work.

This tough, stretchy, lightweight plastic shows up in everything from swimsuits and sportswear to fishing line and guitar strings. Most nylon is not piezoelectric. But some types of nylon have this property — if and only if you first coax it to form a certain crystal structure. Getting it into that special structure as a long, thin thread "is difficult and challenging," Asadi notes. But his team recently found a way to do that.

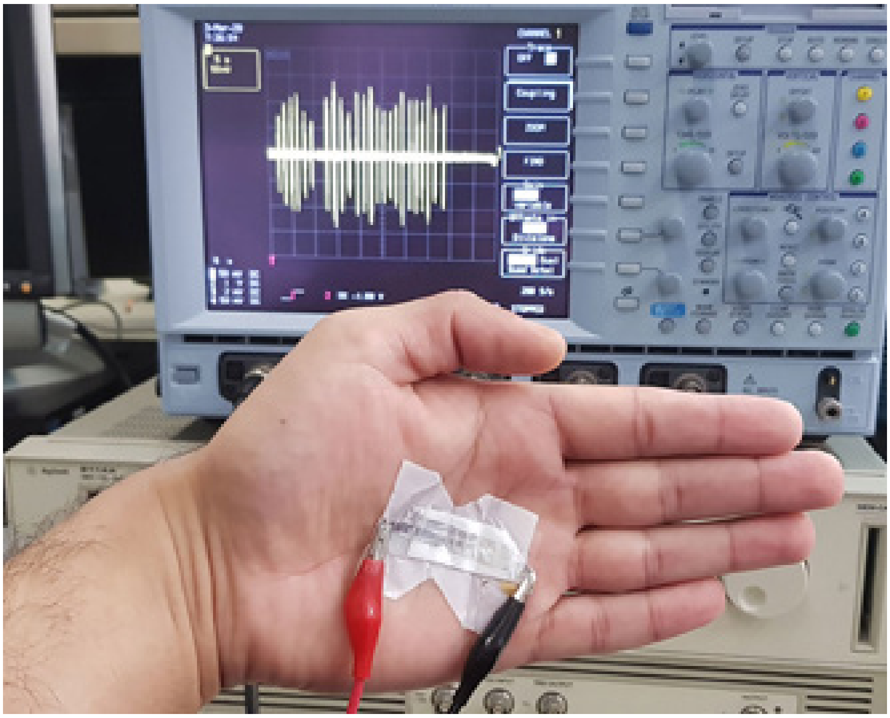
First, the researchers dissolved nylon pellets in a strong acid. Then they used a technique called electrospinning to shoot a very thin thread of the liquid out of a needle. The thread dries as it lands on a plate.

The first time the team tried this, though, the dried thread wasn't piezoelectric. The problem? "Acid molecules like to stay inside nylon," explains Asadi. "They are extremely happy and relaxed. They don't want to go out."

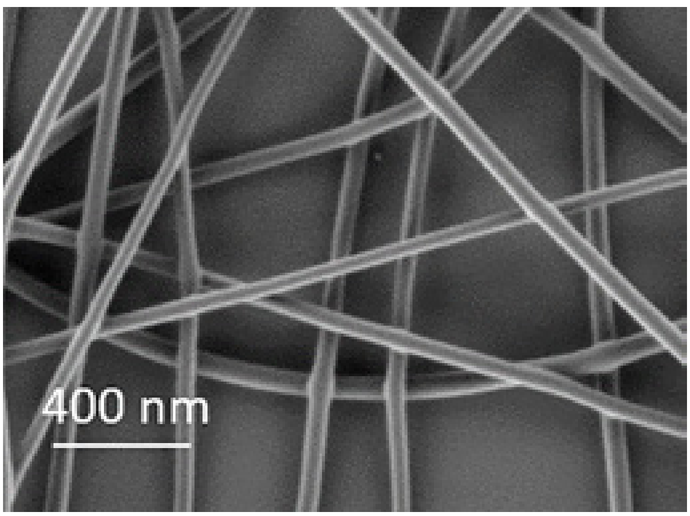
So he added another ingredient. Called acetone, it's the same stuff inside most nail polish remover. This chemical carried the acid out of the nylon thread as it dried. Says Asadi: "It's as if it says to the acid, "OK, good job. You dissolved [the nylon]. Now it's time to leave."

To demonstrate their new fibers were piezoelectric, Asadi hooked up a mat made from them to a circuit. A student then placed the mat on his palm (see opposite page). Opening and closing his hand was all it took to generate electricity.

It wasn't nearly enough to charge a cell phone. "I wish it was," says Asadi. But with a lot more work, he says, such a feat should be possible. Asadi's team described its findings in *Advanced Functional Materials*.



Kamal Asadi's student placed a mat made of piezoelectric fibers on his palm and attached it to a machine that measures electrical charge. When he opened and closed his hand, a charge showed up on the screen.



Asadi's team made very thin nylon threads that generate electricity when you stretch or squash them.

KATHARINA MAISENBACHER, MAX PLANCK INSTITUTE; K. ASADI

FUN FACT

The word "piezoelectric" comes from two Greek words. The first, piezen, means to squeeze. The second, elektron, comes from the Greek for amber. Yes, amber. That's because amber, fossilized tree resin, produces static electricity when you rub it against cloth.

This was one of the first tests to show that nylon threads can turn body movements into electricity. And that's exciting enough for most researchers.

"This is really stretchable," says Zhiqun Daniel Deng. He's an engineer and ocean scientist who was not involved in the research. He works at Pacific Northwest National Laboratory in Richland, Wash. Nylon fibers could make enough electricity to run a low-power sensor, Deng says. But first Asadi's team would have to add a circuit to manage that electricity.

Low-power piezoelectric sensors could help build the Internet of Things. That is a system of sensors that share information about people, places and things in real time.

For example, piezoelectric sensors in roads could detect the motion of vehicles to track traffic or to light upcoming road signs or streetlights as needed. Sensors on the body or in clothing could monitor health or track fitness, powering themselves from the motion as someone walks. Or sensors that monitor the ocean could power themselves from the motion of water. The possibilities are nearly endless.

— *Kathryn Hulick*

SPACE

Staying grounded in space requires artificial gravity

There's no gravity in space, but scientists have a few ideas on how to make it

In books, movies and TV shows, people on spaceships walk around like they would on Earth. In real life, though, astronauts in space float. The difference is that in those fictional worlds, artificial gravity exists. In our world it doesn't — yet. But it may be coming.

Gravity is a fundamental force. It attracts objects with mass toward each other. Objects with a lot of mass — such as Earth — attract other objects toward their centers. This is why we stand firmly on the ground no matter where on Earth we are. Gravity decreases with distance, though. So as people travel to the Moon or Mars, their pull toward Earth quickly weakens, which leaves them floating.

This might seem like fun. But life without gravity isn't great. In the long term, a gravity-free environment weakens our bones and muscles. Without gravity, blood and other bodily fluids don't flow normally and can collect in the upper body. This can cut off hearing and make the face swell.

Also, floating around in zero gravity makes you puke.

However, notes Mika McKinnon, "We know a lot of ways to have the same effect as gravity using other forces." She is a physicist with the Search for Extraterrestrial Intelligence (SETI) Institute in Mountain View, Calif. And at least a few of the simpler tactics might not be that far off.

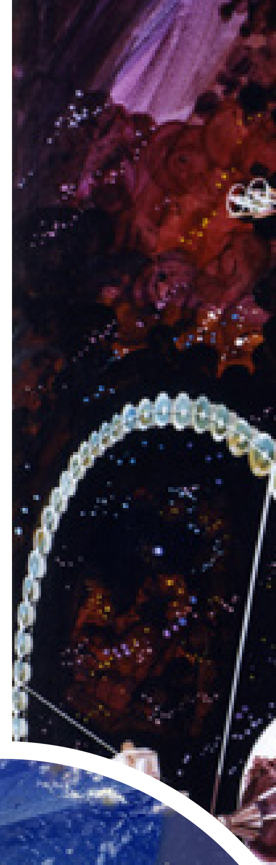
One approach would be to "use electricity and magnetism as a way of substituting for gravity," McKinnon explains. "You can create that magnetic field by running electricity around in circles." The flow of electric current produces magnetism. An astronaut wearing metal boots could just walk along the magnetized floor.

The work required to walk against a magnet might also limit bone and muscle loss in space. But fluids would still be able to collect in the upper body. And your stomach would still be awfully confused.

Scientists could try to harness real gravity, McKinnon says. Everything with mass has gravity. So one simple idea would be to have a lot of mass. Neutron stars, for example, are extremely dense. A teaspoon of neutron-star material might be enough to give us gravity, she says. Or a "tiny pencil prick" of a black hole. Both of these exert vast amounts of gravity for their size.

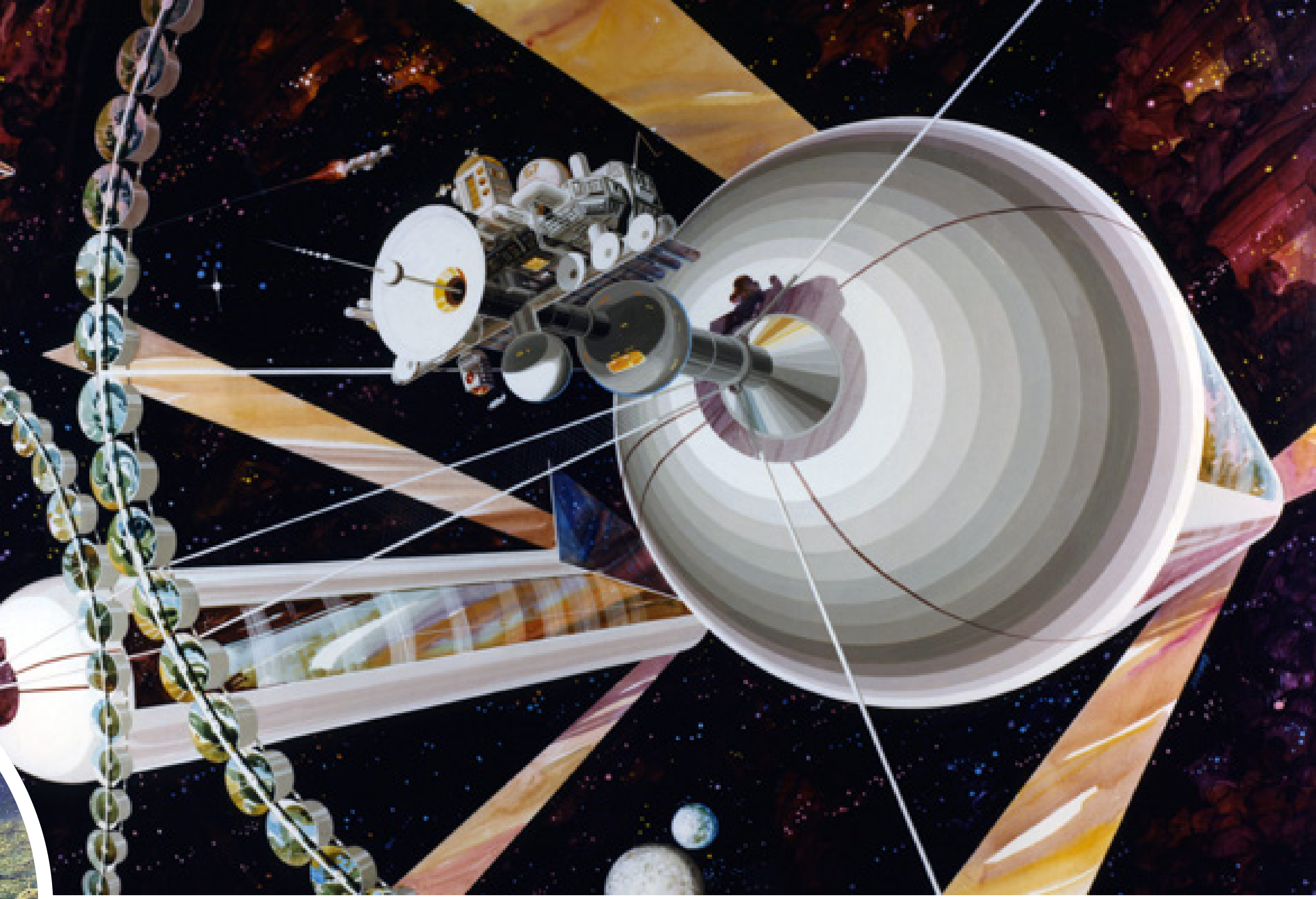
How could you contain a black hole — even a tiny one — in the middle of a spaceship? "That's an engineering problem," McKinnon says.

But if you've ever been on a carnival ride like the spinning teacups, you've already felt artificial gravity. When you are inside a large, spinning object, you feel a pull toward the outside wall. This is because of inertia. Your body is



A pair of rotating O'Neill cylinders could make up a vast space settlement (above, an artist's depiction) housing millions of people. Each cylinder, like the one at the right of the image above, would have land areas (inset) for people and plants, along with mirrors and views into space that could give the colony a day-night cycle similar to the one on Earth.

NASA'S AMES RESEARCH CENTER/ILLUSTRATED BY DON DAVIS



NASA'S AMES RESEARCH CENTER/ILLUSTRATED BY RICK GUIDICE

resisting the change in motion of the object spinning around you.

We feel inertia as something that doesn't exist — centrifugal force. This force seems to pull us to the outside edge of the rotating teacup. And this might be able to produce artificial gravity in space. All you need is either a small ship rotating very fast, or a very large ship rotating slowly. Either way, the spin would pull someone feet-first toward the outside wall.

A large version of such a system is called an O'Neill cylinder. It's named for physicist Gerard O'Neill, who came up with the idea. A pair of these vast rotating cylinders would sit aimed toward the sun and spin in opposite directions. Those opposite spins would help hold them in place.

O'Neill's original design had space habitats stretching 6.5 kilometers (4 miles) across and 25 km (16 mi) long. That's huge. There's also the problem of where to build them. If they were built on Earth, how could you get them into space?

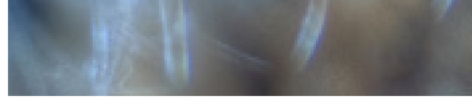
Smaller rotating objects can provide the same effect as O'Neill cylinders. The smaller the object is, though, the faster it must spin to give you the feeling of gravity. And that spin has its own challenges. Spend enough time in a small spinning teacup and your stomach may soon object.

People in a quickly rotating cylinder suffer from what's called the cross-coupled illusion, notes Katherine Bretl. She's an aerospace engineer at the University of Colorado in Boulder. When someone is inside a spinning ride — or a spinning space station — they often feel fine as they look forward. The cross-coupled illusion is that "tumbling feeling you get when you turn your head."

Luckily, Bretl has found a way to overcome the problem. She and her colleagues have been putting people in a spinning chair and making them turn their heads for science. After weeks of training, her studies have found, people can put up with more and more spinning. And to date, Bretl adds, "We haven't had anyone puke."

A room on the space station could rotate fast enough that astronauts would feel a gravitational force of about 1 g — the same as they would feel on Earth. "I think a lot of people look at [artificial gravity] and think it's super far off," Bretl says. "But I don't think it has to be."

— *Bethany Brookshire*



HUMANS

How our eyes make sense of light

Special cells send data describing a scene into the brain, which interprets it

As light enters our eyes, it first heads through a tough outer tissue called the *cornea*. This protects the delicate inner eye from everything the world might throw at it. Light passes right through the cornea and into a transparent, flexible tissue called the *lens*. This lens focuses the light, sending it through the liquid-filled globe of the eyeball to the back interior wall of the eye.

The tissue there, known as the *retina*, contains millions of light-sensitive cells. The light-sensing cells on the retina are known as photoreceptors. Two important types are *rods* and *cones*. Cones are especially concentrated in an area called the *fovea*. When the eye focuses on an object, it directs the light bouncing off the object directly onto the fovea to get the best image.

Each human retina (and if you have two eyes, you have two, one in each eye) contains 125 million rods and about 6 million cones. This is 70 percent of all the sensory receptors in your entire body — for touch, taste, smell, hearing and sight all put together.

Each rod or cone cell at the back of the eye has a stack of discs inside. The discs contain a pigment molecule. It's bound to a protein called an opsin. Cones have a pigment-protein pair called photopsin. It comes in three different types, and each cone has just one type. They come in red, green or blue — the colors that each cone type is best at absorbing. Cones respond to light that has passed through the lens and onto the fovea. As each cone absorbs its color of light, it produces an electrical signal. These signals travel to the brain, filling our worlds with color.

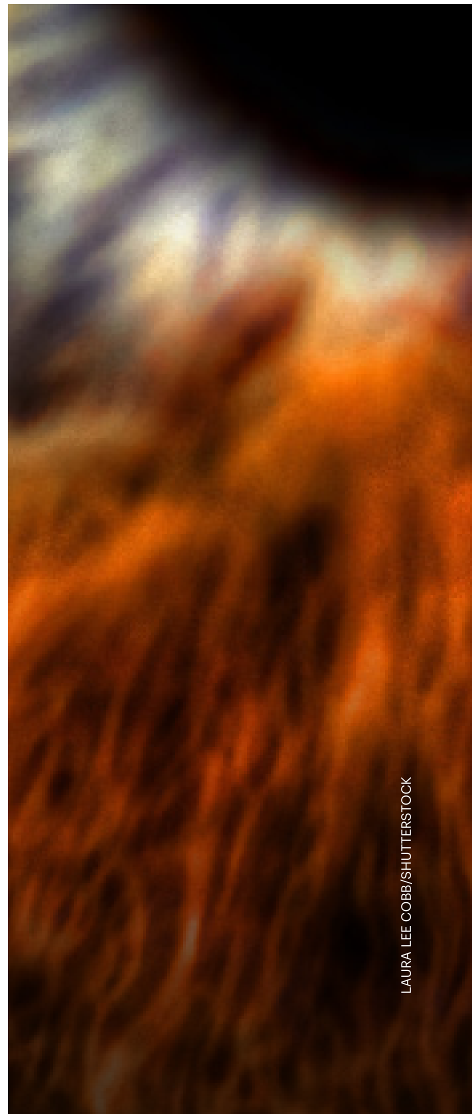
The retina's rod cells work when light levels are low. Instead of photopsins, rods have a different pigment-protein pair: rhodopsin. Rods produce images only in shades of grey. But they are much more sensitive to light than cones are. They are so sensitive that a rod cell can detect a single photon of light — a particle so tiny it has no mass at all.

In the dark, we rely on our rods. And we rely on cones in the light. When they detect certain wavelengths of visible light, the photoreceptors trigger electrical signals. Rods and cones will send these signals through nerves that reach into the brain. They head for the occipital cortex, right up against the back of the skull. There, the brain interprets these signals to make sense of what we're looking at.

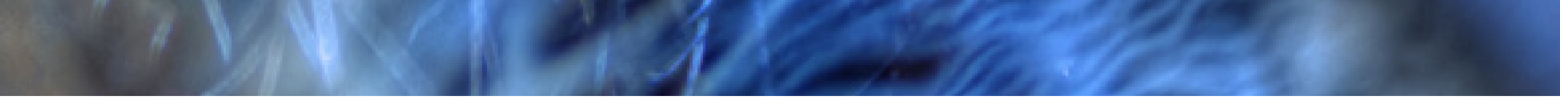
— *Bethany Brookshire and Tina Hesman Saey*

Right: Light bouncing off an object goes into the eye, through the cornea and the lens, which focuses that light on the retina. The retina hosts the eyes' rods and cones. These cells relay signals that move through the optic nerve to the brain.

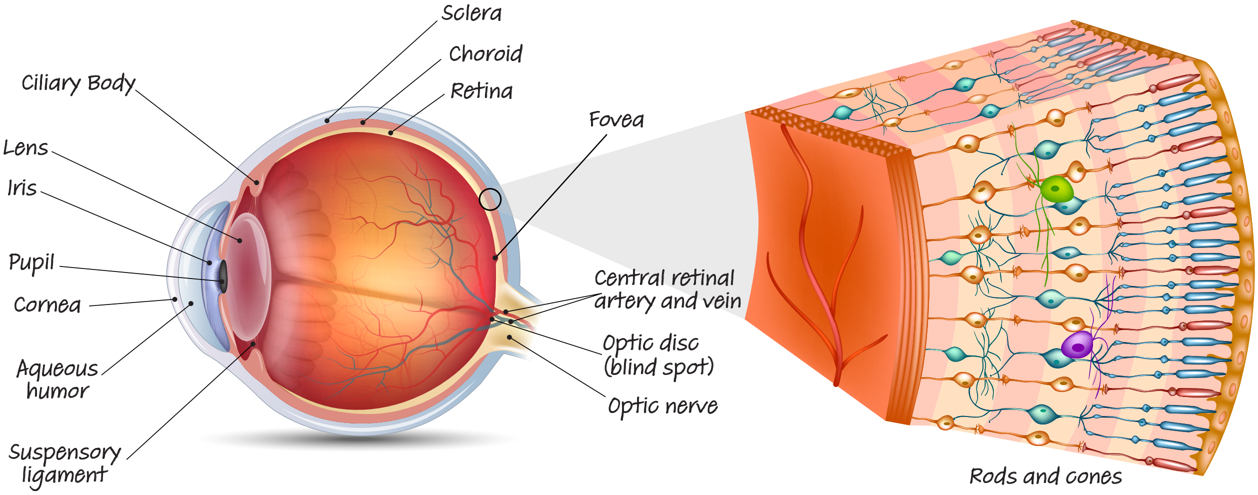
Far right: The back of the retina is filled with rods (blue) and cones (red). The rods are long and straight. Very sensitive to light, they help us see when it's dark. Our eyes have fewer cones, which are sensitive to color.

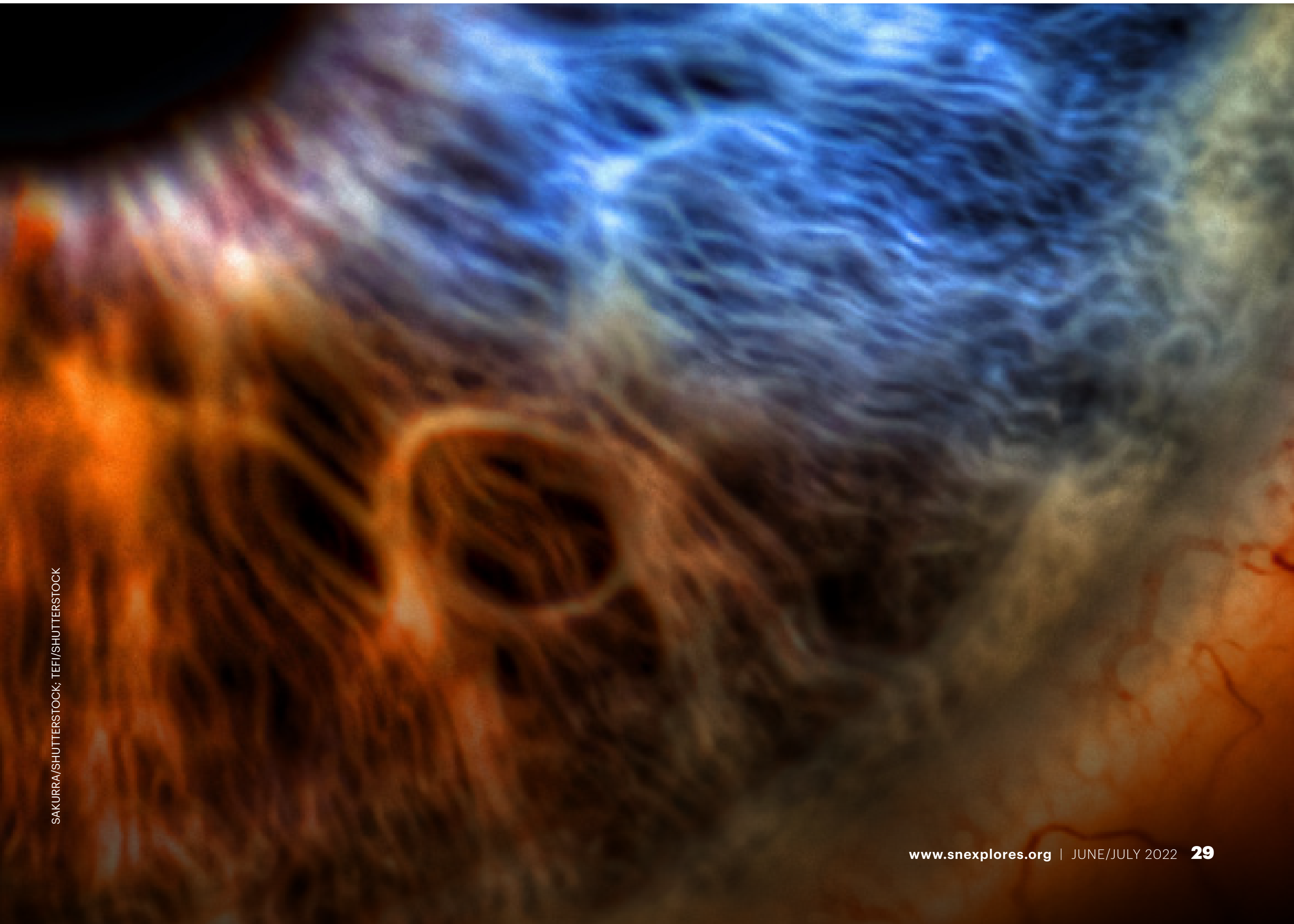


LAURA LEE COBB/SHUTTERSTOCK



Human Eye Anatomy





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ANIMALS

Some dogs can quickly learn new words

Vicky Nina is one of two dogs that learned new words after hearing them only a few times

Sit. Stay. Roll over! Our puppy pals can typically learn such commands with ease. Grasping the names of objects may present a tougher task for our canine companions. But there are exceptions. Some dogs learn toys' names after hearing them only a few times, finds a study published in *Scientific Reports*.

As with young kids, "this learning doesn't happen in the context of formal training. But it happens just during play," says Claudia Fugazza. An ethologist, Fugazza studies animal behavior at Eötvös Loránd University in Budapest, Hungary.

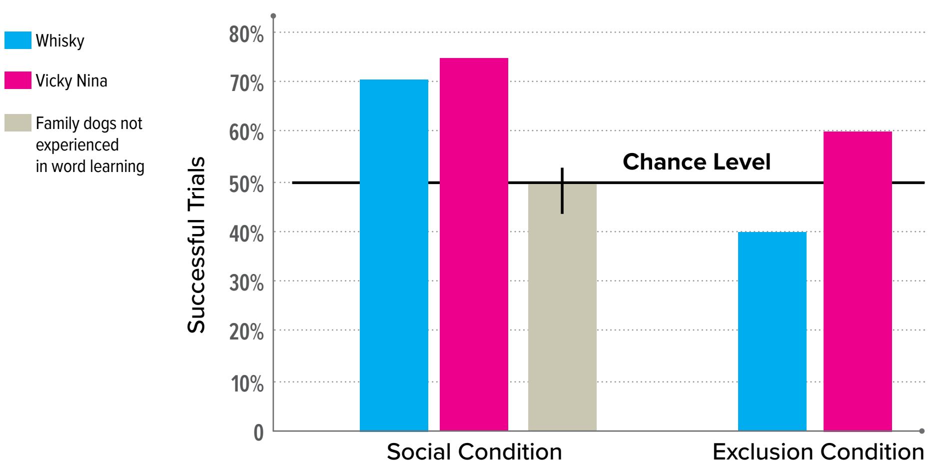
Fugazza and her team found two dogs that already knew many words. Four-year-old border collie Whisky and 9-year-old Yorkshire terrier Vicky Nina each knew the names of around 50 objects, mostly toys. The scientists wondered how quickly the pooches could pick up new lingo.

The researchers tried two different ways to teach the dogs new words. In one (called the exclusion condition), the dogs had to pick out the new toy, such as a bulldog, from a group of known toys. After requesting a few known toys, the dog's owner asked the pet to bring the bulldog. If the dog returned the right toy, it received praise and a treat. The owner repeated this with a second toy. In a second approach (called the social condition), owners would introduce the two new toys' names while playing with their dog. They might toss one and say, "get the ladybug."

The team then tested each dog by placing the two new objects side by side in another room. The owner asked the dog to fetch one by its name to see if the animal brought the correct one. The dogs weren't very successful when they had been taught the names through the exclusion condition. But after playing with the new toys, the dogs were much more successful. They had only four chances to hear the words, so the dogs' quick learning was "impressive," Fugazza says.

The knowledge didn't stick for long, however. Vicky Nina and Whisky tended to forget the new word 10 minutes after passing the toy name test. Dogs may have to hear a word many more times to make a lasting memory. And even then not all dogs may be able to do this. Using the play approach, the team tried teaching another 20 pets that didn't have experience learning object names. These dogs faired more poorly when tested on their new words.

It's not clear why Whisky and Vicky Nina were good at picking up new vocab when other pets weren't. This might be a talent that only some dogs have, Fugazza says.
— *Carolyn Wilke*



This bar chart shows how dogs performed in tests of word-learning. The left set of bars depicts results for trials of words learned during play for Whisky, Vicky Nina and 20 other pets. That teaching is called the social condition. The right set of bars depicts results for trials of words learned through another method. That method, called the exclusion condition, required dogs to pick the new toys out of a group including many known objects after hearing the toys' names. The researchers tried this process only with Whisky and Vicky Nina, because the two dogs already knew many objects by name.

FUGAZZA ET AL/SCIENTIFIC REPORTS 2021

MARCO OJEDA

DATA DIVE

1. Look at the "exclusion condition" results in the bar chart on the opposite page. What percentage of trials did each dog get right?

2. If a dog is given two objects and asked to choose one, it should make the correct choice about 50 percent of the time based on chance alone. That is marked as the "chance level" on the chart. How do the success rates of Whisky and Vicky Nina compare with this chance level in the exclusion condition? What does that mean for how well they learned new words?

3. Look at the "social condition" results in the chart. What percentage did Whisky and Vicky Nina get right? How does that compare with the chance level? What does that mean for how well the dogs learned new words with this method?

4. Why did the researchers not test family dogs in the exclusion condition?

5. How do you think the results might change in each condition if the dogs heard the words more than four times during learning?

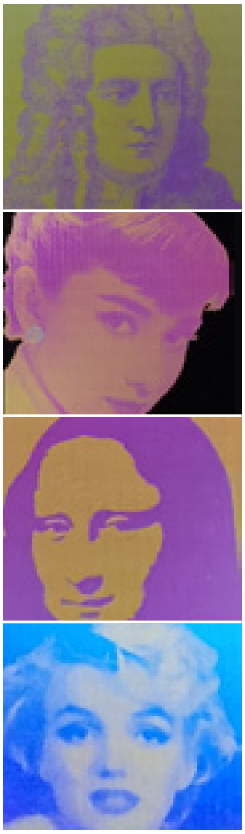
6. Based on what you've read here, how well might your (or your friend's) dog do in this experiment?

Vicky Nina (above), one of two dogs shown to quickly learn new words, sits with a pile of her toys. Since many other dogs don't seem to learn words easily, Vicky Nina may have a knack for new vocab. Researchers are investigating where that skill may come from.

ANSWER

Transparent ink produces images with wonderful color

Clear liquid creates different hues when printed in precise microscopic patterns



By printing tiny drops of clear ink on transparent surfaces, researchers created structural images such as a flower (right) and portraits of famous figures including (above, top to bottom) Isaac Newton, Audrey Hepburn, the Mona Lisa and Marilyn Monroe.

With disappearing ink, one minute you're writing, and the next — poof! Your words are gone. It's almost like magic. Now, scientists have performed perhaps an even more impressive trick. Using transparent ink, they have printed images in a full rainbow of colors. The key to this innovation: They print the clear liquid in precise microscopic patterns.

Those tiny patterns create what's known as structural color. Structural colors arise from the way different colors — wavelengths of light — bounce off microscopic structures. "In nature, there are many beautiful structure colors," says Yanlin Song. He's a materials chemist at the Chinese Academy of Sciences in Beijing. Some bird feathers and butterfly wings, for instance, sport vibrant structural colors, he notes.

Song's team described their process in *Science Advances*. The researchers printed structural colors on transparent, flexible sheets of silicone with lab-grade ink-jet printers and a clear, nontoxic polymer ink. The printer studded the silicone sheets with millions of microscopic ink domes. Adjusting the size of each dome determined what wavelengths of light it would reflect. That, in turn, controlled the dome's color. Each dome acted like a single pixel, adding a tiny bit of color to a larger image.

"The printing speed needs to be improved," Song says. An image 2 by 2 centimeters across (0.8 by 0.8 inches) took about five minutes to make. — *Maria Temming*

K. LI *ET AL*/*SCIENCE ADVANCES* 2021

Want to take your science fair project to the next level?

Here's advice from a finalist of Broadcom MASTERS — the middle school competition of Society for Science

ILLUSTRATION BY JOANNA WENDEL

Science competitions can be fun and rewarding. But for many, they also can be intimidating. Here, Eamon Gordon discusses his inspiration, what he enjoyed about his project and how to take the first step with your own science projects.

Q What inspired you to pursue this project?
A "When I was in third grade, I thought that sounds were quite similar to one another, letters like 'd' and 't,'" Eamon says. "Unlike vowels, they sounded quite similar to me." That made Eamon curious about how people distinguish between similar sounds. When he asked his father, Eamon's dad pointed him to information on voice onset time.

Q What was your favorite part of this project?
A Eamon enjoyed recruiting students he didn't know to participate in his study. In his experiments, Eamon played recordings of words, such as "tad" and "dad," with different voice onset times. Then he asked listeners about how they perceived the consonants in those words. "I went up to strangers and just ask them for some of their time, which was I think a good experience," Eamon says. "I got to meet new people."

Q What would you tell a kid who wanted to start a science project?
A The most important thing is "laying out your plans," Eamon says. "There might be a few road bumps. But overall, I think if you just have a plan, it'll be great." For Eamon, the key to making a plan was finding mentors and other resources to inform his project.

2021 Broadcom MASTERS Finalist

Eamon Gordon

Eamon, 15, studied an aspect of speech called voice onset time. This occurs when you make the sound of a consonant (like the "t" in "tab"). To pronounce that letter, you first close or constrict your mouth. (In the case of the letter "t," your tongue blocks the front of your mouth.) That builds pressure in your vocal tract. Opening your mouth to produce the next vowel sound (like the "a" in "tab"), releases that pressure. The time between the release and the vowel sound is the voice onset time. Eamon's experiments show that the voice onset time affects how listeners hear consonants. Eamon is a student at Goleta Valley Junior High School in Goleta, Calif.