ScienceNews Explores
JUNE/JULY 2026

IS THE MULTIVERSE REAL?
P26

SWAMP SECRETS

The Okefenokee hides a stronghold against climate change

INSECT INVESTIGATION | WORLD'S DEEPEST HOLE | MYSTERIOUS MOONS

3

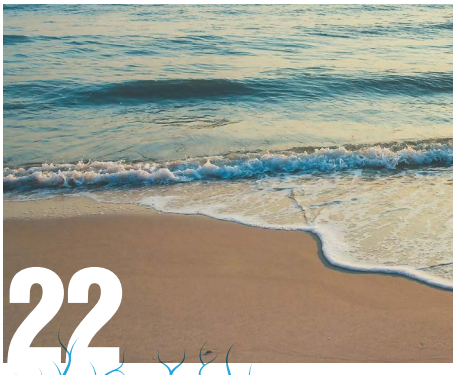
4

6

8

7/32

20



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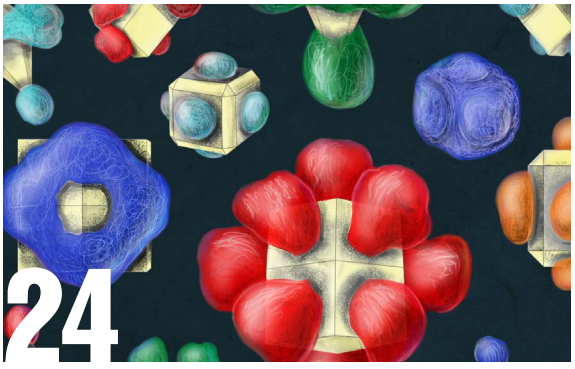

24

26

28

Contents

Science News Explores | June/July 2026 | Vol. 5, No. 6

30

14

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Features

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Q What is the deepest hole on Earth?

— Calvin H.

A In the Russian Arctic near the border with Norway, the deepest hole ever dug by humans hides beneath an iron disc the size of a dinner plate. Though only 23 centimeters (9 inches) in diameter, the Kola Superdeep Borehole is 12,262 meters (40,230 feet) deep. Russian scientists began drilling this hole in 1970 to study Earth's crust. It reached its current depth in 1989, when the drill got stuck. Temperatures at this depth got too hot to use the tools. After several failed attempts to drill farther, the borehole was sealed and abandoned. At about 12.3 kilometers (7.6 miles) deep, the hole didn't get even halfway through Earth's continental crust, which is at least 30 kilometers (20 miles) thick. Nonetheless, the Kola Superdeep Borehole is impressive. By comparison, the deepest natural hole is the Mariana Trench in the Pacific Ocean, which reaches a depth of some 11,000 meters (36,000 feet) below sea level.

Q Why does nobody care about tau, yet they care about pi?

— Jennah N.

A Tau (τ) is the ratio between a circle's circumference and its radius, or roughly 6.28. That makes it twice the value of pi (π) — the ratio between a circle's circumference and its diameter — about 3.14. "It's a historical accident" that pi is more famous than tau, says Daniel Sage. He's a mathematician at the University at Buffalo in New York. Ancient Babylonians and Egyptians used approximations of pi to calculate the areas of circles thousands of years ago. A famous mathematician, Leonhard Euler, popularized the symbol π for pi in the 18th century. And now some people celebrate Pi Day, March 14, by eating pies. But some argue that using tau instead of pi would make certain math formulas simpler and easier to understand. Such tau enthusiasts celebrate Tau Day on June 28. "I think tau is actually more natural" to use than pi, Sage says. But is it worth changing the standard constant people use for calculations about circles after thousands of years? "Oh god, no," he says. Plus, there's no specific baked good to eat on Tau Day.

Q Why is rabies so deadly?

— Samrudh A.

A The rabies virus is deadly because "it basically hides from the immune system," says Sebastian Stockmaier. He's a disease ecologist at the University of Tennessee in Knoxville. The virus spreads through the saliva of an infected animal. After entering the body through a bite or scratch, the virus takes weeks or months to travel along nerves to the spinal cord and brain. The human body often stops immune cells, which fight off viruses, from attacking nerve cells, allowing the rabies virus to avoid detection. The virus also suppresses the body's ability to fight infections. Once it reaches the brain, rabies is almost always fatal. Those infected often die from seizures, coma, paralysis or exhaustion. But rabies is a preventable disease, notes Stockmaier. Vaccinating pets remains one of the best methods of prevention. It's also important to avoid handling wildlife. And if a person has been scratched or bitten by an animal, they should receive a vaccine immediately to prevent the virus from reaching the brain.

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

BRAIN

Adolescence lasts way beyond the teen years

Our brains don't reach adulthood until after age 30, suggests a new study

Society usually describes adulthood as starting at around 18 to 21. Most people may appear fully adult by then. But what isn't visible from the outside are the many rewiring changes underway in our brains. And the brain doesn't reach its adult form until much later, a new study shows — around age 32.

Neuroscientists Alexa Mousley and Duncan Astle led the research. Both work at the University of Cambridge in England. Their team studied brain scans from more than 4,000 people. They ranged in age from birth to 90. In poring over those scans, the researchers identified when and how the brain rewires its neural circuits.

Such rewiring reflects "changes in the way brain regions communicate with each other," says Lucina Uddin. A cognitive neuroscientist at the University of California, Los Angeles, Uddin did not take part in the new work. The timing of the changes, she notes, seems to "accompany major life-stage transitions." These tended to occur around ages 9, 32, 66 and 83.

The human brain contains some 86 billion neurons. That number doesn't change much over our lifespan, but how the cells connect and "talk" to each other does. Unused connections get "pruned" or wither away. New ones can form, and useful ones grow stronger.

Scientists already knew about these kinds of changes. The new study shows that they seem to take place in particular stages.

Five eras — or phases — of brain development emerged from the analysis. Each spanned a time during which the brain reorganizes in specific ways.

The first era runs from birth until around age 9. A baby's brain has lots of connections, and many get pruned away as the child grows.

The next phase — adolescence — kicks off around age 9 and continues to about 32. Now, the brain begins to change in ways that help different regions communicate better. The findings appeared in *Nature Communications*.

The brain's efficiency is boosted by having lots of short paths, Mousley explained in a statement issued by the University of Cambridge. "The adolescent era is the only one in which this efficiency is increasing." Those increases continue on into the early 30s — much longer than scientists had realized.

Brain connections largely stabilize between ages 32 and 66. This is the adulthood era. It's followed by two more phases, early aging — until age 83 — and late aging. Those last two were a bit of a surprise. Scientists had thought the brain's structure stayed roughly unchanged after early adulthood. During the aging eras, connections weaken, and people's brains lose efficiency.

SURFSUP/SHUTTERSTOCK

Life stages — such as childhood, adolescence and adulthood — have often been defined based on changes in outward appearance. But what changes inside our heads may offer a new way to define when we start and stop being an adolescent.

What does this mean for teens? Researchers, politicians, media and others "have been talking about how people reach adulthood later than they used to," says Hillary Schwarb. This cognitive neuroscientist works at the University of Nebraska – Lincoln. This study, while important, only looks at brain connections. What it doesn't do, she cautions, is "explain how thinking or behavior changes" over our lifespan.

So when it comes to how the brain functions, she says, there's still much to learn.

— ALISON PEARCE STEVENS

A chemical in onion juice triggers tears when chopping this root vegetable. Changing how the onion is chopped can avoid eye irritation.

PHYSICS

A hack for cutting onions without crying

Slow, steady cuts keep the tears away

Crying over chopped onions could be a thing of the past. Slicing with sharper and slower cuts can eliminate those painful tears, a new study finds.

A chemical formed from onion juice (propanethial S-oxide) triggers those tears. Slicing the onion ruptures cells, triggering a chemical reaction that forms this compound. Chopping flings tiny droplets of it into the air. If they bind to sensory nerves in the eye, they'll cause stinging and tears.

But slow slicing with a sharpened knife leads to fewer tear-inducing droplets. This technique could offer relief to everyday cooks — and help explain how pathogens spread.

The researchers shared their findings in *Proceedings of the National Academy of Sciences*.

To investigate, physicist Navid Hooshanginejad lugged a 4.5-kilogram (10-pound) bag of onions to his former lab at Cornell University in Ithaca, N.Y. He now works at SharkNinja, a product-design company in Needham, Mass.

His team wanted to find out what about the cutting action determines how onion-juice droplets fly. They built a miniature guillotine, which used blades of varying sharpness. Sensors then measured the force and speed of each cut. A high-speed camera captured the spray of droplets.

Fluid-containing cells sit in each layer of an onion's skin. Slicing opens these cells. Released juices then pool and press against the onion's skin. This pressure sends juices flying once the blade breaks that skin.

Blunt blades require more force to break an onion's skin. That extra force squashes more cells and releases more fluid. Rapid cuts from dull knives can shoot droplets at speeds of nearly 40 meters per second, they found. That's almost 90 miles per hour!

Slow, steady chopping with a sharp blade, however, kept droplets from reaching eye level, Hooshanginejad reports.

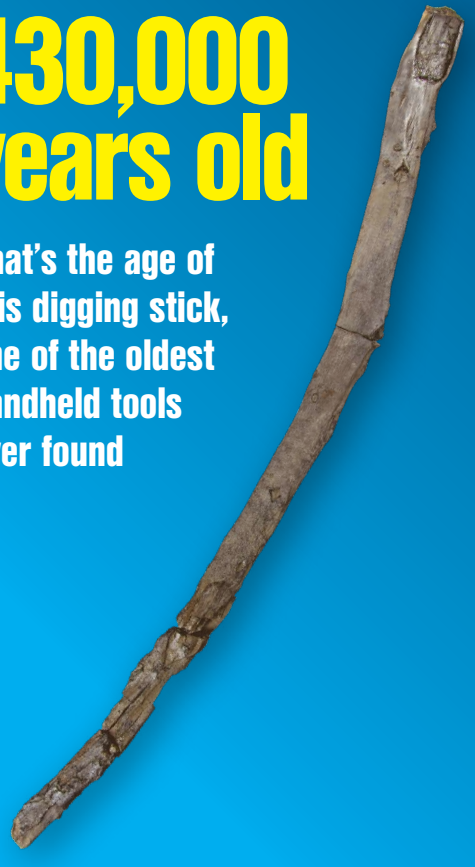
The team's videos show how droplets break apart and travel in the air. Says Hooshanginejad, their findings may help scientists better understand how infectious microbes disperse through the air.

— CARLY KAY

ARCHAEOLOGY

430,000 years old

That's the age of this digging stick, one of the oldest handheld tools ever found



Source: A. Milks et al/Proceedings of the National Academy of Sciences *2026*

KATERINA HARVATI AND DIMITRIS MICHAILIDIS; SUTEREN STUDIO/SHUTTERSTOCK

PLANTS

This flower smells like wounded ants to attract flies

Japanese dogbane uses this perfume to attract pollinators

A Japanese flower lures in pollinators with a strange perfume, new research finds. The odor belongs to *Vincetoxicum nakaianum*, or Japanese dogbane.

Botanist Ko Mochizuki of the University of Tokyo in Japan noticed clouds of grass flies hovering around the plant's flowers. The plant's scent, he found, matches signals released by injured ants. The smell dupes the flies — which feed on dead ants — into visiting the blooms. Once there, the flies pollinate the plants. Mochizuki described his finding in *Current Biology*.

Mochizuki first noticed the grass flies at the Koishikawa Botanical Gardens in Tokyo, Japan. The species might not hunt their own prey, he realized. Instead, they might steal food from other predators. This behavior is called kleptoparasitism.

Grass flies swarming around a flower is "really weird and rare," Mochizuki notes. He suspected the flowers had tricked the flies by smelling like injured insects. When the flies land on the flower, they expect to swipe a snack. Instead, they end up pollinating the plant.

Other plants do this, too. Flowers of the parachute plant (*Ceropegia sandersonii*) smell like wounded honeybees. And smearworts (*Aristolochia rotunda*) mimic the odor of injured plant bugs.

Mochizuki tested his hypothesis a few ways. First, he confirmed that pollen-carrying grass flies visited dogbane in the wild. That showed that in nature, the flies behaved the same way as they did in botanical gardens.

He also tested the flowers' scented chemicals, which matched the mix released by injured ants. The grass flies also showed interest in these chemicals. That suggested they could be after ants, not the flower.

In a final experiment, Mochizuki put the flies in a maze with ants killed by spiders. The flies found the ants, proving that they can hunt by scent alone. Dogbane flowers seem to take advantage of that skill.

Mochizuki now wants to study how other related plant species might evolve "such weird mimicry systems." Other plants that lure in kleptoparasites have trap-shaped flowers. In contrast, dogbane blooms look rather plain.

It seems that flowers with weird shapes aren't the only ones that can play tricks, he concludes.

— *Rohini Subrahmanyam*

Japanese dogbane flowers emit the aroma of attacked ants. This scent tricks grass flies into visiting the plants and pollinating them (inset).

K. MOCHIZUKI

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

The Europa Clipper spacecraft (seen here in an artist's illustration) will reach Jupiter in April 2030. This is one of several existing and planned missions to explore moons within our solar system and search for signs of alien life.

JPL-CALTECH/NASA

Fly Me to the Moons

Our solar system holds so many wondrous moons — just a spaceship ride away

BY **STEPHEN ORNES**

More than 20 years ago, a spaceship from Earth reached Saturn. Called Cassini, its voyage took seven long years. For the next 13 years, it circled the planet, taking pictures and collecting data. Those images showed details of the planet's many moons. Cassini even discovered seven new ones.

Dragonfly is a planned mission to Titan, a moon of Saturn. It will send a robocopter down to fly just above the moon's surface. This is an artist's vision of what that vehicle will look like.

On Christmas Day 2004, Cassini sent a smaller ship — called a probe — to explore Titan, Saturn's largest moon. This craft parachuted through Titan's hazy atmosphere, collecting data to send back to Earth. It recorded the temperature of the air and the speed of the winds. It took pictures of the moon's surface. Later, it analyzed the hard stuff that it landed on.

From above, Titan looks much like Earth. It has a thick atmosphere with clouds and smog. "It's the only icy moon with an atmosphere," notes Elizabeth Turtle. A planetary geologist who studies such distant worlds, she works at the Johns Hopkins Applied Physics Laboratory in Laurel, Md.

Wind whips across Titan's solid surface. Dunes — some of the tallest in the solar system — rise from big deserts near its equator. Rain falls from the sky. Riverbeds streak across the surface and empty into lakes and giant oceans. It's the only place in the solar system besides Earth where scientists have found flowing liquids.

Yet it's also very alien.

Less than half Earth's size, Titan has a surface temperature around −179° Celsius (−290° Fahrenheit). There's no detectable oxygen in the atmosphere. Someone walking on Titan would freeze to death if they didn't suffocate first.

What appears to be a rocky surface is solid ice. The stuff that flows through its rivers is not water but methane and ethane. On Earth, these chemical hydrocarbons exist as gases. But because Titan's so cold, they're liquid here.

And those large dunes? They're not sand. They're grains of hydrocarbons frozen in ice. They look more like coffee grounds or soot. Also unlike Earth, Titan probably has a liquid water ocean beneath its icy crust.

Titan is similar enough to Earth that scientists already have plans to return and explore more. In 2028, NASA plans to send a robocopter, called Dragonfly. This giant drone will hover and skitter over Titan's surface as scientists seek a better understanding of the super-frigid world and look for signs of alien life.

Our solar system is full of such strange and surprising worlds. Humans have explored few of them. Planets get plenty of attention in schools and news articles. Earth's moon does, too. But not these distant celestial satellites.

Scientists will be taking a closer look at many of our solar system's moons in coming years. And there are plenty to choose from.

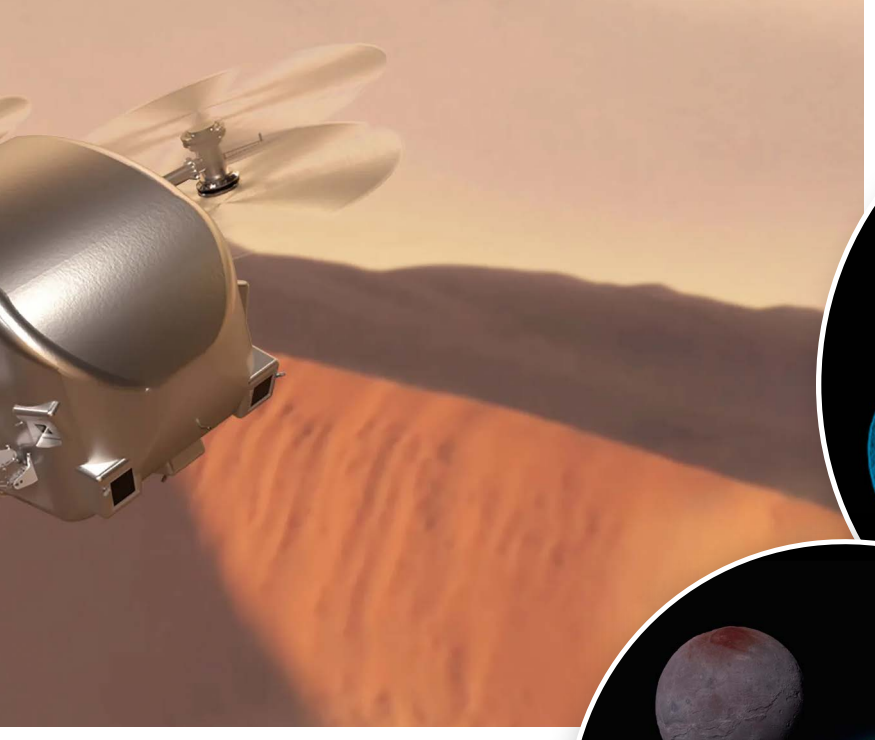
SO MANY MOONS

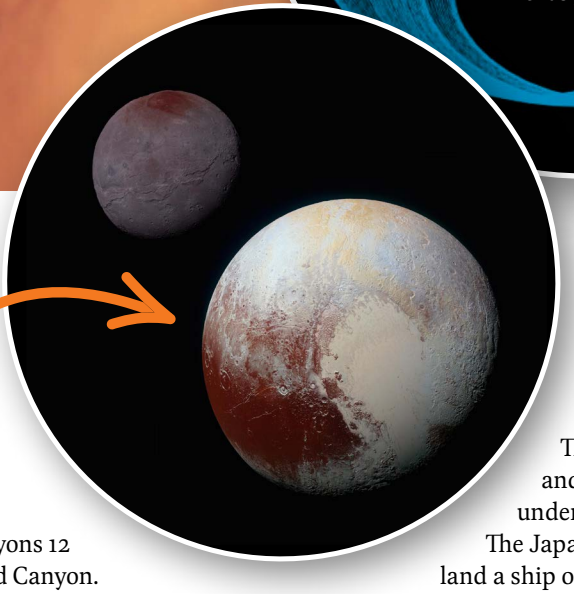
According to NASA, 421 moons have officially been recognized throughout our solar system as of March 25, 2025. But that only includes moons around the major planets and Pluto. Astronomers have identified more than 470 moons orbiting asteroids and "dwarf" planets.

Mars has two moons. Astronomers have spotted and named 274 moons around Saturn. Jupiter has 95 — but those are only the ones with names. *Thousands* of smaller space rocks also orbit it. Neptune has 16

These three pictures show Saturn's biggest moon, Titan. The images are mosaics, made from many pictures taken by the Cassini spacecraft in 2005 and 2006. Titan has seas, coastlines and mountains like Earth, but its chemistry is very different.

UNIV. OF ARIZONA/JPL/NASA; STEVE GRIBBEN/JOHNS HOPKINS APL/NASA





Pluto and its moon Charon may have met with a "kiss," briefly colliding before settling into their current positions.

known moons, and Uranus has 28. One of them, Miranda, is only one-seventh as large as Earth's moon but has canyons 12 times as deep as the Grand Canyon. Because the biggest is so deep and Miranda's gravity is so weak, a rock thrown from the canyon's top would take 10 minutes to reach the bottom.

The dwarf planet Pluto hosts five moons. Charon, its largest, is about half Pluto's size. Charon has long been a mystery. Scientists think most moons began as big space rocks that either collided with a planet or were captured by its gravity. Some moons, like Jupiter's four biggest, may have formed from the gas and dust left over from the planet's formation. But Charon is too big to fit those origin stories.

In January 2025, astronomers presented evidence for a new idea. They think Charon and Pluto came together when the two worlds "kissed" — that is, collided but didn't break apart. Over time, the bodies drifted apart. Then they settled into a linked pair as host and moon.

Venus has no moons, but it does have Zoozve. This asteroid serves as a quasi-moon. It appears to orbit Venus, but its orbit is unstable. One day, the gravity of Venus and the sun will fling Zoozve out into deep space. Earth has quasi-moons, too. There are seven known asteroids that orbit the sun but from one vantage point seem to orbit Earth.

Once asteroid 2002VE68 was trapped by the gravity of Venus, it began orbiting the planet in an irregular pattern (inset above). Zoozve is not a true moon but only a temporary orbiter.

SOUTHWEST RESEARCH INSTITUTE/JOHNS HOPKINS APL/NASA; PHOENIX7777/ORIZONS SYSTEM/JPL/NASA

WHY REACH FOR THESE MOONS?

Dragonfly isn't the only upcoming mission that will visit a far-flung moon. The European Space Agency and NASA both have missions underway to study Jupiter's moons. The Japanese Space Agency plans to land a ship on the Martian moon Phobos and then have it bring back samples.

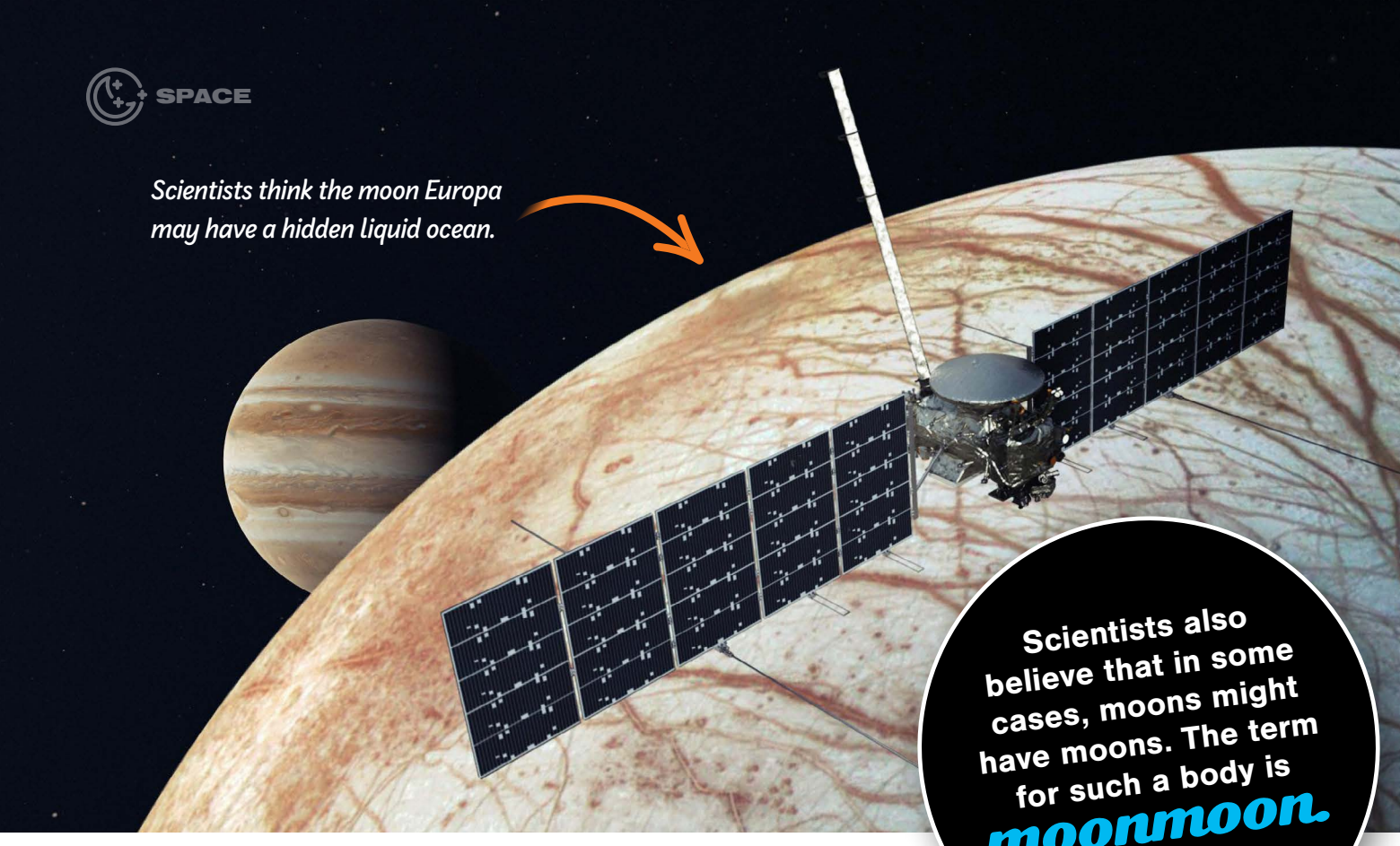
Scientists hope these missions will help us get to know our solar system better. Moons may contain rock or ice, or a mixture of both. Some may have liquid water or liquid methane. On some moons, plumes blast water vapor hundreds or thousands of miles into space.

Others are explosive — like Io, a volcanic moon of Jupiter. Or they can be quiet and dark. Two of Pluto's moons look like giant footballs spinning in space. Some look round, others lumpy. In studying this variety of worlds, scientists hope to answer big questions, such as how these worlds and their parent planets formed in the first place.

But there's another question behind all this exploration: Are we alone in the cosmos? Indeed, if life does exist elsewhere in the universe, these moons may be the best, nearest places to find it.

JUPITER AND BEYOND

The planets beyond Mars are larger and farther from the pull of the sun. Moon formation gets more complicated in the hinterlands. Many of Jupiter's larger moons, such as Europa, probably formed from the big disk of dust and debris that was left after the



Scientists also believe that in some cases, moons might have moons. The term for such a body is *moonmoon*.

gas giant formed. Jupiter has so many moons that it looks like a mini solar system.

The last century or so has brought in a flood of new data on moons, especially for the moons of Jupiter and Saturn.

"They've gone from lights in the sky to real, working, geologic worlds," says Diana Blaney. She's an astronomer at NASA's Jet Propulsion Laboratory (JPL) near Pasadena, Calif. (Astronomers are reluctant to identify any one moon as their fave. But Blaney admits, "Europa and the Galilean system have always been close to my heart.")

In the early 1970s, NASA sent two missions to the outer planets. Called Pioneer 10 and 11, they sent back photos of Jupiter and blurry pics of its big moons. In the late 1970s, the Voyager 1 and 2 spacecraft sent back even better images. One standout was Jupiter's moon Europa. These pictures revealed a white world crisscrossed with reddish streaks. Astronomers compared it to a broken eggshell.

Scientists now suspect those patterns have an exciting origin. Europa may have a liquid ocean beneath its icy crust. Cracks in the crust let water rise and freeze. Like a Zamboni machine at an ice rink, the moon may refresh its surface with liquid water. Those processes might make it possible to host life on this moon.

More missions followed. In 1989, the Galileo mission returned to orbit Jupiter and its big moons. Cassini launched in 1997. Both missions had dramatic finales when they ran out of fuel. Galileo crashed into the thick atmosphere of Jupiter. Cassini plunged into Saturn. This was intentional. If they'd accidentally crashed onto a moon, they might have contaminated it.

In April 2023, the European Space Agency launched a spaceship toward the moons of Jupiter. It's due to arrive in 2031. And in October 2024, NASA launched a ship called the Europa Clipper. Starting in 2030, it will make nearly 50 flybys of Europa.

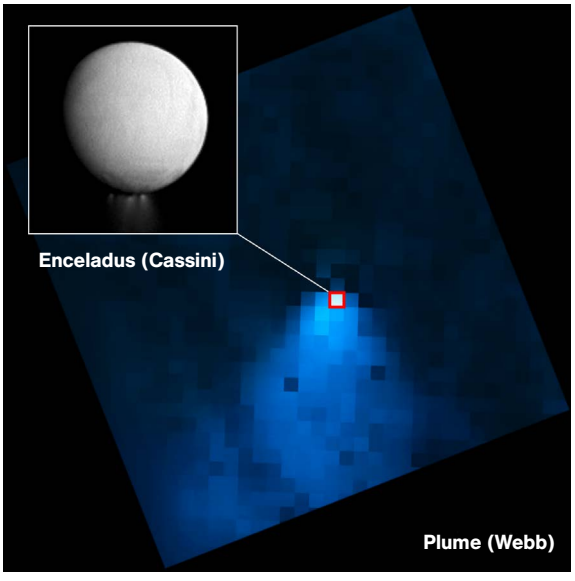
Clipper isn't designed to look for aliens. It will, however, study whether conditions on Europa could support some form of life.

Studying moons "changes our perspective on what makes a habitable world," explains Lynnae Quick. She's a planetary geophysicist working for NASA at the Goddard Space Flight Center in Greenbelt, Md. While Europa is her favorite moon, she's interested in others. She's an expert on cryovolcanoes. They blast out gases and chemicals, not just melted rock. She's got a hand in planning the Dragonfly mission to Titan, too.

Every time humans explore some place new with better instruments, "we have surprised ourselves," says Blaney, who helped design some of Clipper's devices. "I think we're going to get there and be really surprised at what we see. We're going to have to rethink a lot of what we think is going on."

Europa, one of Jupiter's moons, has an icy surface crisscrossed with long lines (shown above in an illustration). The Europa Clipper (shown in front) launched in October 2024 to study this moon and the potential ocean beneath its surface.

JPL-CALTECH/NASA



The Cassini orbiter first spotted plumes of water spewing from Enceladus (inset) in 2005. In 2023, the James Webb Space Telescope spotted a plume extending more than 9,600 kilometers (6,000 miles) from the moon's surface and feeding Saturn's outermost ring.

NASA, ESA, CSA, GERONIMO VILLANUEVA (NASA-GSFC); IMAGE PROCESSING: ALYSSA PAGAN (STSCI); NEON SQUID

CREATING ALIEN MOONS IN THE LAB

The study of distant moons combines many scientific areas. One of those is planetary science. Researchers in this field want to understand how these moons form and change. The extreme gravity and radiation around Jupiter have shaped its moons.

On Io, which orbits closest to Jupiter, those forces smash the moon's rocky layers together. These melt and form magma. It bursts through the surface in more than 400 known volcanoes. The hot liquid rock reaches 1,000 °C (1,832 °F).

Astrobiologists are also interested in these moons. These scientists study how life might arise outside Earth. Among them is Osama Alian (pronounced "alien"). He studies habitability and the origins of life at JPL. He won't admit to having a favorite moon. He doesn't want to be biased, he says.

"But I am partial to Enceladus because its plumes are cool," he says.

Enceladus orbits Saturn. It's tiny — only about 1/25 the size of Earth. But it shoots up big plumes. In 2008, the Cassini mission flew through one of these plumes and detected water, ice and organic particles. An organic material contains carbon. Those are exciting because on Earth, every living thing contains carbon. "Complex carbon molecules don't happen very easily on their own," Alian says. "So any organics that we detect would be super exciting to analyze."

In 2023, images from the James Webb Space Telescope showed that these plumes can reach 9,700 kilometers (6,000 miles). That's nearly 20 times the width of the moon itself.

After studying biology in college, Alian became interested in planets. Astrobiology brought these two interests together. Now, he works in a lab studying hydrothermal vents. These are cracks in Earth's ocean floor that release plumes of hot water. Unusual forms of life thrive there. Some biologists think life began in hydrothermal vents.

Alian is currently designing an experiment that will act like a hydrothermal vent, but in the lab. Using it, he and other scientists can adjust conditions — like minerals, temperature and composition of the water — to see how these can affect living things.

Earth's vents support life. Hydrothermal vents may exist on other worlds, too. The Cassini mission found evidence that similar vents may churn on the floor of the underground ocean on Enceladus. Missions to Mars have turned up chemicals seen at vents, too. And maybe Europa, orbiting Jupiter, has plumes where minerals, water and heat mix.

Scientists can't wait to see what the missions and telescopes of today and tomorrow reveal about the exotic moons in our solar system. They can help answer questions about the many ways that worlds form. They may also point to how life begins. Titan, for instance — the moon that looks so similar to, yet so different from, Earth — may host conditions similar to Earth just before life emerged.

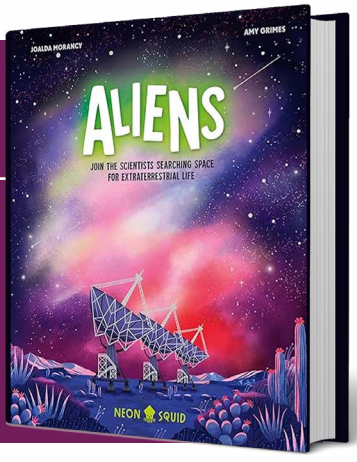
"If we see this thing on Earth, you can't help but wonder," Alian says. "It has to be happening elsewhere."

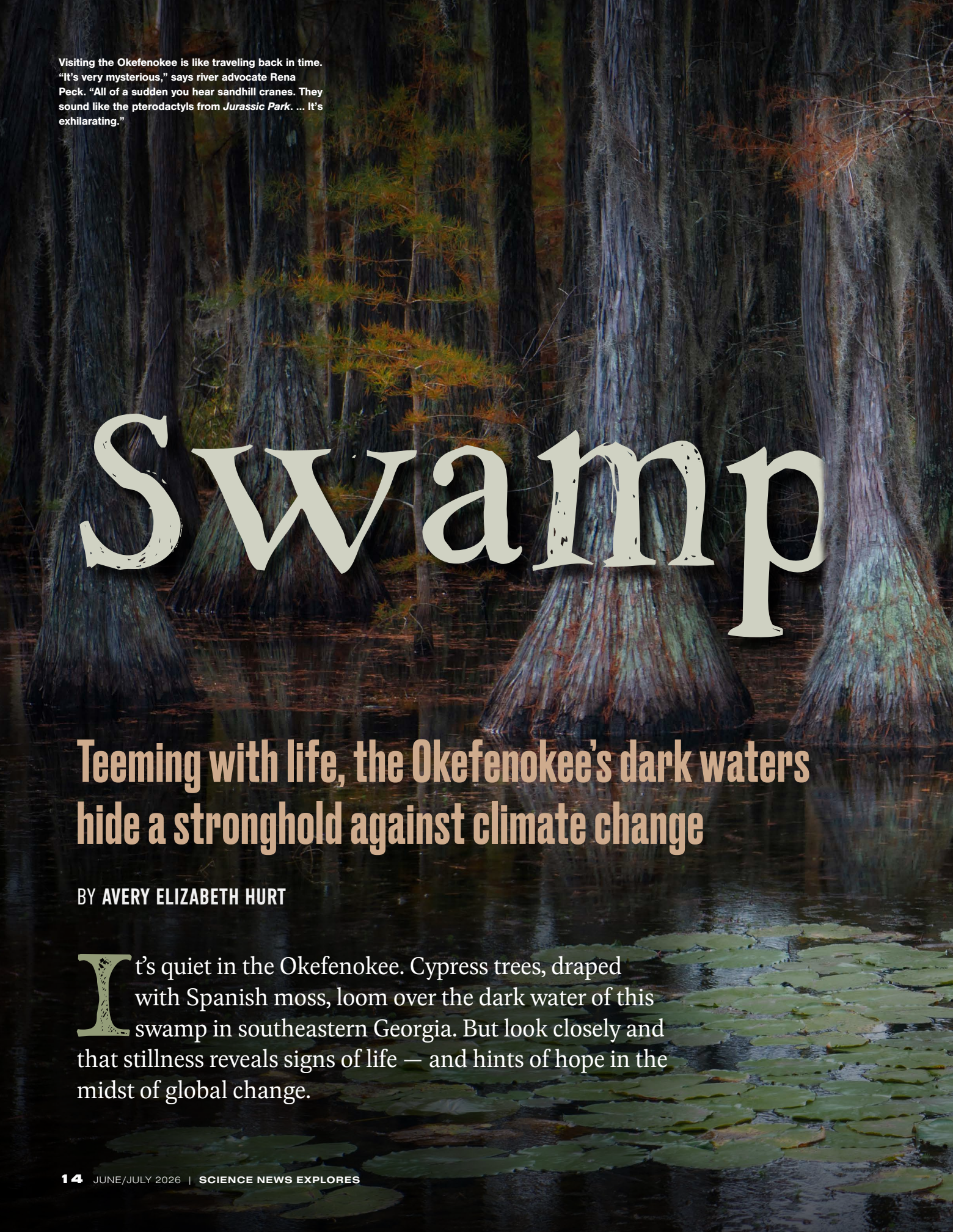
READ MORE

Aliens:
Join the Scientists Searching Space for Extraterrestrial Life

By Joalda Morancy
Illustrated by Amy Grimes

Aliens in science fiction seem like mythical creatures, but the search for extraterrestrial life is very real. With this book, learn more about where scientists are looking for signs of life and what futuristic tools make these missions possible.





Visiting the Okefenokee is like traveling back in time. "It's very mysterious," says river advocate Rena Peck. "All of a sudden you hear sandhill cranes. They sound like the pterodactyls from *Jurassic Park*. ... It's exhilarating."

Swamp

Teeming with life, the Okefenokee's dark waters hide a stronghold against climate change

BY **AVERY ELIZABETH HURT**

It's quiet in the Okefenokee. Cypress trees, draped with Spanish moss, loom over the dark water of this swamp in southeastern Georgia. But look closely and that stillness reveals signs of life — and hints of hope in the midst of global change.

Secrets

SHUTTERJACK/ROOM/GETTY IMAGES

A black bear wanders the edge of the swamp looking for berries. An alligator sunning on a log slips into the water as a boat approaches. A great blue heron swoops overhead while, beneath the surface, a black-banded darter flips its fins and glides silently away.

At night, animals join in a multi-species chorus. The swamp rings with the trills and buzzes of tree frogs and the bass croak of bullfrogs. Nearby, a barred owl calls. Suddenly, something shrieks in the dark. You can't see it. But who could mistake the otherworldly cry of a bobcat? This is life in the Okefenokee. And there's an abundance of it.

Part land, part water, the Okefenokee Swamp formed long ago. Its area was once covered by the ocean. Then the seas receded. This left a ridge, with the sea on one side and a shallow freshwater ecosystem on the other. That freshwater became the Okefenokee. Today, this swamp is thriving. And what's hidden beneath its dark waters may be crucial for saving life elsewhere — if the swamp can survive the threats it faces.

BENEATH THE SURFACE

The surface here is more water than ground. And that small amount of ground can be wet and wobbly. That's how the swamp got its name. Okefenokee is a Muscogee word. It means "land of trembling earth." (The Muscogee are an Indigenous people from this area.)

If you paddle through the Okefenokee, you'll notice that its water is black and shiny. It reflects an upside-down version of the swamp, as if it's looking at itself in a mirror. The water is so dark because the Okefenokee is a unique type of ecosystem — a peatland swamp.

Peat is a thick layer of partly decomposed plants. And that peat does more than stain the water.

As they grow, plants absorb carbon dioxide from the atmosphere. Carbon from the gas will be used to make plant tissues. Later, when these plants die and break down, that carbon will be released back into the air. At least that's how it usually works.

But the Okefenokee has a lot of slow-moving water below the surface of its soil. Still waters hold less dissolved oxygen than flowing water. Less oxygen supports fewer of the bacteria that break down plants and other organic matter. So when plants in the Okefenokee die, they build up into thick layers of peat.

This peat stores the plants' carbon rather than releasing it into the

Learn more about the Muscogee

Lily pads can be seen throughout the swamp.

The Okefenokee is a peatland swamp. Peat is made of partly decomposed plants. This material stains the water almost black, yet the surface is still very reflective.

JOE COOK; ED RESCHKE/STONE/GETTY IMAGES PLUS

Some 15,000 alligators call the Okefenokee home. Research has found high levels of toxic mercury in these predators, a sign that other animals may be at risk as well.

The hooded pitcher plant, which eats ants and flying insects, is one of 18 types of carnivorous plants that live in the Okefenokee.

atmosphere. Places where carbon is stored, or sequestered, in this way are called carbon "sinks."

And the Okefenokee is a *huge* carbon sink. There's an estimated 124 million metric tons of carbon tucked away here. That's roughly as much as 27 million gas-burning cars would release in a year.

Keeping carbon out of the atmosphere helps limit global warming. When it comes to protecting the climate, the Okefenokee "punches above its weight," says Kemen Austin. She works at the Nature Conservancy in Brunswick, Ga.

She was part of a team that studied carbon in peatlands. Earth's peatlands store more carbon than all of the planet's forests combined. Austin's team reported this in 2025 in *Conservation Letters*.

The Okefenokee stores more than carbon in its peat, adds biologist Sara Aicher. She recently retired from the U.S. Fish and Wildlife Service, where she spent her career studying this swamp.

Its peat layers also record what the past climate and vegetation were like. By reading these layers, researchers can learn how conditions have changed over the past 7,500 years and how the swamp responded. Over time, Aicher says, areas that once were open marsh turned shrubby. Some filled in with forest. Charcoal layers in the peat point to when fire shaped this habitat.

All that peat also acts like a giant sponge. It quickly soaks up rainwater. Then, during dry spells, it releases moisture slowly. Regulating water like this reduces the harms of both floods and droughts.

By studying its peat, scientists are learning what makes this swamp habitat resilient — and how it responds to danger. It also offers clues about how other parts of the planet may react to changing conditions such as increased heat, floods and droughts.

THREATENED BY NEIGHBORS?

The Okefenokee has faced many threats throughout its history. More than a century ago, companies built railroads through the swamp, for instance. That made it easier for them to harvest cypress trees.

But many people who cared about the swamp formed groups that tried to save it. In 1929, one group, the Georgia Society of Naturalists, began working to protect the swamp. Other organizations and citizens joined the cause. Together, their work paid off.

In 1937, the U.S. government purchased the land. Then-president Franklin Roosevelt designated the area a National Wildlife Refuge. There would be no more logging, no more attempts to drain the swamp. Today, the refuge spreads over 164,565 hectares (635 square miles) of land in southeast Georgia. That's more than twice the land area of New York City.

Still, the Okefenokee is not completely safe. Activities outside the refuge can harm the protected area.

For instance, in 2019, a mining company announced plans to dig a titanium mine on a huge sand dune that borders the swamp. Called Trail

ARTRISE STOCKER, EVGEN 1234/SHUTTERSTOCK

Ridge, it's left over from when the ocean retreated thousands of years ago. The dune acts as a natural dam that keeps water inside the Okefenokee's shallow basin.

There are other titanium mines on Trail Ridge. But this one would be very close to the swamp. Scientists worried the mine could pull groundwater out of the swamp, explains Ashby Worley. She works at the Nature Conservancy in Brunswick, Ga. There, she specializes in coastal climate adaptation. Water is key to swamp ecosystems, she notes. It also helps moderate fires.

And losing water won't just affect a swamp itself. Dropping water levels could expose some of its peat, Aicher explains. Exposed to air, peat starts to break down. Suddenly, all its stored carbon would get released into the air.

Or as Rena Peck puts it: "That carbon sink would become a carbon bomb." An ecologist, Peck is executive director of Georgia Rivers. This organization works to protect these waters.

Peat has been building up in the Okefenokee for thousands of years, Peck explains. "It's up to 15 feet [4.6 meters] deep at its deepest point. It takes 50 years to build just one inch [2.5 centimeters] of it. So just think, if it was wiped away, how long it would take to get back." If you do the math, that's 9,000 years. So if mining came too close to the swamp, some 9,000 years of carbon-storing peat could be destroyed in just a few years.

Fortunately, the Okefenokee was saved again. A group called the Conservation Fund stepped in. It bought the land on Trail Ridge to keep it from being mined. But the threat is not totally gone. Some areas of Trail Ridge are still vulnerable. Conservation groups are keeping an eye on these, says Worley. "We're trying to figure out what our next step is on how to protect the rest of Trail Ridge."

In January 2025, after getting input from the public, government officials, tribal leaders and environmental groups, the U.S. Fish and Wildlife Service expanded the protected area; it added 22,000 acres to the refuge.

Jon Ossoff is a Georgia senator. He has worked to further expand the protected area to give more buffer to Trail Ridge. Last May, he also got the U.S. government to promise it would not sell the Okefenokee.

POISON IN THE WATER

Mining poses the most urgent threat to the swamp, but it's not the only one. The swamp's gators hold secrets about another.

The American alligator is probably the swamp's most famous resident. Around 15,000 call the Okefenokee home.

Kristen Zemaitis is an ecologist and reptile expert. She studied the swamp's gators when she was at the University of Georgia's School of Ecology in Athens. (Zemaitis now works with the Caretta Research Project, an organization that studies and protects sea turtles.)

For her research, Zemaitis analyzed blood from more than 100 alligators. She was looking for mercury. This metal is toxic to nerve tissue. Mercury poisoning can cause muscle weakness and difficulty walking and moving. In people, it can lead to trouble seeing, hearing or speaking.

Other researchers had found high mercury levels in small animals in the swamp. But no one had looked for mercury in alligators.

A team of scientists collected tissue samples from this alligator to measure mercury in its body.

The red-cockaded woodpecker is one of several threatened or endangered species that can be found in the Okefenokee.

FRIENDS IN OTHER PLACES

The Okefenokee is precious not only to the United States. It's recognized as a Wetland of International Importance. This designation comes from the Ramsar Convention, an international agreement to conserve wetlands around the globe.

The Okefenokee may get even more protection and recognition. Based on its biodiversity and peatlands, it's been nominated to become a UNESCO World Heritage Site. These special sites are protected so future generations can enjoy them. The Great Barrier Reef, Galapagos Islands and Grand Canyon are among other natural World Heritage Sites.

These designations could help people who live near the swamp, too. Kim Bednarek is executive director of Okefenokee Swamp Park. Her organization manages tourism there. Being a World Heritage Site will bring more visitors, Bednarek says. Tourism can boost the income of nearby communities. And, she notes, those towns are some of the poorest in Georgia.

As a World Heritage Site and wildlife refuge, the Okefenokee will be protected to ensure that tourism doesn't harm the swamp, which could be good for the ecosystem *and* its human neighbors.

Visiting the Okefenokee is kind of like going back in time. More than 300 kilometers (185 miles) of "canoe trails" wind through its waters. If you paddle these trails, you might feel a bit of what Native Americans felt, says Peck. "You're doing what people have done for thousands of years."

Just being in the Okefenokee, Peck says, is a like a memory of primeval existence. "It's very mysterious," she says. "All of a sudden you hear sandhill cranes. They sound like the pterodactyls from *Jurassic Park*. You see an alligator pop up. You hear the birds and the bugs and the bubbling up of the gases trapped under the peat. You hear the wind through the marsh reeds. It's exhilarating."

Scientists still have much to learn about this amazing swamp and its value to our planet. The Okefenokee hasn't yet revealed all its secrets.

What Zemaitis and her team found disturbed them. Okefenokee alligators had mercury levels eight times as high as alligators at other sites. The scientists shared their findings in 2025 in *Environmental Toxicology and Chemistry*. Adult gators top the swamp's food web. High mercury levels in alligators show that the poison can accumulate as these animals eat mercury-tainted prey.

"The biggest question now is what else is being affected," says Zemaitis. Other swamp dwellers are likely at risk, too. And mercury's effects could reach well beyond the swamp. Many migratory birds winter in the Okefenokee. Birds are very sensitive to mercury poisoning, Zemaitis says. They could die or spread the poison to other ecosystems when they leave in the spring. Mercury could even endanger people who fish or hunt in the area.

Scientists study alligators (left) to better understand risks to the ecosystem and people who visit this area. Responsible tourism (above) can boost the incomes of nearby communities while protecting the swamp's natural beauty and resources.

STEVE MCCRACKEN; GRACE WILSON; GEORGIA RIVERS NETWORK; JARED LLOYD/MOMENT/GETTY IMAGES PLUS

Hurricane Katrina didn't stop this coastal ecologist from chasing his dream

Elliott White Jr. studies how plants and people interact in wetland ecosystems

Being from New Orleans, La., Elliott White Jr. has a clear understanding of the importance of healthy wetland ecosystems. He was 12 when Hurricane Katrina struck the Louisiana coast, home to vast wetlands. After the destructive storm, his family had to relocate to Galveston, Texas. "That was actually the driving force for me studying wetlands," he says.

White now studies how climate change, sea level rise and human impacts affect coastal ecosystems and local communities. He has to think about how plants, soil, water and animals interact with each other. And he considers how humans help or hurt in these environments. His work brings together environmental and social sciences.

While working on his Ph.D. at the University of Florida, White studied the part of Okefenokee that drains into the Suwannee River. That led him to becoming an advisor on the Okefenokee's application to be named a UNESCO World Heritage Site. This designation would grant the land extra protections for future generations to enjoy. Now, he's at Stanford University in California leading a group that's studying wetlands around the world. In this interview, he shares his experience and advice with *Science News Explores*. (This interview has been edited for content and readability.) — *Rachael Lallensack*

Q What made you want to study wetlands?

A When my undergraduate academic advisor asked me what I wanted to study in graduate school, I hadn't thought that far yet. Then I remembered this ad would play on the radio when I was growing up. It said, "Louisiana is losing a football field of wetlands every 45 minutes."

I had learned that wetlands can reduce the impacts of hurricanes. So I wondered, if Louisiana hadn't been losing wetlands for at least 100 years, would Hurricane Katrina have been so bad? Would my family and I have had to evacuate and relocate? If wetlands can be a part of our natural defense systems against hurricanes, then we need to do what we can to save them.

Q What are you researching right now?

A I'm in The Gambia in West Africa studying a wetland ecosystem called mangrove forests and efforts to restore those forests. Most plants cannot tolerate being in salt water, but mangrove trees can. What's happening in Gambia right now is primarily driven by climate change. There's not as much fresh water coming down the River Gambia. The soil is becoming too salty even for mangroves to live. Huge patches of the mangrove forest are dying off.

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

A Some people may find themselves in spaces where they're the only one that looks like them, and that can be challenging to deal with. But that doesn't mean that you don't belong. You very much belong there.

Q What would you say to kids who experience natural disasters?

A There's always tomorrow. The place you live may be experiencing climate change in a really drastic way, but that's not the end. And when it seems like there's no hope, you just have to look for those silver linings to keep you motivated and to keep you moving forward. Because sometimes when you get stuck, it's hard to get out. And that's true in wetlands, too. Sometimes you get stuck in the mud and it's very hard to climb out.

DAVID KAPLAN; E. WHITE JR.

At Stanford University in California, Elliott White Jr. studies how climate change and human actions affect coastal ecosystems. Outside of his work, White is an avid vinyl collector, with a library of over 800 records.

EARTH

Build your own beach

Use your mini coastline to investigate erosion

By Science Buddies

Beaches are shaped by erosion. Eroding rocks and reefs in the ocean create particles that waves sweep ashore to build beaches. Erosion of a shoreline can also create a headland. This land formation — usually made of large rocks — sticks out from the coast and affects how the surrounding shoreline erodes. Let's build a model to see how water and headlands affect beach formation.

OBJECTIVE

Make a model beach and see how waves affect the shoreline.

EXPERIMENTAL PROCEDURE

1. Pour 1.2 liters (5 cups) of sand into a paint roller pan.

2. Build a "beach" with most of the sand in the shallow end of the pan.

3. Pour 1.4 liters (6 cups) of water into the deep end of the pan. Let the sand and water settle for five minutes, then take a picture of the beach.

4. Float an empty water bottle in the deep end of the pan, along the beach.

5. Bob the bottle up and down to make waves for one minute, then take a picture of the beach.

6. Repeat Step 5.

7. Empty, clean and dry your pan.

8. Repeat Steps 1–7 two more times.

9. Repeat Steps 1–3. Then make a "headland" with 0.5 liter (2 cups) of aquarium gravel in the middle of the shoreline, partly in the water and partly on the beach.

10. Repeat Steps 4–7.

11. Repeat Steps 9–10 two more times.

12. Review your pictures. How does the beach change over time when it does not have a headland versus when it does?

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

SCIENCE BUDDIES

Forget sandcastles. Use sand to build your own mini beach and witness the power of erosion.

TOSMATUDOR/SHUTTERSTOCK

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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?

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ALLIGATOR
ATMOSPHERE
BOREHOLE
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COGNITIVE
CONNECTION
DENSITY
DOGBANE
EXTINCT
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GRASS
MICROBES
MULTIVERSE
NEURON
PEAT
ROBOCOPTER
SMEARWORT
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PATPITCHAYA/SHUTTERSTOCK

MATERIALS SCIENCE

Nanosized ‘stenciling’ trick may give gold particles new properties

A popular style of decorating pottery inspired the technique

A popular technique for decorating pottery is helping scientists “paint” intricate patterns on nanosized bits of gold. This teeny tiny art technique could give the gold specks exciting new properties.

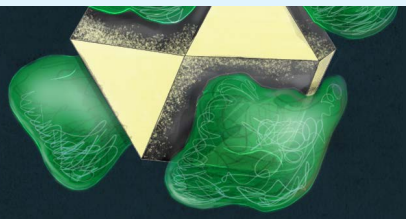
The new nanoparticles could have a wide range of uses. They could go into tiny electronic circuits. They could help tote drugs to specific parts of the body. They could even assemble themselves into “metamaterials.” Such materials might interact with light or sound in new ways.

But building the right types of nanoparticles for such jobs is no easy feat. Scientists must carefully craft the particles’ surfaces. This controls how they will interact with each other and with other things. That’s quite difficult when each particle is less than 100 nanometers across. That’s just one-thousandth as thick as a typical sheet of paper!

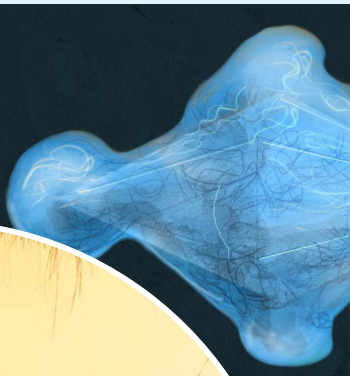
Nanoscientist Ahyoung Kim got an idea for a solution in a pottery class. Kim used handmade stencils to decorate her pieces. First, she drew a design on the ceramic pottery with wax. Then, she colored over the pot with ink. That ink stuck everywhere except where the wax was, leaving the design behind.

Kim had been trying to find a way to decorate nanoparticles of gold. Scientists had reliable ways to make the tiny gold bits but not decorate them. “At that point, I thought, ‘Oh, maybe I need some kind of masklike

MAAYAN HAREL; FRED ZWICKY; A. KIM



The research team included materials scientist Qian Chen, left, and graduate student Chansong Kim, right.



thing'" — like the wax she used on pottery. Kim stenciled nanoparticles as a student at the University of Illinois Urbana-Champaign. Now, she's working at the California Institute of Technology in Pasadena.

SUPER-SMALL STENCILS

Kim was part of a team that used chemicals to carefully stencil patterns on nanosized nuggets of gold. The gold bits were too small to draw on with wax. So she used something called iodide. When she mixed it with the nanobits, the iodide covered some parts of the gold, but left other areas exposed.

Kim also added a material called 2-NAT. It stuck to the still-exposed gold surfaces but not to areas covered with iodide. Finally, she "painted" the gold nanobits with long, hairlike chemicals. A type of polymer, they clung to areas covered with 2-NAT but not to areas covered with iodide. The iodide had acted like the wax stencil in her pottery class, limiting where the polymer "paint" could stick.

By changing the amounts of iodide and 2-NAT, the team could stencil nanoparticles with different designs. The shapes of the particles also affected those final designs.

Computer models helped predict what the designs would look like with different recipes of gold, iodide and 2-NAT. These simulations also predicted how the gold bits would arrange themselves into larger structures. After running those models, the scientists whipped up more than 20 of the designs in the lab.

This stenciling is "pushing the frontiers of what's possible with nanocrystals and how they can be modified," says Sara Skrabalak. She's a chemist at Indiana University Bloomington. Skrabalak did not take part in the new study, but she does work with other tiny materials.

Kim's team described its tiny stenciling trick in *Nature*.

MANY DESIGNS, MANY USES

Gold nanobits can group to make bigger structures. And different stencils affect how.

Normally, gold nanobits cluster closely, like a stack of oranges at the grocery store. But with the polymer patches stenciled on, that changes. The polymers stick out from each gold bit, pushing other gold nanobits away. Instead of packing tightly, the stenciled gold bits pack more loosely. That could change some of their traits.

For instance, it might change how they interact with light, says Maria Rosaria Plutino. She studies nanoscale materials at the Italian National Research Council in Messina. Rosaria Plutino did not take part in the new research. She does, however, study how tiny particles like these might work in fabrics, medicines and other applications. Adding stenciled nanoparticles, for example, might change a fabric's color, she says.

And that's just the beginning. Researchers might stencil nanobits with different polymers and decorate metals other than gold.

Such stenciled nanobits might help make stealth coatings, Skrabalak says. These might hide things from radar, making them harder to spot.

Kim says her team is now exploring combos that could affect how medicines react in the body. The goal: Use the stencil to help direct a drug to where it's needed.

"It's a very nice approach," Rosaria Plutino says. "It opens a lot of different ways to apply this kind of stencil."

— *Skyler Ware*

Ahyoung Kim got the idea for stenciling nanoparticles in an art class where she used wax to stencil a design onto a piece of pottery.

Using an atomic stenciling method, scientists have designed tiny gold particles with an array of shapes, properties and possible uses. They've made more than 20 different patterns, some of which are illustrated at left.

PHYSICS

Do multiple universes exist?

Physics says: Maybe

One concept of the multiverse envisions our universe as one bubble in a vast cosmic foam. Other bubbles in this proposed foam might have different properties than our own.

The Marvel Cinematic Universe really should be called the Marvel Cinematic Multiverse. In the films, alternate realities can be created and destroyed. Characters can hop between them, letting heroes like Spider-Man team up with other versions of themselves. The Scarlet Witch and Doctor Strange even possess the bodies of their interdimensional doppelgängers.

Superhero screenwriters aren't the only ones intrigued by the idea of a multiverse. Some physicists think a multiverse might really exist. Why? Because the existence of many other universes could answer deep questions about our own.

"There are a lot of abstract ideas about other universes," says Paul Halpern. He's a physicist at Saint Joseph's University in Philadelphia, Pa. One popular multiverse idea, he says, comes from the physics of the very biggest things: cosmology. Another comes from the physics of the very smallest stuff. That's quantum mechanics.

A BUBBLE BATH OF UNIVERSES

Shortly after the Big Bang, our universe went through a brief period of superfast expansion. Scientists refer to this growth spurt as inflation. In that time, tiny quantum fluctuations in the structure of the universe got stretched to huge sizes. In parts of space close enough for our telescopes to see, those quantum blips seeded galaxies.

"If you can produce a galaxy from quantum fluctuations, what else can you produce?" wonders Andrei Linde. This physicist was involved in creating the theory of inflation. He's now retired from Stanford University in California.

At even larger scales, Linde says, quantum blips could have seeded

SPOOKY POOKA

regions of space with vastly different properties. Such places would exist far beyond what telescopes can see. In some, electrons might be heavier. Or gravity might behave differently. There, life might not be able to exist.

What's more, inflation has stopped in the universe we can see. But it may continue elsewhere, Linde says. It could blow up more bubbles of space with unique properties forever. Each bubble would be so distant and distinct from the others that they would effectively be different universes.

To Linde and some other scientists, this scenario answers a big question in cosmology. That is: why the masses of particles and strengths of forces in our universe seem perfectly right to create life. At a glance, this looks like "many strange coincidences," Linde says.

But if a multiverse exists, then it's not so strange that conditions in our universe are ripe for life. Among many bubble universes, those particle masses and force strengths were bound to pop up somewhere.

If our universe is one bubble in a fathomless froth, maybe another universe has bumped into ours, Halpern says. That could have left a mark on the afterglow of the Big Bang that fills space. No one has seen this yet, Halpern says. "But scientists are still looking."

BRANCHING TIMELINES

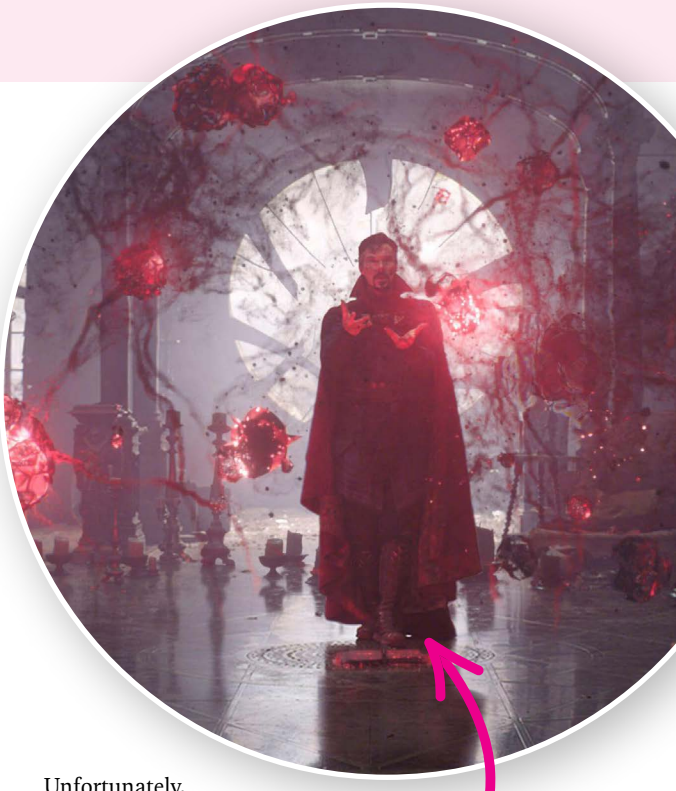
Another multiverse idea comes from quantum mechanics. That branch of physics says that until they're measured, particles can exist in a mix of states at once.

"Once somebody takes a measurement, that blurred scenario collapses into a single possibility," Halpern says. For instance, an electron that existed in a smear of possible places is observed in one spot.

At least, that is the traditional idea in quantum mechanics. But it "is a little bit odd, because it requires a human measurer," Halpern says. If it's true, how did the universe function before humans were around to observe it?

In 1957, physicist Hugh Everett III offered an explanation. Maybe, he proposed, observation doesn't cause a spread of quantum possibilities to collapse into a single outcome. Perhaps all possibilities unfold in alternate realities. For instance, an observer splits into multiple copies of herself who each saw an electron in different places.

"The versions separate seamlessly," Halpern says. "They never will know about each other, and they live in parallel universes."



Marvel characters like Dr. Strange may be able to jump between universes. In the real world, hopping between such islands of existence would be no easy feat.

Unfortunately, that would make this idea extremely hard to test. "We can't have somebody split in an experiment between two possibilities and ask each one what it was like," Halpern says. "If the theory is right, you wouldn't notice it."

COSMIC CROSSOVER

The chances of visiting other universes, if they exist, are similarly dim.

In theory, tunnels in the fabric of spacetime — known as wormholes — might bridge realities. But "we don't know if they're possible to create," says Halpern. If they were, "they would require so much energy and mass that they would be well beyond current technology."

We're talking about the mass of a galaxy, Halpern adds. "If there was [a wormhole] near Earth, Earth would be crushed almost immediately," he says. "So it's not like you can have a wormhole in a secret closet in your bedroom ... and jump in and travel to all these other places."

That's bad news for anyone who dreams of teaming up with their alter egos to save the day. But on the bright side, you'll probably never have to fight off your evil twin, either.

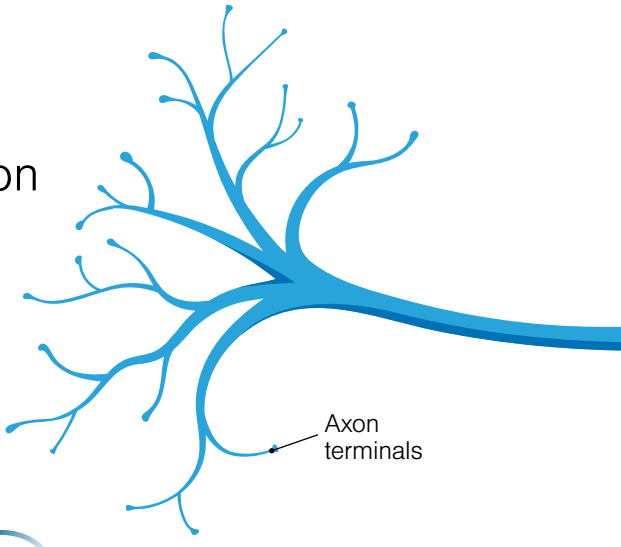
— *Maria Temming*

CAPITAL PICTURES/ALAMY

BRAIN

What are neurons?

These cells relay and process information in the brain and body, allowing you to feel, move, think and learn



It's morning. As you sit up in bed, your feet touch the cold floor, so you lift them and pull on fuzzy socks. You shuffle to the kitchen, grab the cereal and hear the pings as you tip the flakes into a bowl. You watch the stream of milk as you pour — carefully — so you don't spill like you did yesterday.

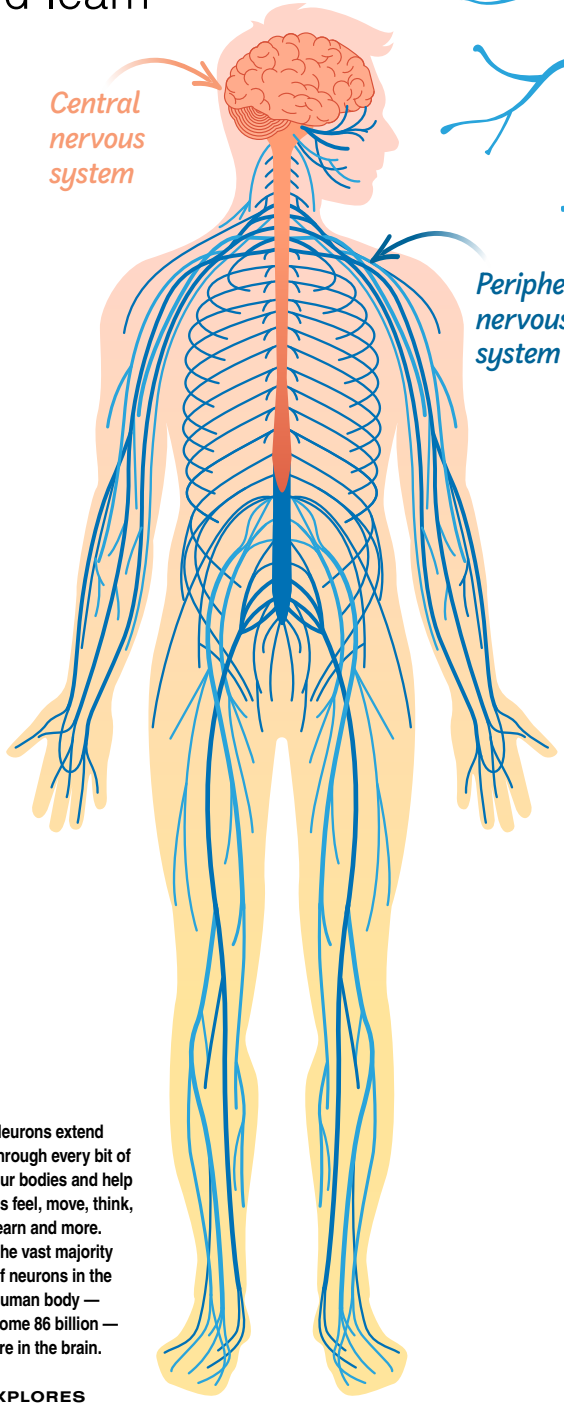
All these experiences are possible because of specialized cells called neurons. They make up the body's nervous system. That includes the brain, the spinal cord and the nerves that extend through all parts of your body. These cells can sense information in the world around you and help you respond to it. They allow you to move, think, remember and learn.

Neurons receive and send messages to share information and tell other cells what to do. They connect with each other and with other types of cells, like muscle cells.

How neurons connect — especially in the brain — can change as we grow and experience the world. Those changes also help us learn and form memories.

Neurons communicate using chemical messengers. These are called neurotransmitters. Branching, hairlike structures called dendrites catch chemical messages from other cells.

When a dendrite gets a message, that triggers a series of chemical and electrical signals inside the cell. Waves of tiny electric charges move down long, thin axons that carry the info toward other cells. Sometimes these axons can be very long — some nerve cells reach from your lower back all the way to your big toe! In the brain and spinal cord, though, most neurons are smaller and link up with many others.



Neurons extend through every bit of our bodies and help us feel, move, think, learn and more. The vast majority of neurons in the human body — some 86 billion — are in the brain.

Some axons are wrapped with a fatty layer called myelin. Myelin acts like an insulator. It helps messages move more quickly.

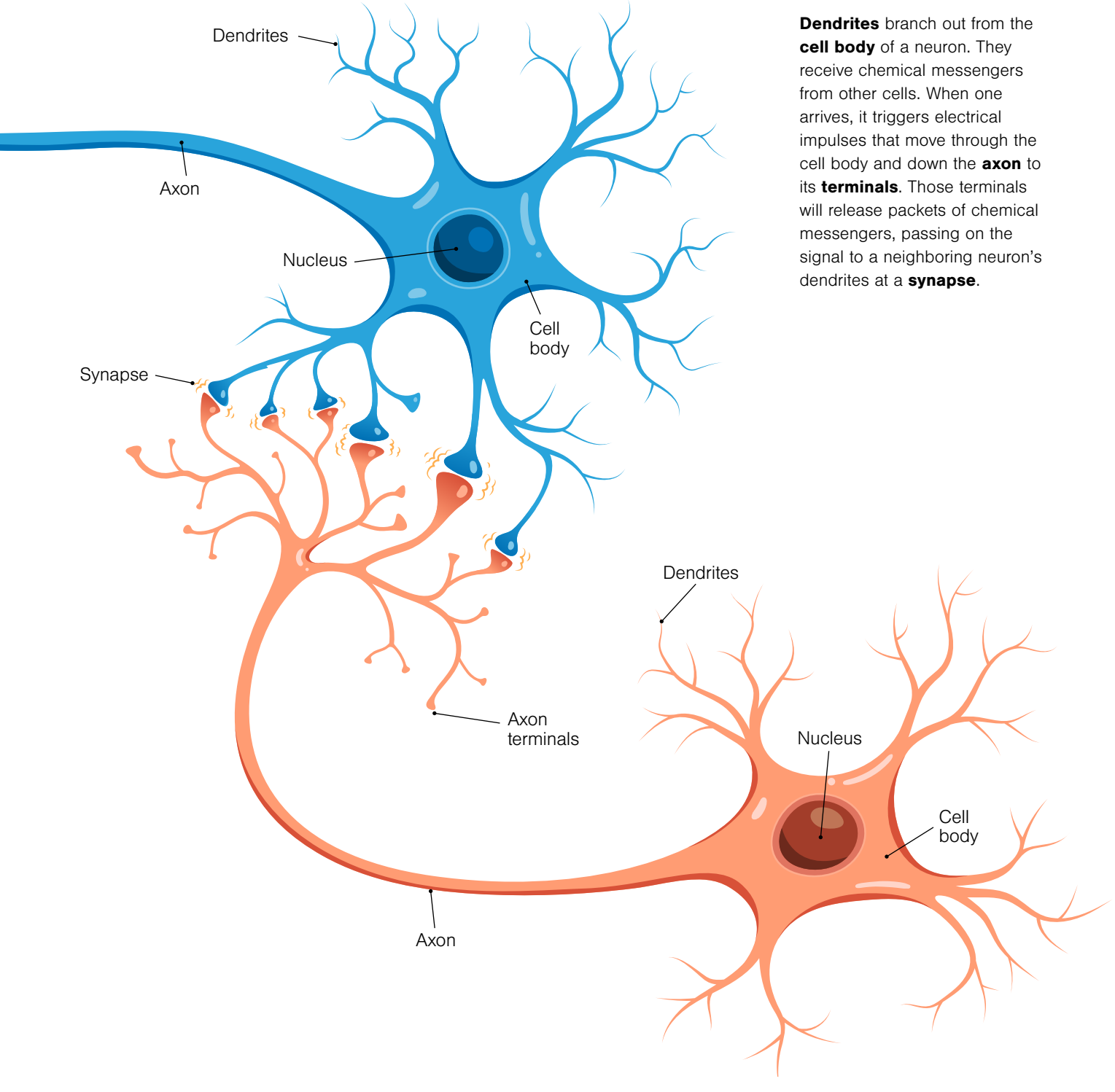
Finally, a message reaches finger-like terminals at the end of the axon. The neuron releases its own chemical messages to be picked up by the dendrites on a neighboring cell. The region where two neurons "talk" is known as a synapse. Here, neurotransmitters pass from one cell to the next by floating across the tiny gap in between.

In this way, neurons relay messages across synapses to move info through networks of cells. It's somewhat like how data move from computer to computer through the internet.

— Bryn St. Clair

VECTORMINE/SHUTTERSTOCK; VITALII DUMMA/ISTOCK/GETTY IMAGES

ANATOMY OF A NEURON



Dendrites branch out from the **cell body** of a neuron. They receive chemical messengers from other cells. When one arrives, it triggers electrical impulses that move through the cell body and down the **axon** to its **terminals**. Those terminals will release packets of chemical messengers, passing on the signal to a neighboring neuron's dendrites at a **synapse**.

LIFE

How many insects are in the air?

Weather radar data help survey insect populations

Butterflies and other insects use the air to mate, migrate and more. On a typical summer day, skies above the United States host around 100 trillion of these flyers.

DELBARS, BUTTERFLY HUNTER/SHUTTERSTOCK

Mayflies mate in mid-air. Monarch butterflies make cross-continental flights. Dragonflies hunt as they soar. But despite how much insect activity happens in the air, scientists haven't had a clear sense of insects' abundance there. Now a team has found a way to estimate the density of insects in airspace using weather radar data.

Radar stations across the United States surveil the air for water drops, snow and hail. "But using it for insects, somehow, is something that we haven't thought too much about," says Elske Tielens. She studies interactions between organisms in the air. She works at the Swiss Federal Institute for Forest, Snow and Landscape Research in Zurich, Switzerland.

Radar sends out radio waves and analyzes the waves that bounce back. The technique can distinguish some types of particles based on certain properties, such as shape. Rain is usually spherical. Insects tend to be rounded but longer in one dimension. These differences let meteorologists filter animals out of the data, Tielens says. Her team flipped that approach to remove rain.

The team used 10 years of weather radar data from almost 140 sites across the contiguous United States. That gave them daily estimates of insect density in the air. "It's the biggest time series data set that we have for insects in the U.S.," Tielens says. They found that U.S. skies host around 100 trillion flying insects on a typical summer day.

This approach could also provide hints about overall insect abundance, Tielens says. Researchers have noticed dwindling numbers of insects at certain locations. That's led some to worry that insects everywhere could be faltering.

The team didn't observe an overall decline in insect density over the

United States from 2012 to 2021. At some sites, insect density increased. At others, it decreased. Places with warming winters tended to see decreases in insect density. So did areas that had more buildings and roads. The scientists shared their results in *Global Change Biology*.

This work shows how data gathered for one purpose can help answer other questions, Tielens says. "It turns out you can use [radar] in many more ways than you expected." — *Carolyn Wilke*

DATA DIVE

1. Look at Figure A. What's the average daily insect density for 2012? How does that compare with the value for 2021?

2. Why might some years have higher insect density?

3. Look at Figure B. How does the insect density at sites in the northern United States compare with that of the southern United States?

4. What are some places where insect density increased from 2012 to 2021?

5. What are some places where insect density decreased?

6. How might scientists study factors that impact insect populations?

E.K. TIELENS, P.M. STEPANIAN AND J.F. KELLY/*GLOBAL CHANGE BIOLOGY* 2025

AIRBORNE ECOSYSTEM

FIGURE A

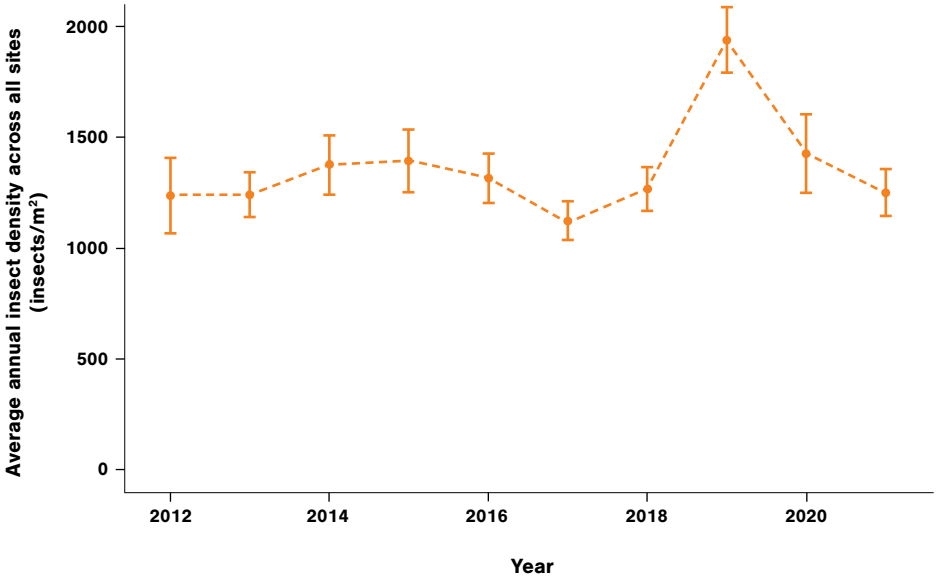
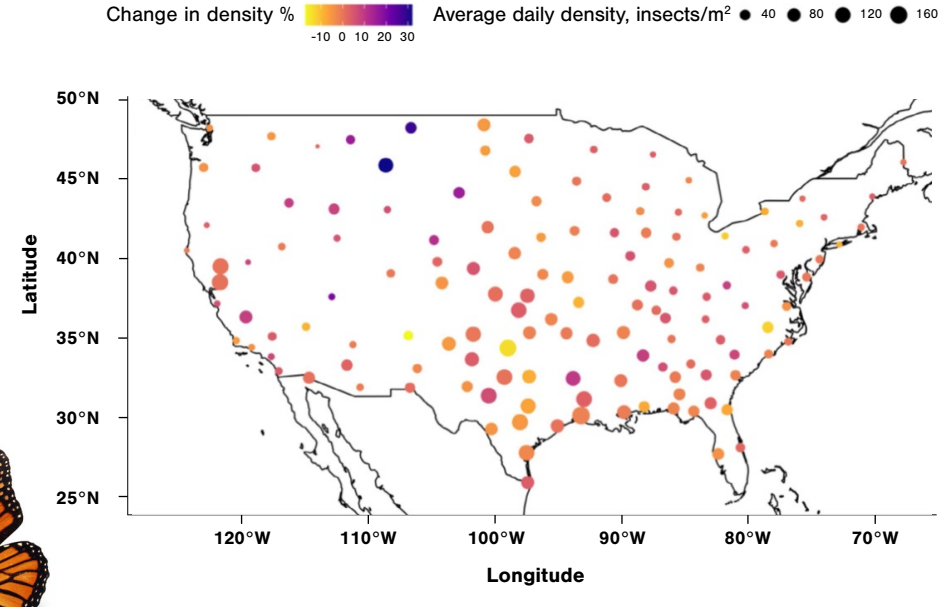


FIGURE B



Researchers studied insect abundance using weather radar data. At each of 138 sites, scientists used a radar scan taken at noon every day of the year. They removed the rain, snow and hail from these weather scans. That allowed them to see the density of insects above each site each day. Then they added up all the scans from one site for a whole year. That let them see the annual insect density at every site. They averaged these values across the sites and plotted that average every year from 2012 to 2021 (Figure A). They also studied the average density of insects at each site over the 10-year period (dot size in Figure B) and the change in density during that time (dot color).

ANSWER

Cheetah mummies lie frozen in time in desert caves

The extinct cats were close relatives of modern-day cheetahs

Researchers have uncovered dozens of ancient cheetah skeletons and mummies in caves in Arabia. No one has spotted a cheetah in that area for decades.

Cheetahs were once common in Africa and across large tracts of South Asia. Habitat loss and human conflict may have led to their extinction on the Arabian Peninsula. They were last seen there in the 1970s.

In 2022 and 2023, wildlife biologist Ahmed Al-Boug went looking for the extinct cheetahs' remains. He works at the National Center for Wildlife in Riyadh, Saudi Arabia. He and his colleagues surveyed 134 underground caves in northern Saudi Arabia.

The team found preserved cheetah remains in five of those caves: 54 skeletons and seven mummies. The animals may have fallen into the caves and been unable to escape. Over time, the desert's extreme heat desiccated the bodies.

Al-Boug and his team used carbon dating on several of the cheetah remains. They ranged from about one century old to over 4,200 years old.

The team determined the full genetic codes, or genomes, of two cheetah skeletons and one of the mummies. This analysis suggested the ancient cats were close relatives of two living subspecies, one in Africa and one in Asia.

The team published its findings in *Communications Earth & Environment*.

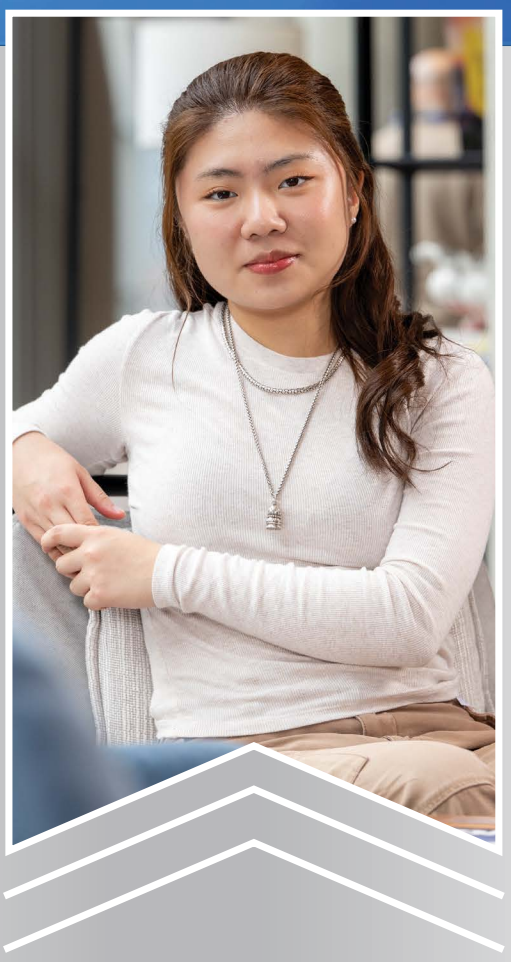
— *Jake Buehler*

Researchers found this cheetah mummy, seen in a laboratory, while exploring caves on the Arabian Peninsula. DNA from ancient wildcats' skeletons and mummified remains shows they were close relatives of cheetahs living in northwest Africa.

A. AL-BOUG *ET AL/COMMUNICATIONS EARTH & ENVIRONMENT*

INSIDE THE MIND OF A YOUNG SCIENTIST

A Regeneron Science Talent Search finalist answers three questions about her science



Science competitions can be fun and rewarding. But what goes on in the mind of one of these young scientists? Claire Jiang, a finalist at the 2026 Regeneron Science Talent Search, shares her experience.

Q What was the most rewarding part of this project?

A Claire has juvenile idiopathic arthritis, or JIA. This chronic illness causes joint pain and damage in kids. Claire built a model of JIA-affected joint cells to study in the lab. Adding to the scientific knowledge about an illness that affects her personally "is honestly one of the greatest accomplishments I could ever have imagined," Claire says. "Growing up with JIA was a little bit scary."

Sharing her research has also helped Claire feel more comfortable discussing JIA. "I used to be really scared to talk about my diagnosis," she says. But "research has really contributed to my self-confidence and being OK with talking about my diagnosis."

Q What was the most challenging part?

A "I never pull all-nighters, but I definitely was [going to sleep] later and later trying to figure out and analyze this data," Claire says. She spent her lunch periods in the lab at her school and worked on her project during weekends.

Q Any advice for research newbies?

A "Always believe in yourself. There were nights that I felt that my research was bad and it didn't make sense and I didn't understand what was going on ... all this spiraling," Claire says. "Going through this is part of the process. But once you persevere, that's what makes you really happy. The fact that you persevered and got through it."

Regeneron Science Talent Search finalist

Claire Jiang

Claire Jiang, 18, built a cell model to better understand juvenile idiopathic arthritis — the most common type of arthritis in kids and teens. When she did this research, Claire was a high school junior at Bergen County Academies in Hackensack, N.J.

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