Science News Explores

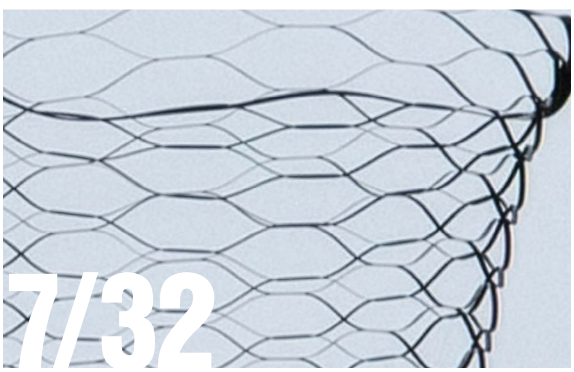
MARCH 2026

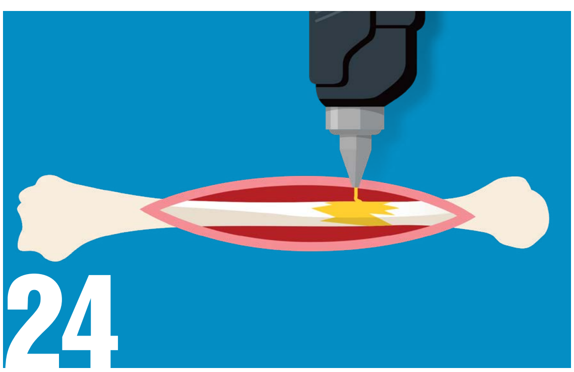
THE GRAND FINALE

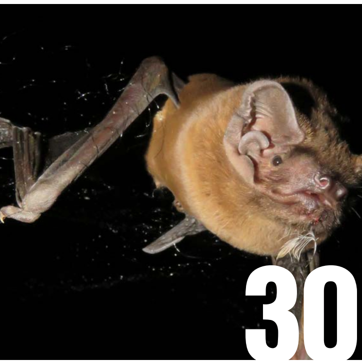
Scientists have bold ideas about how the universe could end

HOW TO BECOME INVISIBLE
P26

PARACHUTES FULL OF HOLES | ANTS ON THE MENU | ROSES MAKE STRESS BEAUTIFUL







Contents

Science News Explores | March 2026 | Vol. 5, No. 3

Features

Departments

COVER: JOHAN SWANEPOEL/SHUTTERSTOCK

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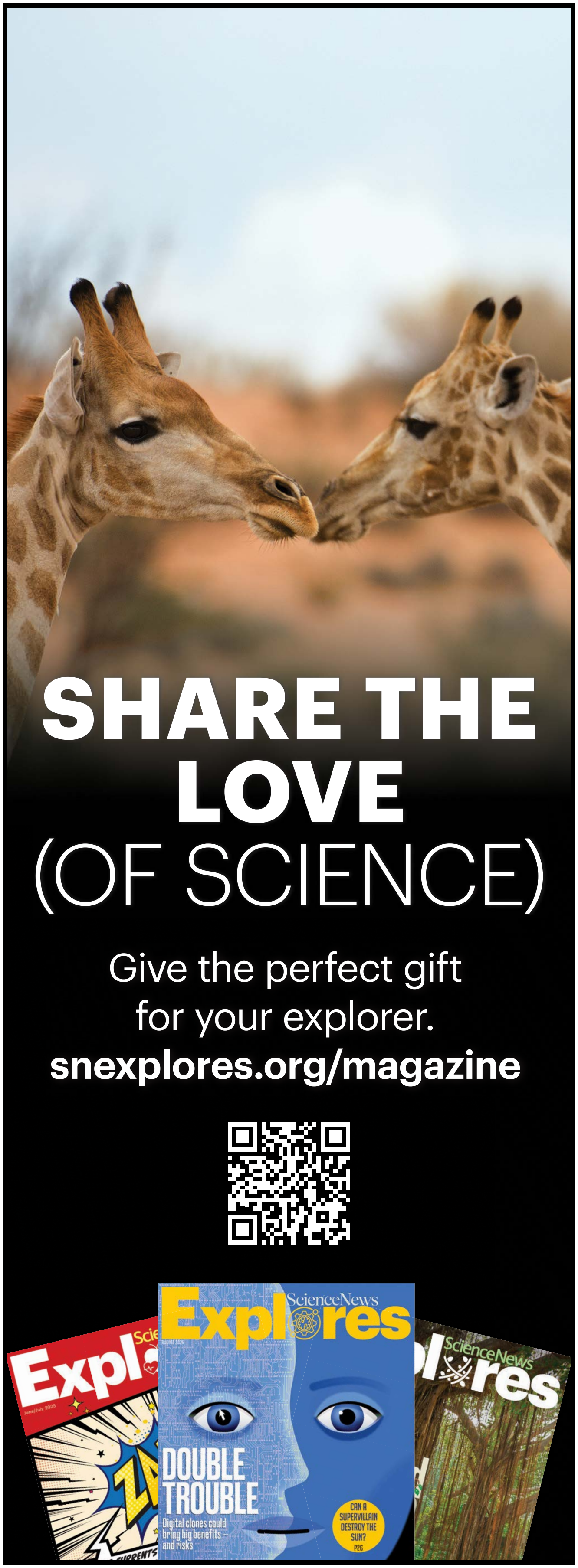

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Q Why does your mind want so badly to believe a fairy tale or legend?

— Jericho S.

A Many people assume it's easy to figure out if a myth like Bigfoot is fake. But "understanding reality is really hard," says Rohan Kapitany. At Durham University in England, he studies why people believe what they do. "It's actually something humans have been struggling with for hundreds of thousands of years." The most appealing stories tend to be both surprising and familiar, he says. That makes them easier to remember and enjoy. We also often believe tales "that are relevant to us and that people around us share," he says. For that reason, Kapitany would expect belief in Bigfoot to be higher in the Pacific Northwest, the rumored haunting grounds of this supernatural ape. There, people are more likely to encounter the idea of Bigfoot in their daily lives.

Q Why can't we break the laws of physics?

— Joey B.

A The ideas currently accepted as laws of physics have held up in many tests. But "it doesn't mean they can't be broken," says Benjamin Lehmann. He's a physicist at the Massachusetts Institute of Technology in Cambridge. "When we say that something is a law, what we really mean is that it's just some observed pattern," Lehmann says. "The history of science is all about … trying to see where do those patterns break down." Scientists can then come up with better laws to describe what they see. For instance, Isaac Newton's 17th-century law of gravity stated that things without mass do not interact through gravity. But now, scientists have seen how the gravity of massive celestial objects, such as black holes, warp the paths of massless light particles through space. In the 20th century, Albert Einstein came up with a revolutionary theory of gravity, known as general relativity, which explained those effects.

Q If the things that make plastic are natural, why does plastic hurt nature?

— Dia H.

A When a natural resource such as oil is used to make plastic, "it's heavily processed," says Lisa Erdle. This ecotoxicologist studies how plastics affect the environment at 5 Gyres in Santa Monica, Calif. Through that chemical processing, plastic becomes incredibly sturdy. "A piece of plastic that is half a centimeter thick will last so much longer than a banana peel," Erdle says, even though they both come from natural sources. As a result, plastic trash builds up and cannot break down easily in the environment. There, it endangers wildlife. "When animals eat plastic, they can have a sense of being full even though they haven't eaten their real food," Erdle says. That can cause animals to starve. Plastics are also laced with many chemicals designed to make them waterproof, add color or give them other properties. "Those can leach out of the plastic when they're eaten by wildlife," Erdle says. And those chemicals can disrupt animals' hormones, increase their risk of cancer or cause other problems.

OLEG AND POLLY/SHUTTERSTOCK

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

MATH

How rose petals get their iconic shape

The flowers' surprising geometry could inspire new self-molding materials

Would a rose by any other shape smell as sweet? Maybe. Yet the shape of a rose is part of its beauty — and why these flowers fascinate scientists.

As rose petals grow, they take on a distinct shape. Each one molds itself into a curved cup with points called cusps. At a glance, these petals may not look much different from those of other flowers. But mathematically, scientists have now discovered, rose petals' shape differs from other blooms.

The shape of a rose arises because the flower gets "frustrated" as it grows, researchers report in *Science*. This discovery may inspire new self-shaping materials for robots and electronics.

Rose petals' distinct rolled edges and pointed tips are a beautiful result of physical stress.

KATE CUZKO/SHUTTERSTOCK

Plants generally shape themselves as they grow. But the way a plant naturally tends to grow is not always allowed by the laws of physics. When some force gets in the way of a plant growing into its preferred shape, this is called an incompatibility. And it can stress a plant.

Many plants have what's known as Gauss incompatibility. It arises when different parts of a plant grow at different rates. That may be the edge of a leaf growing faster than its center. Some flower petals and seed pods reduce this stress by forming a wavy edge.

Scientists had assumed that a rose's shape arose the same way. But the sharp points of rose petal cusps look quite different from the smooth ruffles of carnations. So researchers at the Hebrew University of Jerusalem in Israel suspected some other geometry was at play.

To solve this mystery, the team examined real rose petals, plastic replicas and computer models of petals. A different type of incompatibility better explained the rose's shape, they found. It's called MCP (for Mainardi-Codazzi-Peterson) incompatibility.

Unlike the Gauss type, this type depends mainly on a shape's curvature. A rose petal does not maintain a smooth curve across its surface. As a result, a petal growing on a rose cannot maintain a smooth shape without tearing or folding. This MCP incompatibility leads to very specific points of stress.

On rose petals, that stress is expressed by forming sharp folds in the form of cusps.

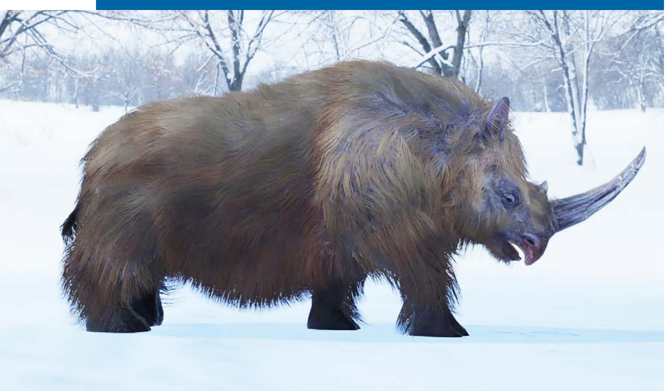
To confirm this, the researchers designed replica petals with that incompatibility baked into them. These took on the exact shape of real rose petals. "This proved [MCP] is completely sufficient to explain the shape," says physicist Eran Sharon, a member of the research team.

This is a “beautiful example” of how physics and geometry can offer insight into living tissues, says Suraj Shankar. He did not take part in the study. He does, however, study physics at the University of Michigan in Ann Arbor.

The new work also may have uses beyond understanding living things, he adds. Roses’ self-shaping traits could inspire materials for soft robots and flexible electronics.

This work also shows how geometry can show up in the most unexpected places, says Michael Moshe, a physicist who worked on the study. “Geometry is attractive because the questions are intuitive,” he says. “But many times, the consequences are surprising and beautiful.”

— SARAH WELLS



FOSSILS

More than

1.6 METERS (5.2 feet)

The length of the longest known horn of the extinct woolly rhino, found in permafrost in Siberia.

Source: G.G. Boeskorov *et al/Journal of Zoology* 2025

AUNT_SPRAY/CREATAS VIDEO+/GETTY IMAGES PLUS; UNIVERSITY OF NORTH CAROLINA AT GREENSBORO

HEALTH

Short bursts of exercise can boost classroom performance

Just nine minutes of high-intensity interval exercise does the trick

Even short bursts of vigorous activity in a classroom may help students focus. Here, a study participant wears an EEG cap to measure brain activity while she does jumping exercises.

Our bodies weren’t made to sit for hours in a classroom. That may be why many kids struggle to stay focused in school. Movement breaks can help students focus better. Just a few minutes of activity improves brain function and learning, new research shows.

Eric Drollette wondered how little exercise was needed to boost focus. He’s an exercise psychologist at the University of North Carolina at Greensboro.

He led a team that designed a nine-minute, high-intensity interval program that could be done in a classroom. It uses bursts of heart-pumping activity with short breaks in between. Think high knees, star jumps, jumping jacks, hops and kicks.

They described it in *Psychology of Sport and Exercise*.

Twenty-five students 9 to 12 years old tried out the program. At Drollette’s lab, they wore a heart rate monitor and an EEG cap that recorded brain activity.

Then they did the high-intensity interval exercises, rode a stationary bike or watched a short video.

After each activity, participants did some tests. One showed five fish in a line on a screen, and kids had to note which direction the center fish faced. Other tests focused on math or language.

During the fish test, the team noted a change in what Drollette calls “the uh-oh mechanism” — when you realize you made a mistake. High-intensity exercise reduced that response, suggesting that exercise had made kids’ brains more efficient. The other two activities didn’t show that benefit.

Students also performed better on the language tests after the high-intensity workout. But they did a little worse at math. That could be from fatigue, which tends to affect higher-level thinking tasks first, Drollette says.

Being active can help with both mental and physical health, says Drollette. His recommendation: “Find opportunities to stand up and get moving.”

— ALISON PEARCE STEVENS

MICROBES

Live ants — and their microbes — make this yogurt tasty

The insects and bacteria acidify and thicken milk into a creamy, tangy treat

This traditional method of making yogurt starts with four ants and a jar of warmed cow's milk. The insects and their bacteria acidify and thicken the milk.

DAVID ZILBER

In parts of Eurasia, the key to a tangy yogurt treat scurries along the forest floor. That secret ingredient? Ants!

A once-popular yogurt-making technique uses ants and their microbes. The bacteria are used to kick-start the fermentation process that makes yogurt so thick and tangy.

The traditional recipe requires live ants — not frozen or dehydrated ones. Now, scientists have identified the exact microbes the ants have that make this creamy treat so tasty. They shared the details in *iScience*.

Yogurt-making dates to around 7,000 years ago. The process starts with warmed milk. Then people add safe, healthy bacteria to acidify and thicken the liquid. They keep the mixture warm for several hours, giving it time to ferment.

The bacteria used in making yogurt can come from many sources. Anthropologist Sevgi Mutlu Sirakova works at Ludwig-Maximilians-University Munich. That's in Germany. Her ancestors came from a village in Bulgaria. Around there, it was once common to make yogurt with the help of red wood ants (*Formica rufa* and *F. polyctena*).

Sirakova traveled with a research team to her family village. There, they put the insect-based practice to the test.

The team placed four live ants into a jar of warmed raw cow's milk. They then buried the jar in an ant mound. The nest kept the mixture warm so it would ferment overnight. The next day, the now-acidic milk had begun the early stages of becoming yogurt. It even developed a tangy and herb-like taste.

Molecular tests showed that *F. polyctena* ants carry bacteria that produce lactic acid and acetic acid, which thicken milk. Enzymes supplied by both the ants and bacteria can digest the milk. This breaks it down to make that creamy yogurt.

Frozen or dehydrated ants carry microbes that don't ferment milk as well as those from living ants, the team found. Sometimes, though, live ants can be infected with a hitchhiking parasite. In rare cases, that hitchhiker can harm people's livers. That's why, researchers say, you shouldn't try this at home.

— Erin Garcia de Jesús

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

SINKING CI

Uplifting solutions aim to protect communities against the dual threats of falling land and rising seas

BY ALISON PEARCE STEVENS

KONGJIAN YU/TURENSCAPE

Sanya Mangrove Park in Hainan, China, collects stormwater from the surrounding city. Wetlands inside the park filter the water and allow it to soak back into the ground.

DANIKANCIL/ISTOCK/GETTY IMAGES PLUS

DEFINITION

sub·si·dence
(*n.*) the gradual sinking of an area of land

The streets are flooding in Jakarta, Indonesia. But people just go about their lives. Adults wade through water to work, shop and care for their families. Children splash and play in water-logged streets. This flooding isn't caused by a storm. It's not even raining. Here, floods happen every day, as high tides swamp the city's low-lying areas.

Part of the problem is rising sea levels. But Jakarta has a bigger issue: Its land is sinking.

This sinking is what scientists call subsidence. Jakarta is sinking around 30 millimeters (about 1 inch) per year. Sinking and higher tides cause seawater to flood about one-fourth of the city. If things don't change, more than one-third of Jakarta could be underwater in another 25 years.

And Jakarta isn't alone. Cities are sinking across the globe. Although some subsidence happens naturally, human activities drive most of it.

The good news is that people are finding ways to slow and even reverse that sinking.

As land returns to higher levels, flooding in many of these places will stop. Wells will continue to provide water instead of running dry. And innovative ways of fighting subsidence are helping to return nature to cities and surrounding areas.

PEOPLE — A GROWING PROBLEM

Although earthquakes can cause land to abruptly sink, such natural events aren't the main cause of subsidence. People are. Or rather, our need for underground resources, especially water.

Most fresh water on Earth is locked up as ice. Less than 1 percent of the world's fresh water exists in rivers and lakes. The rest of that liquid water lies beneath the surface. It's known as groundwater.

In many parts of the world, people drill down into aquifers to pump that water out. It's an important source of water for nearly 2 billion people. But in some places, that pumping is causing the land to sink.

It's a particularly big problem for large cities. The more people who live there, the more water they need to pump from the ground.

Not all cities sink equally fast. Geology plays a role, too, notes Leonard Ohenhen. He works at the University of California, Irvine. As a geodesist, he monitors and measures the Earth. "Some cities sit on solid, hard rock that barely compresses," he says. "Others are built on thick layers of clay, sand or sediment that can compress easily."

Cities atop sediment are most likely to sink.

Ohenhen's team has shown that subsidence is a growing issue for cities across the United States. They looked at the 28 most populated cities, many of which are inland. Their estimates suggest that at least 20 percent of the urban area is sinking in each of those cities, mainly due to groundwater pumping. In all, some 34 million people are affected. The researchers shared their results last year in *Nature Cities*.

IN MANY PARTS OF THE WORLD, PEOPLE DRILL DOWN INTO AQUIFERS TO PUMP THAT WATER OUT. BUT IN SOME PLACES, THAT PUMPING IS CAUSING THE LAND TO SINK.

Subsidence comes with real, but often invisible, problems for the built objects that support a city. Think highways, railways and bridges. These "can crack or break when one section sinks more than another," Ohenhen says. Water and sewer lines can break as the land beneath them shifts. And buildings, when not constructed properly, can begin to break apart. Ohenhen's team found that in the U.S. cities it surveyed, more than 29,000 buildings are located in areas facing a high or very high risk of damage.

New construction can boost subsidence, says Pei-Chin Wu. She's a geologist at the University of Rhode Island in Kingston. To improve safety during construction in areas with soft soil, workers pump out water before adding the foundation for a new building.

Afterward, she says, they don't usually replace the water they'd taken out. So the area subsides.

Wu grew up in Taiwan's capital city, Taipei. It sinks and rises through the seasons. The whole city subsides during the dry season, as people pump out groundwater. "When the rains come — and when the water level goes up — it will recover," she says.

The rains filter down into deep aquifers under the city. This pushes the land up again. The process doesn't happen everywhere, though. In places where there's been lots of construction, the ground never fully recovers.

Wu uses satellite data to study subsidence in coastal cities around the world. These satellites bounce a signal off the land. Computers calculate the distance to the ground based on how long it takes for each signal to return. This shows the height of the land. By comparing repeated measurements for the same site, geologists can detect small changes in height over time.

In a 2022 study, Wu found that subsidence is a bigger problem, globally, than people had realized.

Sinking ground in coastal cities can leave them especially vulnerable to flooding. In some places — such as Jakarta, Indonesia — even the twice-daily high tides can flood large areas (left). The street where this boy is playing floods every day during high tide (right).

ED WRAY/STRINGER/GETTY IMAGES NEWS

And it's been happening fastest in Southeast Asia. Why? Cities there are growing quickly.

Subsidence is slowing in many cities, too, she found. It's still ongoing, but the rate of fall is not as fast as it was 10 years ago. That's thanks to the removal of less groundwater.

RETURNING WATER TO THE GROUND

In mainland China, flooding has become a big problem. So has drought. Northern cities often get little rainfall. Those in the south can get way too much. So China developed a sponge city plan to balance the two.

Sponge cities use green roofs (covered by grass or other plants), permeable pavements and other features to get water off of streets as quickly as possible, explains Michele Lancia. He works at the Eastern Institute of Technology, Ningbo, in China. As a hydrogeologist, he studies how water interacts with rock and soil.

In south China, these features protect people from flooding. In the north, collected water can be "stored, purified and reused," he says.

Managing water use — and reuse — could also help prevent future subsidence. The key is getting water into aquifers. This process is known as recharging. But China's current system isn't designed to do that.

Lancia is exploring new ways to recharge aquifers. Where successful, it could reduce flooding while ensuring water is available.

MANAGING WATER USE — AND REUSE — COULD ALSO HELP PREVENT FUTURE SUBSIDENCE.

This sinkhole at Lafayette Blue Springs State Park is one of many in Florida that have formed naturally due to the state's geology. But groundwater removal in the state has caused many new ones to form. Some may develop into lakes as they fill with rain or spring water.

This cranberry bog has been flooded in preparation for harvest.

China isn't the only place where flooding and water supply are an issue. In Virginia, in the United States, the Hampton Roads Sanitation District (HRSD) hopes to address both problems — and reverse subsidence along the way. HRSD developed the Sustainable Water Initiative for Tomorrow, or SWIFT, program. SWIFT aims to return wastewater to the ground. First, the water must be purified until it's clean enough to drink. Then HRSD pumps it deep underground into what's known as the Potomac Aquifer.

"Back in [the] early 1900s, you'd put a well in the Potomac Aquifer," says HRSD hydrogeologist Dan Holloway. "Water would come out of the well above your head. You wouldn't need a pump. You'd need a valve" to shut it off.

That water pressure dropped over the past century as people removed more and more water from the aquifer. Wells slowed from gushes to drips — then to nothing at all. People finally had to start pumping. The level of the water in the aquifer has since dropped about 38 meters (125 feet).

Pumping created another problem: salty groundwater. Fresh water naturally flows downhill from the rolling hills of central Virginia out to the sea. That fresh water pushes out toward saltwater, Holloway explains. In the past, that has kept the groundwater largely salt-free.

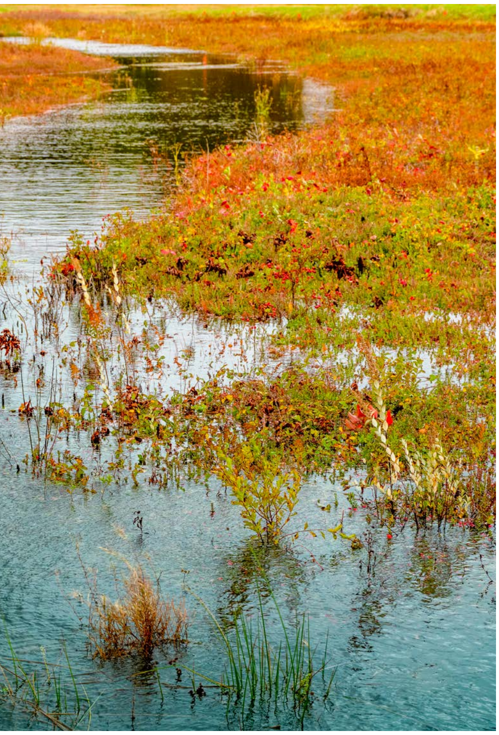
Holloway likens it to a bedsheet pulled tight at a sloping angle. A marble on the sheet will always roll downhill. But a groundwater pump makes a hole in the water level around the pump. The more that is pumped, the bigger the hole. Removing too much water in that spot is like pinching that bedsheet and pulling it down. "Now both directions want to come in," he says. "The marble rolls towards the hole." Fresh water continues to flow from farther inland. At the same time, salty seawater now moves in from the coast. This can make the groundwater salty.

By adding purified wastewater to the aquifer, SWIFT is designed to combat both subsidence and the intruding saltwater. And it works.

"When we put water in the ground, the aquifer expands," Holloway says. The ground level nearby rises in small but measurable amounts. The program is still in the early stages, returning 3.8 million liters (1 million gallons) to the ground each day.

The goal over the next five years is to increase water additions 50-fold. Eventually, SWIFT could stop land

MICHAEL WARREN/ISTOCK UNRELEASED/GETTY IMAGES PLUS; SANGHWAN KIM/ISTOCK/GETTY IMAGE PLUS



Flooded landscapes are essential to the practice of paludiculture, or cultivating crops in wet environments. Cranberries, for example, grow in bogs like this one (left). Peatlands (right) support fibrous plants, such as cattails and reeds, that can be used as construction materials.

CATOLLA/ISTOCK/GETTY IMAGES PLUS

subsidence in the area and ensure a continuous source of fresh drinking water for millions of people.

PUTTING NATURE TO WORK

In Europe, the Netherlands is known for dikes that hold back the sea. "Almost half of the Netherlands is below sea level," notes Tom Wils. He works in the country at Utrecht University. As a physical geographer, he studies landscapes. Without dikes, this nation's low-lying peatlands would be underwater.

These areas weren't always below sea level. Around the year 900, the peatland "was about 2 meters [6.5 feet] above sea level," Wils says. Peat forms in wet spots, where moss and other plants partially decay. A carbon-rich layer builds up over time that can be used as fertilizer or fuel. But the land was too soggy to make good farmland. So the Dutch began to drain the bogs. That's when their land subsidence started, Wils says.

Today, the Dutch use their peatlands to raise dairy cattle. They drain off excess water so the land isn't too wet to support the cows. As a result, the land continues to sink. The Dutch peatlands now lie 2 meters (6.5 feet) below sea level.

Wils is studying new ways to reduce subsidence while supporting the land and people here.

One approach is called paludiculture. That's a fancy term for "cultivating crops that grow in wet environments," Wils explains. These include cattails and reeds — two types of fibrous plants that can be used as construction materials. Cranberries and rice can be grown at such sites for food.

Adding water back to the land fluffs up the peat. It also allows new peat to form, which raises the height of the land.

Most Dutch paludiculture fields are experimental. But the country's low-lying peatlands now host a successful cranberry farm.

Of course, there are challenges to this wet farming. Flooded fields can release methane (CH_4), a powerful greenhouse gas. It's a stronger threat to climate change than carbon dioxide (CO_2). Flooded rice paddies commonly spew methane. So Wils is studying ways to cut their release of this gas. He doesn't want a fix for subsidence that worsens climate change.

Nature can help with subsidence, too. Because peatlands are often part of river deltas, they can be crisscrossed by many streams and rivers. When they flood, nearby reeds, trees and other plants can trap sediments to help form new peat. It takes time for this new peat to build up, Wils notes. But areas where this happens can work as a nature-based solution to help lift the land.

Wet agriculture isn't just an option for the Netherlands. It's used in Germany, Switzerland and the United States. And some Asian countries, including Indonesia, are using it to rebuild peat and prevent additional sinking.

No single solution to subsidence will work at every site. But with enough creative problem solving, we can lift up the land to help protect urban areas from undergoing repeated future flooding — not only in Jakarta and Taipei, but also in plenty of other cities across the planet.

THE GRAN

Scientists have bold ideas about how the universe could end

BY **STEPHEN ORNES**

NICOLLE R. FULLER/SCIENCE SOURCE


ND FINALE

Some endings are easy to predict. Throw a ball in the air and it will fall back down. Run off a diving board and you'll land in a pool. But forecasting something as big and complex as the end of the universe? That's not easy.

People have been making predictions about the end of everything since the start of civilization. And scientists have been chasing this question for hundreds of years. They've proposed many possibilities — often with ominous names: The Big Rip. The Big Crunch. The Big Freeze.

Some scientists even suggest there may never truly be an end at all.

These predictions might sound wild. But they aren't just imaginative speculation. They have been shaped by what scientists know about physics and their observations of distant stars and galaxies.

Ironically, centuries of research have not led to certainty. If anything, scientists have become less certain of the fate of our universe — and they often disagree.

THINGS FALL APART

The night sky might look calm and still. But our universe is always in motion. Planets orbit stars. Stars move together in galaxies. Some galaxies collide. Others fly apart.

Foretelling the future of the universe requires knowing what pulls things together and what pushes them apart.

Nearly 400 years ago, physicist Isaac Newton described what pulls stuff together: gravity. Everything with mass attracts everything else with mass. This attraction is stronger for objects that are more massive and closer together. It's what keeps planets like Earth from being flung from the sun.

But for their orbits to be stable, those planets had to be arranged in just the right way. If they were too close to the sun, they'd fall into it. If they were too close to each other, they might smash together. Newton once wrote that only "divine power" kept the whole planetary system from collapsing.

Later discoveries further shaped ideas about the fate of our cosmos.

One was the second law of thermodynamics, discovered in 1850. It says that energy moves from a warmer region to a cooler one — but never the other way round. Later, scientists realized this one-way law also applies to messiness. A raw egg, for instance, is nice and orderly. It has yolk and egg white in two distinct parts. Scrambling the egg makes it disordered. But you can't unscramble the egg to make it orderly again.

Scientists explain this by noting that there are many more ways to be disorganized than to be organized. So any system is more likely to end up in one of those messy states.

In 1852, a scientist known as Lord Kelvin wrote that energy should spread out in the universe, too. Today, the universe has some order. Stars are hot.

WATCH KATIE MACK DESCRIBE POSSIBLE ENDS OF THE UNIVERSE

Read more about her on page 20

Our universe is full of galaxies sailing past each other, as these are. Sometimes, they collide.

NASA, ESA, CSA, STSCI

SEE HOW THE UNIVERSE GREW UP!
P28

If the universe is expanding, what is it expanding out from? According to the Big Bang theory, the universe started as a single point called a singularity.

MARK GARLICK/SCIENCE PHOTO LIBRARY/GETTY IMAGES

The space between them is cold. But eventually all that energy will spread out so much that everything will cool down close to absolute zero.

Because movement requires energy, nothing will ever move again. "The result would inevitably be a state of universal rest and death," Lord Kelvin wrote 10 years later. This leads to one possible end of everything, dubbed the "Heat Death of the Universe" or the "Big Freeze."

Many scientists resisted this idea. They believed the universe would stay as it is forever. But they were wrong.

THERE GOES THE COSMIC NEIGHBORHOOD

The last century has completely changed what we know about the universe.

In the 1920s, scientists discovered that no matter which direction you look, most galaxies are flying away from Earth. The farther the galaxy, the faster it moves away. This suggests the whole universe is expanding.

The universe, it seemed, is not unchanging. It must have been smaller yesterday, and even smaller the day before that. And it must have had a tiny start in the distant past.

Scientists call that moment the Big Bang. It's when a tiny, dense pocket of something blew up to jumpstart the universe. One problem with this theory is that no one knows what happened right before — or how it started. (Scientists continue to work on that.)

An expanding universe fits with the Big Freeze idea, in which everything spreads out. That idea remains popular, in part because it lines up with what scientists see in the universe today.

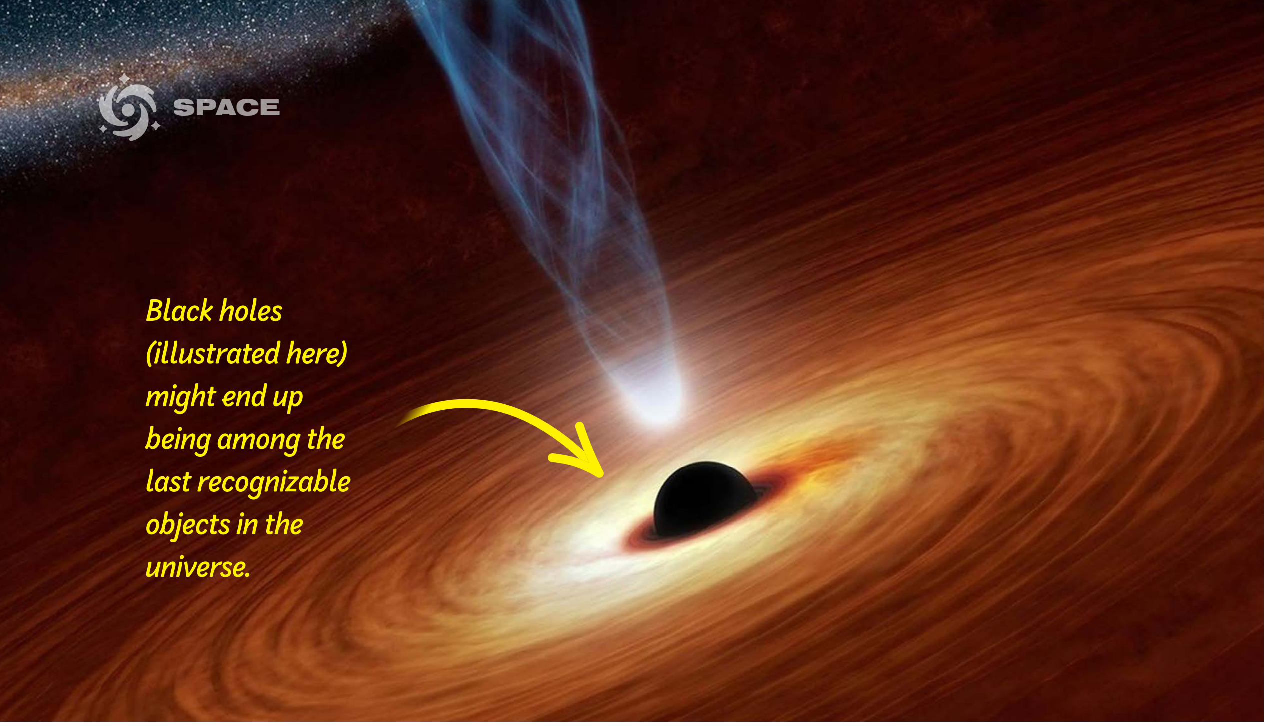
In this scenario, over trillions of years, stars and planets will form, die and fall apart. Some big stars could explode and become black holes, which eventually will gobble up everything else. Long after that, black holes might evaporate and vanish. The universe will grow big, cold and quiet — and stay that way forever.

"People don't like the idea of the heat death," says Katie Mack, because "it's too sad." A cosmologist in Canada at the Perimeter Institute in Waterloo, Ontario, Mack has written a book on the destiny of the universe. It's called *The End of Everything (Astrophysically Speaking)*.

But Mack is not concerned about the Big Freeze. After all, it would happen a long, long time from now. This slow disappearance of ordinary matter would unspool over 10^{40} years or so. That's a 1 followed by 40 zeroes. The Earth won't be around to see the Big Freeze. And by then, people will have moved to another planet, evolved into a new species or gone extinct.

DEFYING GRAVITY

By the end of the 20th century most scientists suspected that the universe was expanding. They thought that expansion was like a ball thrown in the air. A ball moves upwards — then slows down. Likewise, cosmic expansion was thought to be slowing down. After all, gravity is pulling all the matter in the universe together.



Black holes (illustrated here) might end up being among the last recognizable objects in the universe.

In the Big Crunch scenario, first galaxies, then stars and planets, would smash into each other (illustrated here). Some scientists have proposed that this scenario might trigger another Big Bang, leading to a new universe.

If the expansion slowed but never stopped, the universe would be infinite. If it slowed down and stopped, then the universe would have a finite size. And if it stopped and then reversed, the universe would start to shrink.

That last idea is exciting and terrifying. Galaxies would crash into each other. Then stars and planets, too. The collisions would blaze like spectacular fireworks at the end of time. This scenario is called the "Big Crunch."

Some scientists have proposed that a Big Crunch might trigger another Big Bang. In that case, the whole universe would start over. Maybe our universe has expanded and contracted many times in the past and will keep doing so in the future.

In the late 20th century, scientists tried to measure how much the expansion of the universe was slowing down. They pointed powerful telescopes at distant stars. But again, they discovered they were wrong. The expansion of the universe is not slowing. It's speeding up.

Something must be pushing everything away from everything else. Scientists now call this unknown thing "dark energy."

It behaves "almost like it has negative gravity," says Arjun Dey. "That's the part that's really mysterious." Dey is an astronomer at the National Science Foundation's NOIRLab in Tucson, Ariz. There, he studies distant stars and galaxies using a telescope atop a mountain in the desert. The tool he uses is called the Dark Energy Spectroscopic Instrument, or DESI.

DARK ENERGY APOCALYPSE

Scientists still don't know much about dark energy. They do know, though, that there's a lot of it. It makes up some 70 percent of everything in the universe.

"That's very disturbing," Dey says. "We don't understand it."

Understanding dark energy is important for knowing how the universe began and evolved. It's also critical for predicting how the universe will end.

If dark energy pushes the expansion of the universe at the same rate, then a Big Freeze is most likely. As galaxies and stars zoom apart, their light will no longer be visible to each other. If Earth weren't already obliterated by the death of the sun, we would see the lights in the night sky dim and eventually fade to black.

But that's not the only possibility. Dark energy might speed expansion of the universe even more. If so, the fabric of reality could rip apart like a piece of paper. First galaxies would get shredded, then stars and planets. This is the idea behind the Big Rip.

But maybe dark energy is changing in the other way. Scientists have found hints of this from DESI. In April 2024, researchers there unveiled data on how the universe has been expanding over the last 11 billion years.

Surprisingly, those data hint that dark energy may have been weakening over that time.

The DESI team has not confirmed that finding. But they have continued studying exploding stars and bright patterns in the cosmos. They've examined the cosmic microwave background — the light echo of the beginning of the universe. And this has turned up even more evidence of a change in dark energy.

If dark energy can change, then maybe the universe has had many phases where the expansion speeds or slows. If dark energy gets too much stronger, a Big Rip might be more likely. If it loses too much oomph, the universe might contract into a Big Crunch.

Or perhaps the universe expands and contracts in cycles, says Paul Steinhardt. He's an astrophysicist at Princeton University in New Jersey. For decades, he's studied how the history of the universe connects to the future. He investigates the idea that scientists might be wrong not only about the current universe, but also its beginning.

"You could begin with an infinite universe," Steinhardt says. "It contracts, bounces — and [now] we're 14 billion years after the bounce."

That idea doesn't require a Big Bang. In fact, Steinhardt doesn't like the idea of a Big Bang because it doesn't fully explain why the most distant reaches of the universe look the way they do. If the expanding universe we see today started with a bounce, he says, "you don't need the bang."

STRANGER IDEAS STILL

A universe that grows and shrinks, over and over, isn't even the wildest idea out there.

It's not impossible, for example, that a blob of nothingness could suddenly appear somewhere in the universe and grow at the speed of light until it burns up everything. Mack calls this possibility the "bubble of quantum death." It's not very likely, she says. But thanks to the bizarre rules of quantum physics, we can't completely rule it out.

It's also possible that what we call the "universe" is only one small cosmic neighborhood, says Andrei Linde. He's a physicist at Stanford University in California. His work has shaped much of what we know about the cosmos.

When the universe began, most scientists believe it expanded extremely quickly in a phase called inflation. But that growth spurt could have produced many "mini-universes," Linde says. Think of them like the black and white hexagons on a soccer ball. We may live in one black hexagon and not see the rest.

As the universe — that is, the soccer ball — expands, "there will be a practically infinitely large black part," Linde says. "And those who will live in a black part will never see a white part."

Even as mini-universes grow, shrink or vanish, the entire universe could go on forever. "Some part of the universe ends," Linde says, as "some part of the universe is being resurrected."

Contemplating fates of the universe gives scientists freedom to think about wild possibilities. It also shows how incomplete today's theories are. "They're limited by our imagination," Dey says.

The end of the cosmos fits into the larger, enormous question of where the universe came from and where it's going. And that question has led to remarkable discoveries and inspired the design of new telescopes, technologies and ideas.

"It tells you how useful imagination is in science," says Dey. "Things have changed quite dramatically in our understanding of the universe."

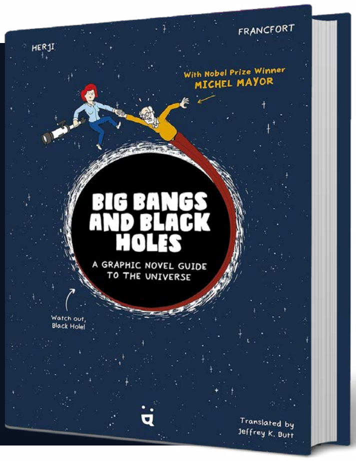
READ MORE

Big Bangs and Black Holes:

A Graphic Novel Guide to the Universe

By HERJI, Jérémie Francfort, Jeffrey K. Butt (translator)

There's still so much we don't know about space! From the Big Bang to black holes, read more about our place in the cosmos and how it all began.



HELVETIQ

This cosmologist studies the invisible parts of the universe

Katie Mack is looking at dark matter to better understand how galaxies form and evolve

Before Katie Mack became a scientist, she was the kid taking apart TV remotes and building solar-powered cars out of LEGOs. “I’d take things apart and put them back together to figure out how they work,” she says. This tinkering kickstarted her love of science.

But Mack wouldn’t come across her future career until she was about 10 years old. That was when she read *A Brief History of Time* by physicist Stephen Hawking. His explanations about black holes and the Big Bang inspired Mack to figure out how the universe works. When she found out Hawking was a cosmologist, she says, “I became convinced that I wanted to be one, too.”

Now a cosmologist herself, Mack studies invisible material known as dark matter at the Perimeter Institute for Theoretical Physics in Waterloo, Ontario, in Canada. While dark matter doesn’t absorb or emit light, it can affect objects with its gravity. “So we have this idea that dark matter is out there, but we don’t know what it’s made of,” she says. But researchers suspect it helps hold the universe together.

Sleuthing out dark matter’s true identity can help answer larger questions about the universe, says Mack. These include better insights into how galaxies form and evolve over time. In this interview, Mack shares her experiences with *Science News Explores*. (This interview has been edited for content and readability.) — *Aaron Tremper*

Q Who were some of your role models growing up?

A When I was younger, my mom was working toward her Ph.D. in nursing. She trained as a nurse and worked in hospitals but also did clinical research around treating cancer. I learned a lot from her about how science and research work. Also, my grandfather was a meteorologist in the Navy. He served on the Apollo 11 mission. His job was to make sure that the location of the splashdown after the mission would be safe.

Sometimes, I’d see scientists on TV. Whenever there was an earthquake, one of our local seismologists, Kate Hutton, from Caltech, would talk about it. It was inspiring to see a scientist talking to reporters about how the world works.

Q What are some misconceptions about the work that you do?

A One of the biggest things that I encounter when I talk about dark matter is people saying that it’s not real. They assume it’s just a mistake somewhere in the math or that scientists need to rethink gravity. People often bring this up as though we haven’t thought about that. They assume scientists just had a cool idea and ran with it. That’s not really how it goes.

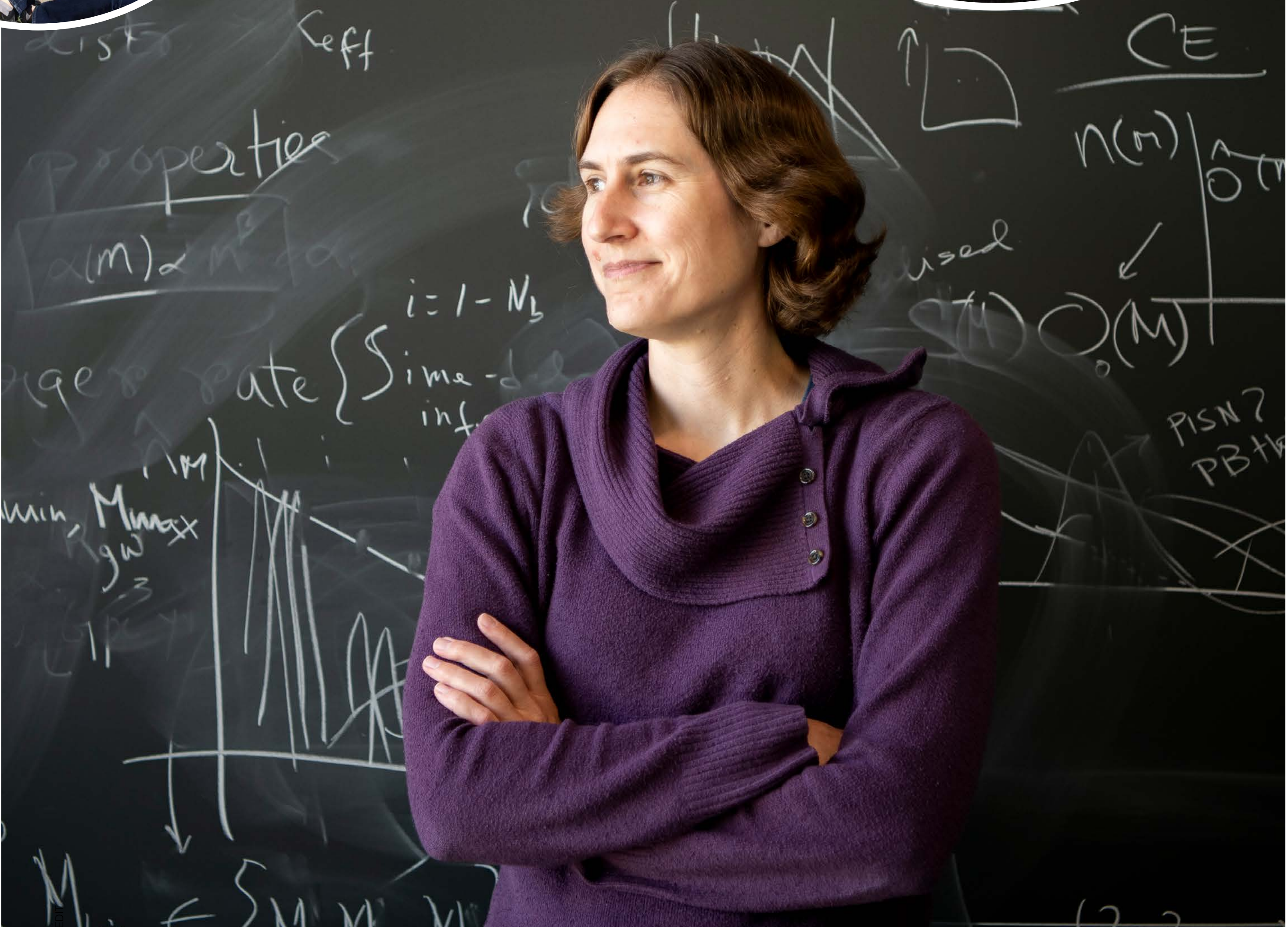
Q What piece of advice do you wish you’d been given when you were younger?

A I would give myself a little encouragement and tell myself that it’s OK if what I’m doing is really hard. That doesn’t mean that I wasn’t cut out for it.

A lot of people get really discouraged as soon as they find that they’re having trouble in a field. They assume that it should come easily if it is going to be their career. I don’t think that’s necessarily true. It’s OK to not be born good at something. You can learn and develop your skills. Just because something is much harder for you than your classmates doesn’t mean that you shouldn’t do it.

Cosmologist Katie Mack studies dark matter, an invisible substance that researchers suspect holds the universe together. Teasing out the identity of this elusive matter can help researchers better understand the universe’s beginnings and its possible end. During the pandemic, Mack earned her pilot certificate to fly airplanes in her free time (inset, center).

SARAH SCOLES; K. MACK; DEMELZA KOOIJ; K. MACK



EARTH

How about this weather we're having?

Investigate weather and climate patterns in your area over history

By Science Buddies

What's the difference between weather and climate? Weather may change many times from day to day or season to season. Climate describes weather patterns over many years in a particular region. In this experiment, you will investigate the difference between weather and climate in your area using an online database.

OBJECTIVE *Investigate historical weather and climate variations where you live*

EXPERIMENTAL PROCEDURE

1. Choose a series of months and years for which you will look up the average temperature in your area. (You may need to adjust this series based on the available data in the database you will use.)

2. Make a table with a column for each year and a row for each month. (See an example at snexplores.org/weatherclimate.)

3. Go to wunderground.com and click the "More" tab at the top of the homepage. Select "Historical Weather" from the dropdown menu.

4. Search for your city or town. Click on the "History" tab at the top of the page and select "Monthly."

5. Look up the first month in your table, such as "January 2025." Record its average temperature in your table.

6. Repeat Step 5 for all the months and years in your table.

7. Choose a year and graph the average temperature over each month of the year.

8. Choose a month and graph all of its average temperatures over each year.

9. Has the average temperature in your area changed over the years? Has the average temperature changed or stayed the same from month to month? Are there any recurring patterns or cycles?

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

In many places, the weather is warming up enough to melt snow and allow spring plants to grow. What about in your neighborhood?

FOTOMAREKKA/SHUTTERSTOCK

These words are hiding in this issue. Can you find them?

The words below came from the stories in this magazine. Find them all in the word search, then search for them throughout the pages. Some words may appear more than once in the issue. Can you find them all?

Check your work by following the QR code at the bottom of the page.

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ALTIMETER
AQUIFER
BIG BANG
BIOINK
BUZZ
CLIMATE
COSMOLOGIST
CUSP
FOCUS
GALAXY
GLASSWING
GRAFT
HELIUM
INFLATION
INTERVAL
KIRIGAMI
MAGNETOMETER
NOCTULE
PARACHUTE
PARTICLES
PEATLAND
PETAL
PIGMENT
SONGBIRD
SUBSIDENCE
TRANSPARENT
WEATHER
YOGURT

TECH

This modified glue gun can help patch broken bones

An antibiotic graft material squirted onto fractures boosted healing in rabbits

A repurposed glue gun has helped repair broken bones in rabbits. Instead of a regular glue stick, the glue gun melts a material that helps bones heal.

Some breaks in bones need a little help to mend. So surgeons sometimes take a bit of bone from elsewhere in the body to make a patch called a graft. Or they can use a synthetic — human-made — material that mimics bone.

Synthetic grafts are often 3-D printed. Usually, X-ray scans and measurements of injuries are needed to make sure the graft will fit just right. Designing and making the graft takes some time and can delay repairs.

But the glue gun method doesn't require images of the fracture. And it doesn't need any special graft design. The handheld device can simply squirt the graft material right onto a break.

The idea was to design a printing system that could be easily used in operating rooms, says Jung Seung Lee. He's a biomedical engineer at Sungkyunkwan University. That's in Seoul, South Korea. Compared with regular bone grafts, he says, this system can save time and money and reduce the need for complex procedures.

The printing device holds sticks of a specially made "bioink." It's safe to use in the body. It consists of two compounds commonly used for 3-D printing implants. One, hydroxyapatite, is a mineral found in bones. The other is a body-safe plastic called polycaprolactone, or PCL. That's included to support new bone as it grows. In an implant, it "gradually degrades in our body over months," Lee says. Over time, newly grown bone will fill in as the graft breaks down.

The ratio of the two compounds in the bioink determines the material's strength and stiffness. So the researchers can tailor the mixture for each use. They also added antibiotics into the bioink to prevent infections.

CRAFTING GRAFTS

Like the glue sticks used for crafting, the bioink fits in the handheld printer. It can be squeezed out where it's needed. But regular hot glue guns work at temperatures far too high for living tissues.

So the researchers modified their glue gun to work at lower temperatures. They also adjusted the tip for better control. Thanks to the low melting point of PCL, the bioink can be applied at about 60° Celsius (140° Fahrenheit). It cools to body temperature within 40 seconds. The whole process takes just a few minutes.

Lee's team tested the printer and bioink on broken leg bones in rabbits. Another set of rabbits got a material called bone cement used to attach implants to bones. The rabbits that got the bioink had better healing and regrowth of bone tissue. And the animals showed no signs of infection during the 12 weeks after surgery. The team shared its results in *Device*.

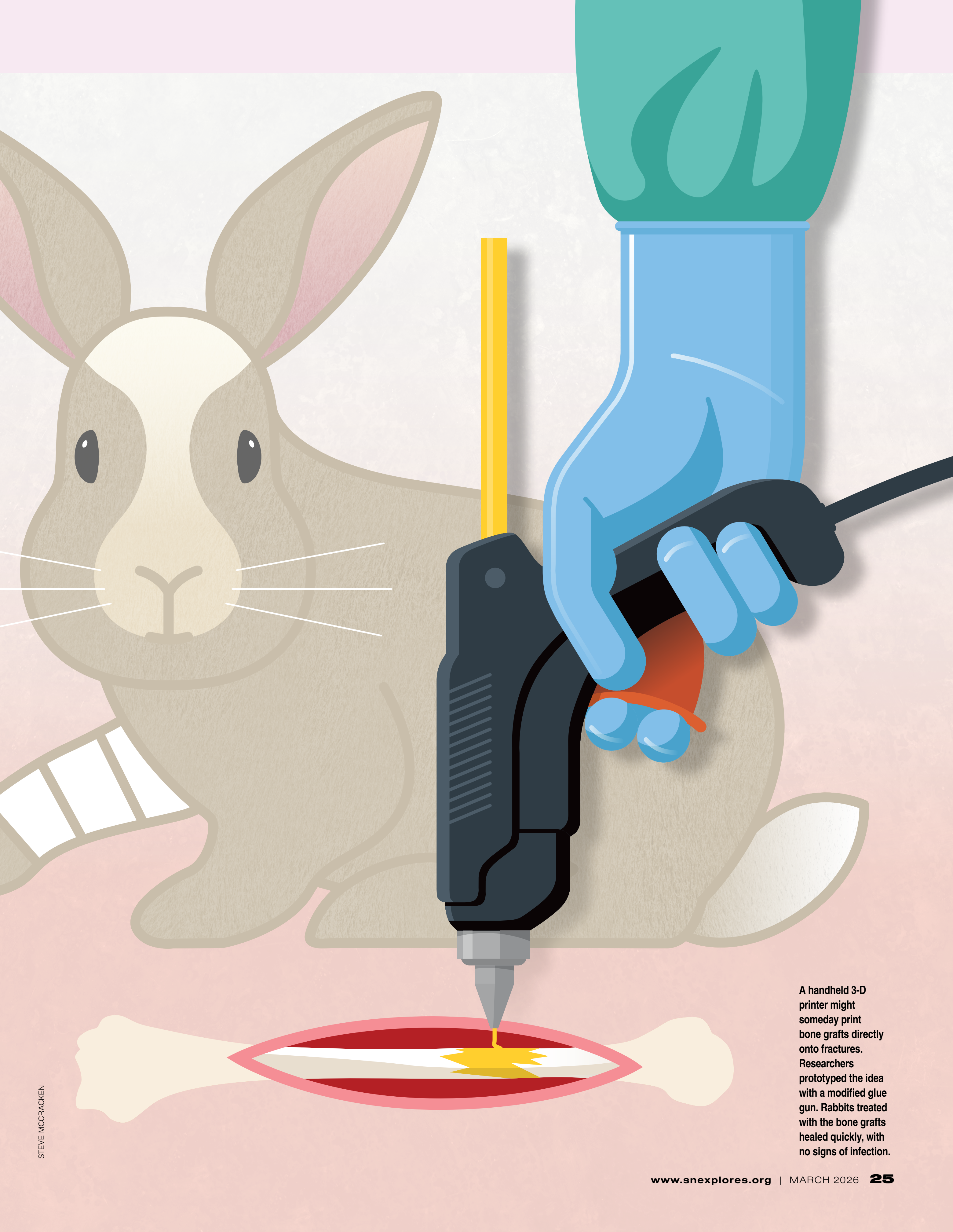
For now, the printer is still a proof-of-concept for people. Lee aims to develop it into a multi-use printing system. For instance, it might apply chemicals that promote healing during surgeries. But first, researchers will have to do more studies to make sure the technology is safe. They'll also need to figure out how to disinfect the device between uses.

There may be other limitations. "The high temperature of the extruded material is likely to stress or kill the cells," says Deborah Mason. She's a molecular and cell biologist at Cardiff University in Wales. She wasn't involved in the study. Lee's team is working to modify the tip of the device. That could help the bioink cool more quickly after extrusion.

In the future, this sort of device could help surgeons with more complex repairs, suggests Nieves Cubo-Mateo. She's a biomaterials engineer at Nebrija University in Madrid, Spain. She wasn't part of the study.

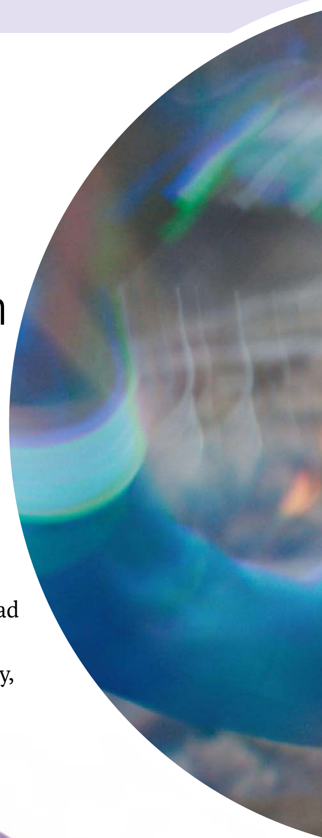
But there is a long way to go for that to happen, she says. The printer would need to work with other tools that surgeons use. Those include imaging technologies and robotic devices used during surgeries. That would take the new device beyond just a "defect-filler," she says. Someday, it could be a "bone printer pen" useful for many types of surgeries.

— *Payal Dhar*



STEVE MCCRACKEN

A handheld 3-D printer might someday print bone grafts directly onto fractures. Researchers prototyped the idea with a modified glue gun. Rabbits treated with the bone grafts healed quickly, with no signs of infection.



ANIMALS

Is it possible to be invisible?

Some animals have real-life ways to be see-through

In *The Incredibles*, Violet Parr is a lot like other teenagers. She has embarrassing parents, a troublesome little brother and a crush so intense it makes her want to disappear. But unlike other teens, Violet can actually vanish when the boy she likes looks her way.

Characters with invisibility powers — like Violet, the Fantastic Four's Invisible Woman and H.G. Wells' Invisible Man — can do all sorts of cool things. Escape embarrassing situations. Snoop on other people. Get into places where they're not allowed. It's no wonder invisibility is one of the powers people most wish for.

Many animals, too, find it helpful to hide in plain sight. And though it's out of reach for people, some animals are nearly transparent.

Being invisible is useful for animals that spend a lot of time in places with no good hiding spots, like the air or open ocean, says Kate Feller. She studies vision and behavior at Union College in Schenectady, N.Y.

The secret to invisibility is all about light. "The way we see things is when light is reflected back off of an object onto our eyes," says Feller. The more light that can pass through something undisturbed, the harder it is to see that thing.

Light can't easily pass through most animals, Feller says. Light that hits our bodies usually gets absorbed or bounced around. But animals with nearly invisible body parts have figured out tricks to get around this.

CUTTING OUT COLOR

A lot of animals get their colors from molecules called pigments. These compounds appear different colors depending on which wavelengths of light they absorb and which they reflect. Green pigments, for instance, reflect green light and absorb all other colors. For an animal to vanish in plain sight, it needs to get rid of these colorful compounds.

Most baby fish lack pigments. This helps them hide from predators when they are too small to swim fast. They typically develop pigments as they grow up. Yet some species stay see-through their whole lives. One is the ghost catfish (*Kryptopterus vitreolus*). Its head has pigments, but its body is almost fully transparent. Seen from far away, it looks like a floating head!

PHOTO 12, CAPITAL PICTURES/ALAMY

Ghost catfish (top) and amphipod crustaceans (bottom) boast see-through body parts.

Some body parts are hard to hide. Eyes need pigments that absorb light so an animal can see. And even clear stomachs will show up if animals eat colorful food. Ghost catfish eat only small bits of food and "hide" their meals in a long, thin, tube-shaped stomach, says Qibin Zhao. This physicist and materials scientist studies ghost catfish at Shanghai Jiao Tong University in China.

Blood can't be transparent, either. The molecules that carry oxygen have colored compounds. So up close, the ghost catfish's vessels are still visible.

STOPPING LIGHT FROM BOUNCING AROUND

Even pigment-free objects are not entirely invisible. Light travels at different speeds through different materials. As a result, light zipping through one material will bend or bounce when it hits another material. Light bouncing off an animal makes it shine, just like the sun reflecting off a puddle.

Some animals' see-through parts are nearly reflection-free. Glasswing butterflies, for instance, have wings that are almost fully transparent. Their wings have fewer reflective scales than other butterflies' wings. The wings are also covered in tiny wax bumps. These bumps soften light's transition from air to tissue, allowing it to pass through the wing mostly undisturbed.

Tiny amphipod crustaceans do a similar thing, says Feller. These animals are so transparent you could read text right through their bodies. Their shells are covered with little round bacteria. These may create a smoother path for light, like the wax bumps on glasswing butterflies.

Even when light makes its way inside the body, an animal isn't necessarily in the clear. Each cell in the body is full of many components that bend light as it passes through. Light then scatters around the body, making things look foggy.

The more tissue that light needs to pass though, the foggier things get, says Zhao. That's why most invisible animals are pretty thin. Ghost catfish are only some 2 to 3 millimeters (about one-tenth of an inch) thin.

NOW YOU SEE ME

In theory, we could draw on some of the same tricks to vanish: Don't let light bounce around in your body. The Invisible Man in H.G. Wells' story was a physicist who studied light refraction. He became invisible by changing how much his body bent light.

But that would be hard for a person — or any land animal — to do in real life. Animals are mostly water, Zhao says. Light doesn't bend that much when passing from water into a sea creature. But going from air into an animal's body, it bends a lot — making invisibility much harder on land.

So, disappearing might sound tempting next time your crush looks your way. But in the real world, you're probably better off just talking to them.

— Sofia Caetano Avritzer

MARIUS DOBILAS, KAN SUKARAKAN/SHUTTERSTOCK

Violet Parr from *The Incredibles* and the Fantastic Four's Invisible Woman vanish with ease. No real humans can pull off this feat — but some animals come close.

SPACE

How the universe grew up

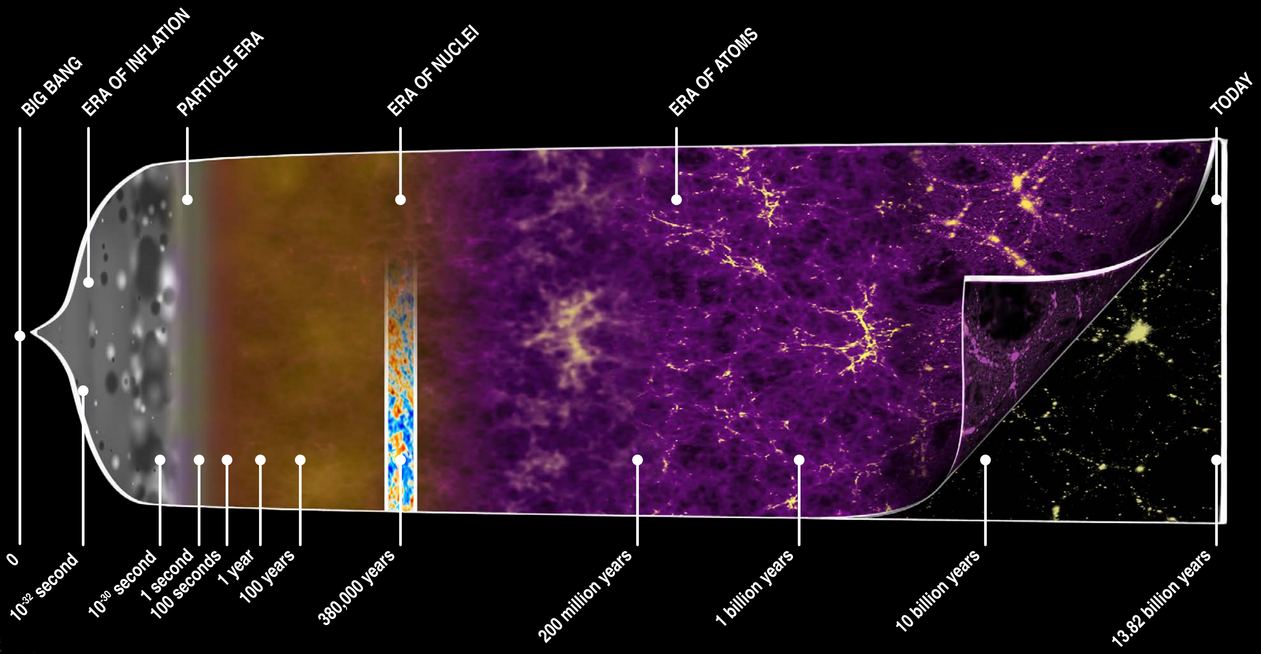
The biggest changes happened in the first second after the Big Bang

When astronomers think about how the universe has evolved, they divide the past into distinct eras. They start with the Big Bang — a gigantic expansion that was the beginning of space, energy and matter.

Ever since that cataclysmic beginning, the universe has gradually changed from being pure energy to existing as different mixes of matter and energy. This timeline lays out some of the most important milestones in that history, starting from 0 as the moment of the Big Bang. (All times are approximations based on energy and temperature.)

— Trisha Muro

TRIFF/SHUTTERSTOCK



ESA AND THE PLANCK COLLABORATION; ADAPTED BY L. STEENBLIK HWANG

0 to 10^{-43} second:
PLANCK ERA
Current physics cannot describe what happened here. To do so, scientists will have to find a law of physics to unify gravity, relativity and quantum mechanics (the behavior of very small things).

10^{-43} to 10^{-35} second:
GRAND UNIFIED THEORY ERA
Gravity becomes a distinct force, separate from everything else.

10^{-35} to 10^{-32} second:
ERA OF INFLATION
The strong nuclear force separates from the remaining two unified forces: the electromagnetic and weak forces. Scientists believe that sparked an intense "inflation" of the universe, in which it grew some 100 million billion billion times bigger.

10^{-32} to 10^{-10} second:
ELECTROWEAK ERA
The weak force separates into its own unique interaction. All four fundamental forces are now in place. Boson particles have emerged as "carriers" for these forces.

10^{-10} to 10^{-3} (or 0.001) second:
PARTICLE ERA
Quarks combine to form elementary particles of matter. However, matter and antimatter are equally abundant. This means that as soon as a particle forms, it gets annihilated by its antimatter opposite.

10^{-3} (0.001) second to 3 minutes:
ERA OF NUCLEOSYNTHESIS
Antimatter becomes exceedingly rare. As a result, matter-antimatter annihilations no longer happen as often, allowing our universe to grow almost entirely from leftover matter. Space continues to stretch and cool, letting heavier particles — like protons, neutrons and electrons — form. Some protons and neutrons fuse into the first atomic nuclei.

3 minutes to 380,000 years:
ERA OF NUCLEI
Atomic nuclei combine with electrons to become hydrogen and helium atoms. This opens up space for light to travel through the universe. (This light is known as the cosmic microwave background. We cannot see anything that existed before it.)

380,000 years to 1 billion years:
ERA OF ATOMS
Stable atoms of hydrogen and helium drifted together due to gravity and heated up. As clumps of atoms grew both bigger and hotter, they sparked fusion in the newly forming centers of stars. Stars fused hydrogen into helium, then heavier elements. Stars also began to attract one another into clusters. Galaxies formed. And as heavier elements became more abundant, planets could also begin to exist.

1 billion years to the present (13.82 billion years):
ERA OF GALAXIES
Today, clumps of galaxies, stars, nebulae and other structures stud the sky.

A NOTE ABOUT NUMBERS

This timeline spans an enormous range of time. Very large and very small numbers take up a lot of space if written out. Instead, scientists express such numbers as they relate to 10. These multiples of 10 appear as tiny numbers to the upper right of a 10. They identify how many decimal places come before or after the 1. A negative exponent means that the number is a decimal. So, 10^{-6} is 0.000001 (6 decimal places to get to the 1) and 10^{6} is 1,000,000 (6 decimal places after the 1).

ANIMALS

Some bats feast on songbirds mid-flight

Migrating birds become a grisly midnight snack for greater noctules

Vampire bats are not the only bats that deserve the title of creepy creature. Another bat species snatches birds out of the air for a gruesome midnight feast.

Songbird DNA has shown up before in the poop of three bat species. So researchers knew these flying mammals ate more than just insects. But how does a bat hunt a bird? It turns out that Europe's largest bat, the greater noctule, can capture, rip apart and eat songbirds mid-flight. Researchers shared these findings in *Science*.

The team equipped greater noctule bats (*Nyctalus lasiopterus*) with biologgers. These devices had multiple sensors. Accelerometers recorded 3-D movement. Magnetometers logged direction. Altimeters measured height in the sky, or altitude. And microphones captured sound.

Listening to the recordings "is like flying with the bats," says Elena Tena. You can hear their wings flap and even frog calls as they fly over marshes. Tena is a bat conservationist at Doñana Biological Station in Seville, Spain. The team captured and tagged bats at Doñana National Park for the study.

Microphones also captured the feeding buzzes bats made as they approached their prey. These buzzes, followed by chewing sounds, indicated a successful hunt.

Most of the 611 hunting events probably involved insects. But in two cases, bats flew above the height of migrating songbirds. One of these was more than 1,200 meters

Greater noctule bats seem to have a taste for songbirds. This one was caught sporting a feather and with blood in its mouth.

JORGE SERENI

LISTEN TO AUDIO HERE!

(nearly 4,000 feet) high. The bats then homed in on a bird and approached with feeding buzzes.

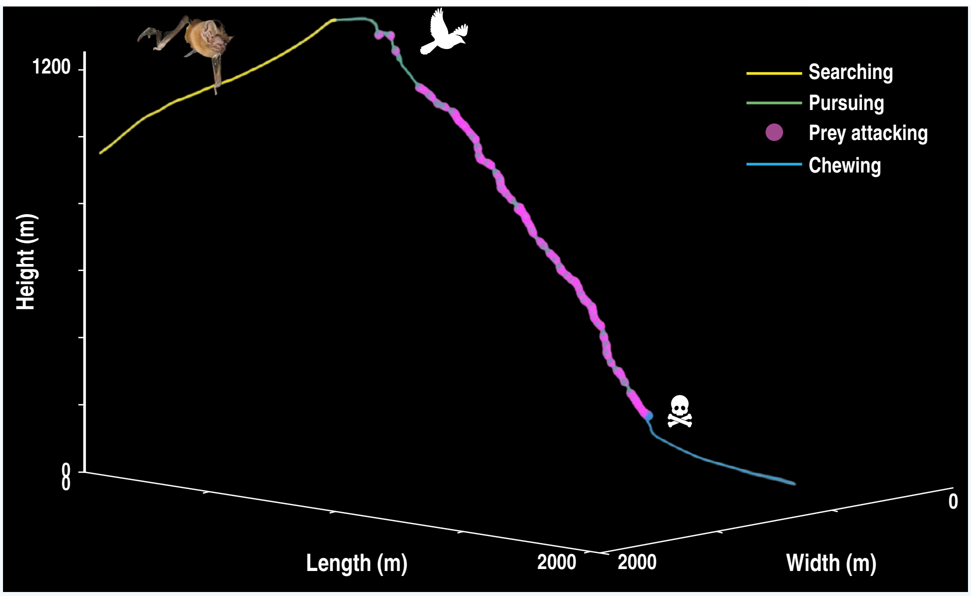
The pitches, or frequencies, of those buzzes are too high for birds to hear. Both birds responded at the last moment. They were likely reacting to the bat's touch or the sound of its wings and seemed to do dives and spirals to escape.

One bird escaped near the ground. The other wasn't so lucky. Microphones captured its distress calls followed by a 23-minute in-flight meal. The bat flew normally while it chewed, Tena says. "Sometimes you could hear that it must be biting bone."

Removing wings seems to be part of the bats' process. "Sometimes, when we were capturing [bats], suddenly, some wings [would] fall to the ground," Tena says. DNA from wounds on the wings confirmed the bite of a greater noctule bat.

"We still know very little about this species," Tena says. Yet this research is a leap forward in understanding the greater noctule's role as one of Europe's top aerial predators.

— *Alison Pearce Stevens*



This graph plots the altitude of a greater noctule bat as it searches for — then attacks — its songbird prey. After a downward sprint of several minutes, the bat finally catches and eats the bird.

DATA DIVE

1. What is altitude? What type of sensor measures movement in this dimension?

2. What is the range of altitudes shown on the graph? How does that compare to the height of migrating songbirds?

3. How does the bat's altitude change as it searches for prey? Why might this be?

4. How does the bat's altitude change as it attacks its prey? Why might this be?

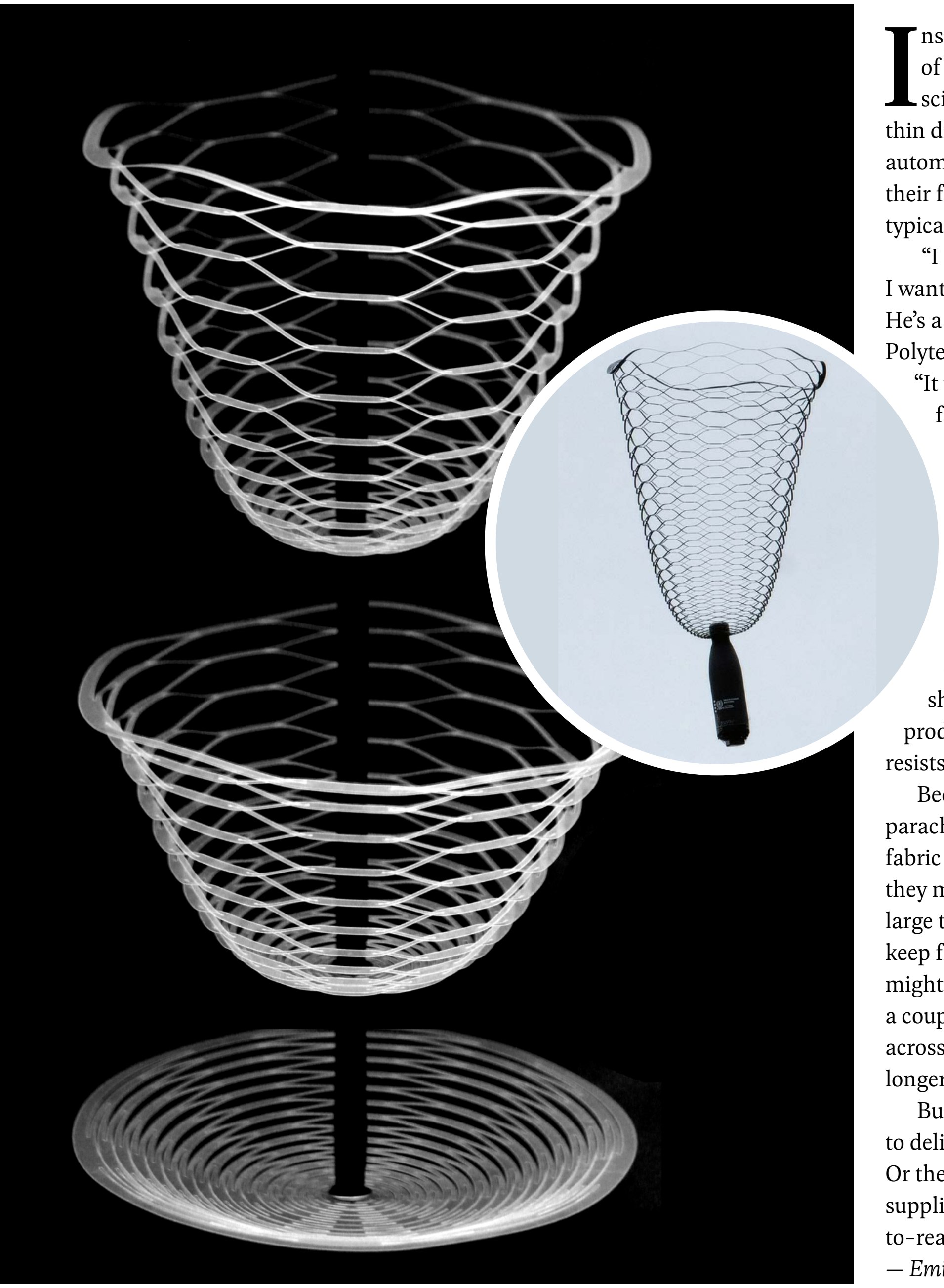
5. What other types of measurements could offer more insight into how bats eat birds mid-flight? How would you graph those data?

LAURA STIDSHOLT

ANSWER

These parachutes unfurl thanks to Japanese paper-cutting techniques

Cleverly cut disks could be useful for package delivery and aid drops



Inspired by the Japanese art of kirigami, or paper cutting, scientists made parachutes from thin disks of plastic. They open automatically when dropped. And their falls are more predictable than typical cloth parachutes.

"I can toss this thing any way I want," says David Mélançon. He's a mechanical engineer at Polytechnique Montreal in Canada. "It will always realign and then fall straight down." His team described the design in *Nature*.

Slits are arranged in a series of rings that extend to the disk's edge. They allow the disk to expand into an elegant netlike vase as its attached cargo falls. Pulled open by the rush of air, the shape slows the payload's fall by producing drag. That's a force that resists an object's motion.

Because they're full of holes, the parachutes produce less drag than fabric parachutes of the same size. So they might not be practical to use for large things. Consider a person. To keep from crash-landing, a human might need a kirigami parachute a couple hundred meters (yards) across, Mélançon suggests. That's longer than two football fields!

But the chutes might be used to deliver packages by drones. Or they could drop food or other supplies from airplanes in hard-to-reach areas.

— Emily Conover

A thin plastic disk with a pattern of cuts unfurls in a wind tunnel into a netlike parachute. A similar parachute was used to gently lower a water bottle dropped from a drone (inset).

DANICK LAMOUREUX; INSET: FRÉDÉRICK GOSSELIN

INSIDE THE MIND OF A YOUNG SCIENTIST

A Thermo Fisher Scientific Junior Innovators Challenge winner answers three questions about his science

Science competitions can be fun and rewarding. But what goes on in the mind of one of these young scientists? Tobias Lam, winner of a first place mathematics award at the 2025 Thermo Fisher Scientific Junior Innovators Challenge, shares his experience.

Q How did you design your project?
A As a longtime piano player, Tobias was fascinated by how music affects focus. To test his curiosity, he set up an online experiment with 65 participants, splitting them into three groups. One group worked in silence, another played video game music, and the last listened to different tones in each ear. This type of sound is called "binaural" beats. It gives the illusion that someone is listening to a pulsing beat.

"When I was researching about what types of music can help our attention spans, binaural beats and video game music were consistently coming up in the search results," Tobias says. "Also, they're two types of music that I hadn't studied in previous projects."

Q What was your favorite part of the project?
A "Once I finally got the results and started to see clear trends," Tobias says. "That was very exciting." Those trends were not statistically significant. That is, he can't completely rule out that they arose from chance. "But this doesn't mean that my experiment was a failure," he says. Instead, it could be a launch point for another investigation.

Q How would you investigate further?
A "If I were to repeat this study, I would probably … give the participants more time to listen to the music," Tobias says. "That would just allow for much clearer trends and stronger results." Musicians also tended to do better on the task, his data showed. That's "really interesting," Tobias says, "and something I could study in the future."

First Place, Mathematics Award

Tobias Lam

Tobias, 14, studied whether listening to certain tones or melodies boosts focus. He hopes his results might help students find better ways to focus while studying. Tobias completed this project as a seventh grader at Long-View Micro School in Austin, Texas.

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