ScienceNews Explores
September 2024

Pet Power

Rare earths' hidden electrons make much of modern tech possible

WHAT'S THE SPEED OF LIGHT IN JELL-O?
P22

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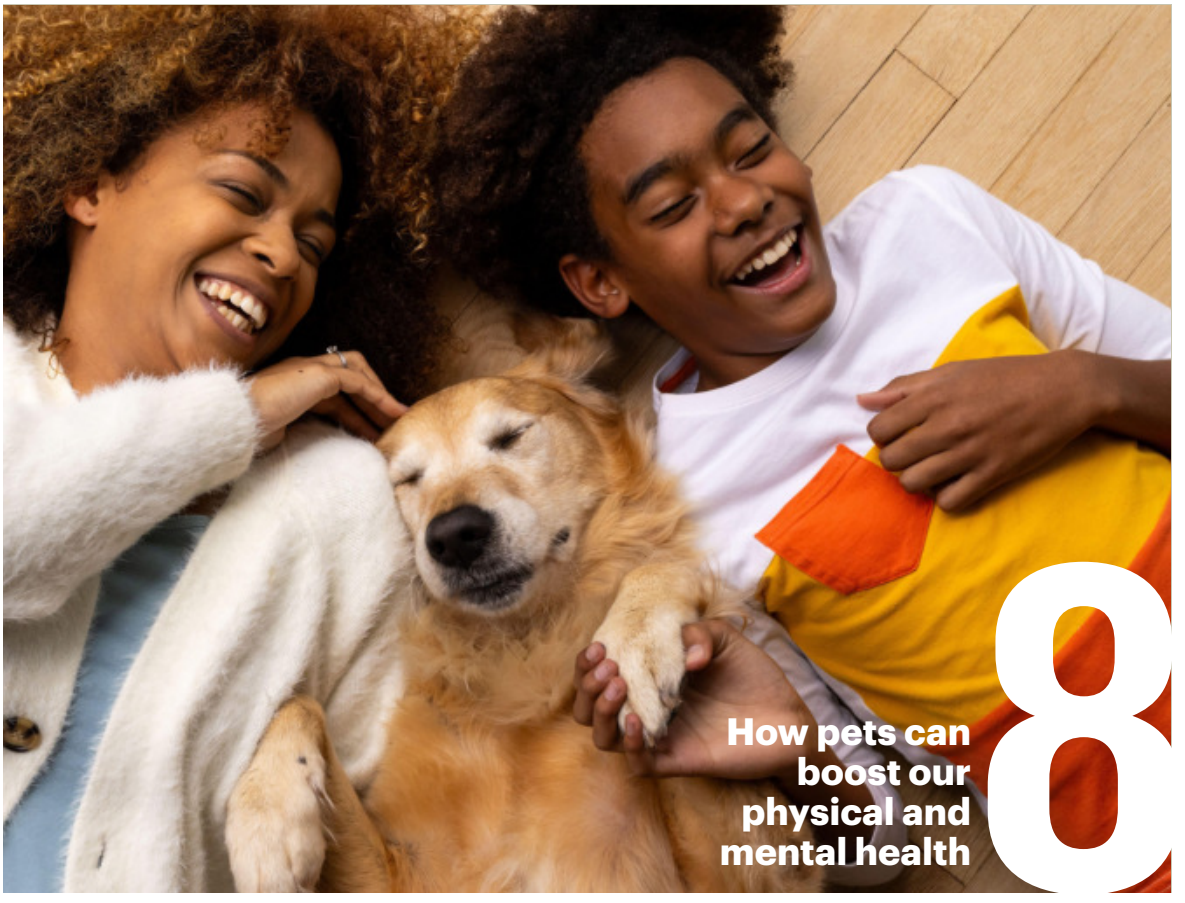

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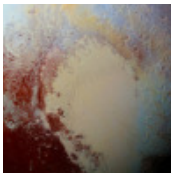

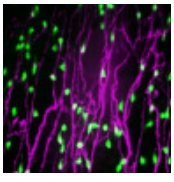

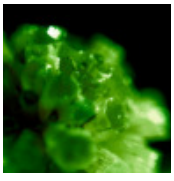

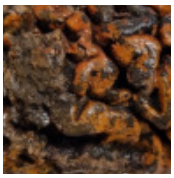

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Q How do flies put together all the different images from their eyes?

— *Briar R.*

A Flies are one of many types of animals that see using compound eyes. These eyes are made of many smaller units called ommatidia, explains Jamie Theobald. He studies insect vision at Florida International University in Miami. Each unit captures only a small part of the fly's field of vision. The fly's brain then assembles these snapshots into a single image. A fly's tiny head can only hold so many ommatidia, though, meaning the insect's eyesight isn't too sharp. Their vision is blurrier than a person's. Flies, however, process light faster than we do, making them better at detecting fast movements. This helps them perform high-speed maneuvers such as fighting competitors and avoiding your flyswatter, says Theobald.

Q Why does helium make your voice high-pitched?

— *Mikah S.*

A When we speak, our vocal cords vibrate. These vibrations produce sound waves with different frequencies. Combined, these frequencies make up our voices' overall sound quality. How fast these sound waves travel helps determine the pitch we hear. The densities of the gases through which the sound waves travel can affect how fast they move and which frequencies sound louder. Helium is less dense than air, allowing sound waves to travel faster and amplifying the higher frequencies in our voice. The result is a higher-pitched, squeaky tone. Breathe in a denser gas and the opposite happens. Inhaling pure gases like helium, though, can be dangerous. Too much can deprive a person of oxygen, causing them to pass out, suffer brain damage or even die.

Q Why do bananas bruise?

— *Calvin H.*

A Bumps and knocks often lead to banana bruising, says Evans Okoli. At the University of Reading in England, this crop scientist studies how climate change impacts grains. Rough handling can cause damage to a banana's flesh. This releases natural compounds called polyphenols. Polyphenols help protect plants from ultraviolet (UV) light damage, insects and infections. But these compounds also cause brown bruising when they interact with oxygen. While eating a bruised banana isn't harmful, it can affect how it tastes, says Okoli. Bruising is hard to prevent, but it is more likely to happen as bananas age. Wrapping aluminum foil around a banana's stem or storing the fruit in a cool location can make this yellow treat last longer. However, avoid putting bananas in the fridge, says Okoli. The cold temperature makes bananas ripen faster by releasing more of the ripening hormone, ethylene, turning the peel brown.

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

Sarah Zielinski
Editor, *Science News Explores*

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SPACE

A rocky wreckage may lurk beneath Pluto's heart

Such a heavy remnant could have held the basin in its odd location

A rocky underground treasure may explain Pluto's heavy heart.

Sputnik Planitia is a large impact basin that makes up part of Pluto's famous heart. For this feature to sit where it does on Pluto's side, scientists think something dense must lie beneath it. Now, computer models hint that may be a huge rocky remnant.

Researchers reported this in *Nature Astronomy*.

Sputnik Planitia is roughly the size of the African country Sudan. It sits a few kilometers (miles) below the rest of Pluto's surface. It's thought to be an impact basin left by something slamming into Pluto billions of years ago. "That's the easiest way to make a giant hole in the ground," says Adeene Denton. She's a planetary scientist at the University of Arizona in Tucson. But the basin's site — across Pluto's equator — is perplexing.

Knocking a huge hole in one side of Pluto should make it wobble. And over millions of years, that wobbling should have tilted Pluto to bring the basin closer to one of its poles.

Some scientists thought the impact that formed Pluto's heart also created an underground ocean. The weight of that water could have kept Pluto from tilting. But it's hard to explain how an ocean could stay liquid on frigid Pluto.

"What if Pluto didn't have an ocean at all?" Denton wondered.

Using computer models, her team tested what would happen if space rocks of different sizes crashed into Pluto. One scenario involved a rock roughly 730 kilometers (450 miles) across. That's big enough to have a dense, solid core cloaked in less dense materials.

As an object that size plowed into Pluto, its exterior would have vaporized. But its heavy center would have eventually settled below Sputnik Planitia's surface. There, it could keep the heart from tilting away from Pluto's equator.

— *Adam Mann*

Pluto's heart-shaped basin was suspected to hide a vast ocean. Now, it seems a huge rocky remnant may lurk there instead.

NASA IMAGES/SHUTTERSTOCK

COMPUTERS

This test could help weed out AI-written text

New ways to spot bot talk may reduce cheating and misinformation

Imagine you're helping judge a writing contest at your school. You want to make sure everyone did their own work. If someone used an artificial intelligence, or AI, model such as ChatGPT to write an entry, that shouldn't count. But how can you tell whether something was written by AI? New research reveals one method: ask a bot to rewrite it.

"If you ask AI to rewrite content written by AI, it will have very few edits," says Chengzhi Mao. When AI rewrites a person's text, it typically makes many more changes. Mao is a computer scientist at Columbia University in New York. He and his colleagues designed a tool called Raidar that uses AI rewriting to detect bot-generated text.

AI writing has already flooded social media. It has fueled fake news websites and scam books that try to steal sales from real books. Some students use AI to cheat. Tools like Raidar could help expose AI-powered liars, scammers and cheaters.

Mao's group shared the tool at the International Conference on Learning Representations in Vienna, Austria.

Mao regularly uses ChatGPT to polish his own writing. He sometimes asks the bot to improve an email. He noticed that this bot can do a pretty good job the first time it rewrites something that he wrote. But if he asks it to improve an email again — revising its own writing — then it won't change much.

"That's how we got motivated," Mao says. He realized the number of edits a bot makes to a piece of writing might say something about the original text.

"It's a pretty neat idea," says Amrita Bhattacharjee. At Arizona State University in Tempe, she has researched AI text detection. But she wasn't involved in developing Raidar.

Mao and his colleagues first gathered writing samples from people and several chatbots. They did this for a few kinds of text, including news and student essays. Then, the team had several AI models rewrite all the human-written and bot-written samples.

Next, the researchers calculated the number of changes between the original and edited version of each writing sample. Based on the number of changes, Raidar could sort writing samples into human- and AI-generated.

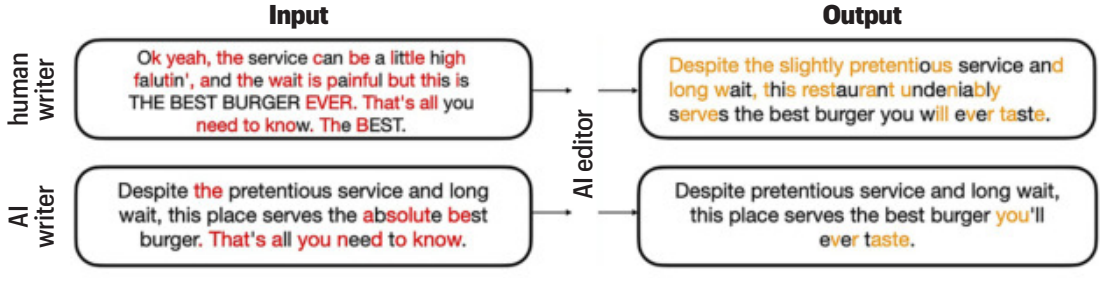
Raidar's sorting is not perfect. It sometimes identifies a human text as AI, or vice versa. But it performs better than other tools designed to detect AI-written text, the researchers found.

Most other tools use AI models and statistics to learn to recognize the kind of text that bots produce. These tools typically work best on longer passages of text. But Raidar works well even on text that's just 10 words long.

Mao's team is working to make Raidar an online tool. Until then, anyone can try out the idea behind it. For example, a suspicious teacher could ask any chatbot to rewrite a student's work. If the bot makes very few edits, that could be a red flag that the student used AI.

Bhattacharjee notes that teachers shouldn't take action based on the Raidar system alone, though, because it isn't always correct. Also, some students may have good reasons to use AI, such as cleaning up grammar.

— *Kathryn Hulick*



A human and AI model wrote reviews (far left). An AI model then rewrote both reviews to be more concise (left). Red text was deleted in revision; orange text was added. The AI model made many more edits to the human-written review than to the AI-generated review.

COLUMBIA UNIVERSITY; RED VECTOR/SHUTTERSTOCK

EARTH

Climate change is changing how scientists measure time

Melting ice sheets shift Earth's mass and slow its spin, making global timekeeping tricky

Climate change may be making it harder to know exactly what time it is.

Satellite measurements show ice sheets atop Greenland and Antarctica are rapidly melting. That melting is shifting more mass toward Earth's waistline. And that extra bulge is slowing the planet's rotation. The climate change–driven mass shift is messing with international timekeeping standards. Geophysicist Duncan Agnew made the new finding. He works at Scripps Institution of Oceanography in La Jolla, Calif.

Coordinated universal time, or UTC, is set by atomic clocks. And UTC is regularly adjusted to match Earth's actual spin. Many factors alter the speed of the planet's rotation.

Gravitational drag from the sun and the moon might cause a shift. So might changes to the rotation speed of Earth's core. Friction between ocean waters and the seafloor could, too. Even earthquakes can rock the spin.

But the impact of a quake is much smaller than that of the ice sheets' melting. Agnew says he finds this point particularly startling. Humankind "has done something that affects, measurably, the rotation rate of the entire Earth," he says.

The need for occasional tweaks to atomic clocks gave birth to the "leap second." In 1972, international timekeepers agreed to add this extra tick to UTC as needed. Timekeepers have added 27 leap seconds to the clock since the idea was introduced.

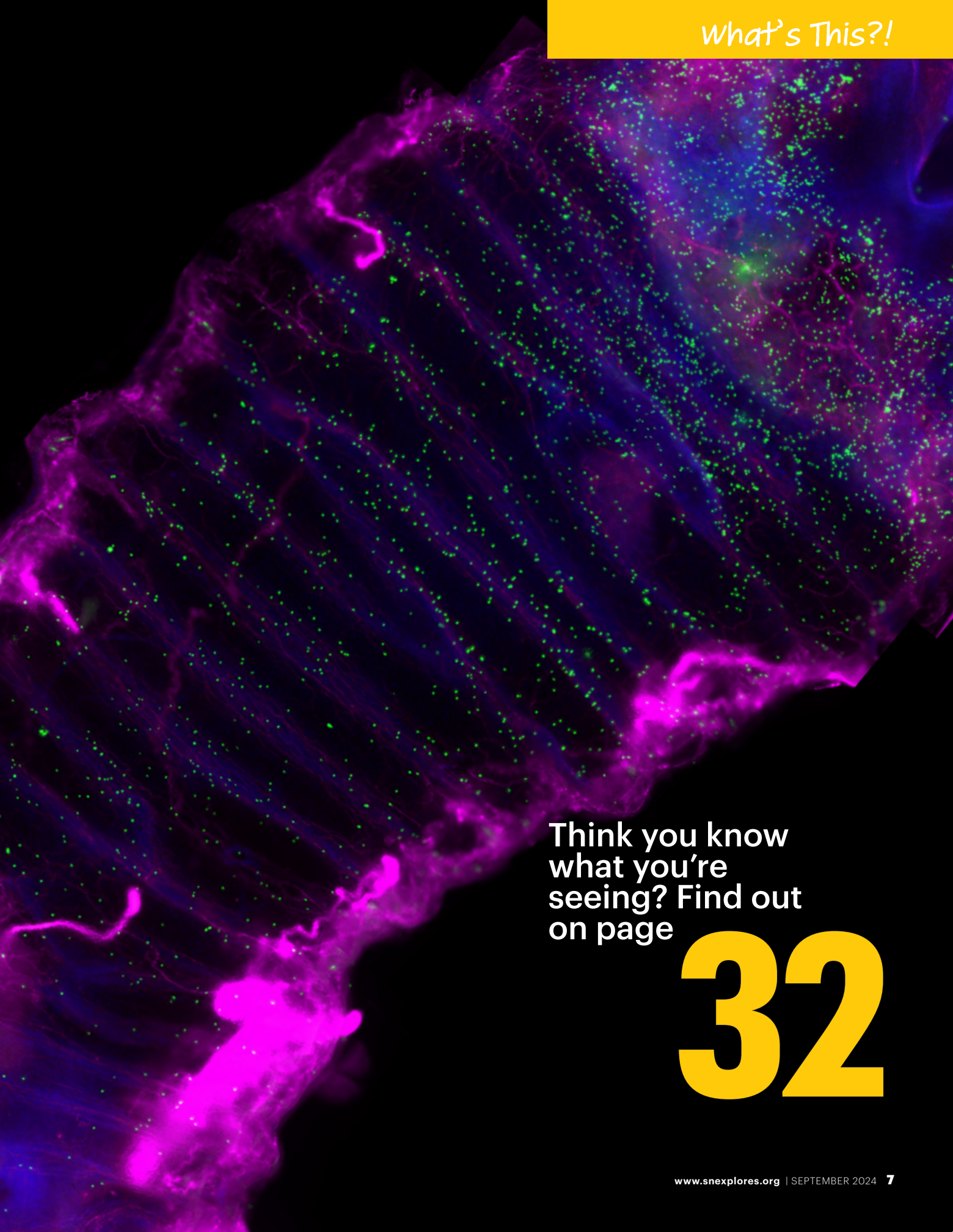
Currently, Earth's rotation and atomic clocks are nearly in sync. A leap second hasn't been added since 2016. But those clocks may need to be adjusted again soon, Agnew's calculations show.

The biggest changes to Earth's rotation right now are coming from its heart. The rotation of Earth's core is slowing down. That slowdown is causing its outer layers to spin faster. To keep things in sync, timekeepers must begin removing leap seconds from the UTC, rather than inserting them.

Thanks to climate change, global timekeepers now have an extra three or so years before they need to adjust. But the old way won't be accurate beyond 2029. One way or another, the world is going to have to start losing time — or international timekeeping guidelines will need to change.

— *Carolyn Gramling*

MONTICELLO, PATRYK KOSMIDER/SHUTTERSTOCK



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

Pet Power

Animal friends can boost health and well-being

SPBEAUTY/ADOBE; RHEALEA/SHUTTERSTOCK

By **Alison Pearce Stevens**

When Percy Lee has a bad day, he hangs out with his chinchilla, Rin. "She's like emotional support for me," says the 15-year-old. Percy, who lives near Kansas City, Kansas, particularly enjoys snuggling with Rin and watching her explore. "When I get upset and overwhelmed, playing with her is one of my main coping mechanisms," he says.

Percy, the author's nephew, isn't alone. After a long day, lots of people enjoy unwinding with their pets. They might find comfort in cuddling a cute cat or petting a playful pup. Even spending time with non-snuggly animals, like turtles or fish, gives many people a boost.

Kerri Rodriguez studies the bonds between people and animals at the University of Arizona in Oro Valley. "One of the biggest benefits of having a pet is that they never judge you," she says. "They don't care if you said something silly, if you have a ketchup stain on your shirt or if your breath smells," Rodriguez says. Often, pets are simply happy to see us. They make us feel loved.

That animal affection may have benefits that go far beyond temporary mood boosts. Researchers like Rodriguez have found that pets can reduce stress, boost people's immune systems and perhaps even help them learn. Understanding such perks better might inspire people to spend more time around animals, improving their mental and physical health.

Lowering stress

Patricia Pendry is a developmental psychologist. At Washington State University in Pullman, she spent years studying how stressful home environments affect kids' health. That inspired her to search for ways to reduce children's stress — including spending time with animals. In recent experiments, Pendry has investigated whether hanging out with animals has a measurable effect on the body's stress system.

Pendry's work focuses on a hormone called cortisol. Your body makes more of that hormone when you are stressed. It makes less when you are calm. Pendry measures cortisol in the saliva of college students before, during and after spending time with animals. Sometimes the animals are specially trained therapy dogs that have been brought to campus. Other times, they are cats and dogs brought in by the local humane society.

When students arrive, they spit into a tube to provide a saliva sample. Then they spend the next 10 minutes doing one of four things. Some go into a room to pet the visiting animals right away. A second group watches the petting group while waiting in line. A third group looks at photos of the animals but doesn't see them in person. The last group waits to get into the room without any glimpse of the pets. The students provide two more saliva samples to measure cortisol during and after that 10-minute window.

Students who petted the animals had lower cortisol levels at the end of the 10 minutes than any other group, the data showed. Interacting with animals reduces how much cortisol the body makes by boosting its levels of oxytocin, Pendry believes. Oxytocin is a hormone that helps calm the stress system.

"As you're petting and stroking in this rhythmic way, your body makes oxytocin," she explains. But people don't even have to touch an animal to get that response. Simply making eye contact with a dog can raise a person's oxytocin levels, other research suggests.

It's only just become possible to measure oxytocin in spit samples like those that Pendry collects. So she hasn't yet studied in detail how higher oxytocin levels might lower cortisol levels. But Pendry plans to see how both hormones respond to animal interactions in her next project.

Research has found that petting animals can lower a person's levels of cortisol, a stress hormone. Interacting with animals may also boost levels of oxytocin. Oxytocin is a hormone that helps calm the stress system.

MADURA MAHANAMA/SHUTTERSTOCK

Even animals that you can't pet can have soothing effects. One study found that kids in the hospital were less fearful and anxious if their room had a goldfish in it.

A calming presence

The calming effect of animals can help some people overcome specific challenges.

For instance, there's some evidence that reading aloud to dogs can help kids improve their reading skills. Reading to a dog is thought to provide support to students, helping them feel more confident in learning new skills.

In one 2020 study in Australia, researchers brought therapy dogs to four schools. First and second graders who struggled to read had one-on-one sessions with the dogs. They read to the animals, getting help from an adult as they needed it. Over the course of a 12-week study, the children improved their ability to read and felt more confident about reading.

Therapy dogs can help kids in other stressful situations, too. A 2021 study found that therapy dogs could reduce kids' anxiety while they had their teeth cleaned at the dentist.

That doesn't mean animals will make anyone feel calmer in any situation, Rodriguez says. "I know this is a bit of a bummer thing to say, but animals aren't magical cures to everything." In her research, Rodriguez is trying to figure out when animals can help and when they may not. One day, people might use those interactions as an alternative form of medicine — treating anxiety with snuggle time the way they might treat a headache with Tylenol.

Rodriguez's work has already shown how much service dogs can help people who have mental-health challenges.

SERGII FIGURNYI, PIXEL-SHOT/SHUTTERSTOCK

Service dogs aren't pets. They're specially trained to help their person. For instance, people who have experienced trauma may struggle with anxiety and other mental-health issues. Service dogs can help reduce those issues, Rodriguez has found.

Dogs don't have to be specially trained to make a difference, others have found. One 2021 study of about 50 teens in Israel looked at the mood impacts of non-service dogs. Teens who spent one year training a dog, the study found, experienced less anxiety and depression from post-traumatic stress disorder.

Service animals also can help children with autism. Some kids with this disorder can become easily overwhelmed by sensory inputs. They may struggle to communicate with other people. A service dog can lean against these kids to provide calming pressure when they're upset. Having a dog can also open up opportunities for a child to meet new people and socialize when other kids want to interact with their dog.

These dogs don't just help the kids they're assigned to, research by Rodriguez suggests. Knowing that a dog is looking out for their child can help parents rest easier, too. And that may aid relationships throughout the whole family.

And it's not just dogs that can offer emotional support to kids with autism. Kids with autism who interacted with a guinea pig were more likely to approach and interact with other people, a 2010 study found.

A boost to the immune system

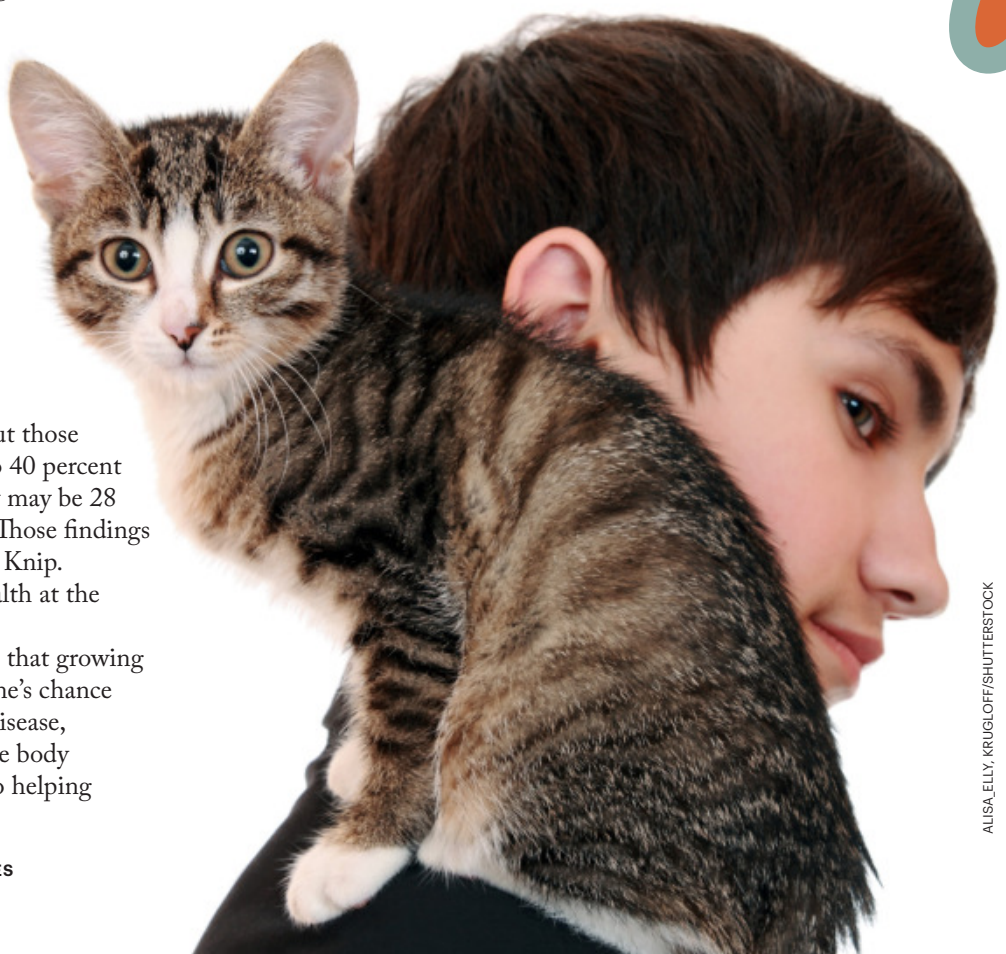
Kids may not have much control over whether they have animals at home. But those who do grow up with pets can be up to 40 percent less likely to develop asthma. And they may be 28 percent less likely to develop allergies. Those findings come from a 2020 study led by Mikael Knip. He researches child and adolescent health at the University of Helsinki in Finland.

In another study, Knip's team found that growing up around dogs may cut in half someone's chance of developing type 1 diabetes. In this disease, the immune system destroys cells of the body that make insulin, a hormone crucial to helping the body use food.

Allergies, asthma and type 1 diabetes all arise from problems with the immune system. Having pets may help prevent those conditions by training kids' immune systems.

The immune system is designed to fight off microbes, or germs, that could harm the body. But not all microbes are harmful. Early in life, the immune system must "learn" which germs cause harm and which don't. When it develops properly, the immune system only attacks harmful germs. Without the right training, the immune system can start reacting to things — inside the body or outside it — that aren't actually threats. That's what happens when someone has allergies, asthma or type 1 diabetes.

Animals themselves probably don't help train our immune system. "The idea is that early exposure to a dog or a cat in the house leads to an increased exposure to 'healthy' microbes," Knip explains. All kinds of microbes collect on an animal's paws and fur while they're outdoors. The animal then



ALISA_ELLY, KRUGLOFF/SHUTTERSTOCK

brings those microbes home, which exposes family members to the germs. Those exposures help train kids' immune systems.

Pets that spend all their time indoors do not help protect against immune-based diseases, Knip notes. Animals need to bring outdoor germs inside to boost someone's immunity. Larger animals, like dogs, seem to provide greater immune benefits than cats. "Dogs are, in general, bigger than cats," Knip says. And they may "bring more microbes into the house."

People seem to only get immune-system benefits from pets when they're very young. In Knip's diabetes study, for instance, kids had lower odds of developing diabetes only if there was a dog in the house when they were babies. "The first three years of life — and the first year in particular — are critical" for training the immune system, Knip says.

So if you're reading this now, you're already past that critical, early-life window. But if you grew up in a house with a big dog, you've probably experienced the immune benefits and didn't even know it.

Reaping the benefits

If you don't have pets, how can you get some of their benefits? Talk to your family about getting an animal. "It's really important to choose the right type of pet for you and your family," Rodriguez cautions. Maybe a dog or cat isn't an option. It may seem like too much work. In that case, "consider something like a turtle or a hamster," she says. "These pets can still be really fun to interact with but come with a bit less responsibility."

Even time spent watching a fish tank can provide some stress-relief. A 2023 study found that kids in the hospital were much less anxious and fearful when their room had goldfish in it.

If you can't have a pet of your own, it's possible to find other ways to interact with animals. "Talk to your neighbors, family members or friends," Rodriguez suggests. "Can you volunteer to walk their dog for them one day a week? Maybe they have a cat or a bunny that needs [to be] played with?" You could even visit a cat café for a quick cuddle now and then, or volunteer at an animal shelter.

Interacting with animals can be rewarding, Rodriguez says. "But animals have feelings and emotions too! Remember to always respect an animal's boundaries and personal space, just like you'd like to be treated."

CASH1994, ANNEKA/SHUTTERSTOCK

Growing up with pets in the home can help young people's health and well-being. But not all pets work in all homes. "It's really important to choose the right type of pet for you and your family," says Kerri Rodriguez.

A childhood dog inspired this veterinarian to help others

Sunday Agbonika uses animals to support children with autism in Africa

Growing up in Nigeria, Sunday Agbonika always had a dog. One was a German shepherd named Skipper. Skipper did everything with his family, says Agbonika. But his experience was unusual. "[Pet] dogs weren't such a thing in Nigeria at the time," says Agbonika. Skipper inspired him to learn more about how animals can help people.

Agbonika went to veterinary school. After graduating, he came across a video by Nathan Selove, who gives talks about living with autism. In the video, Selove explained how he struggled with school and was often bullied. After getting a service dog, though, his grades and relationships improved.

Agbonika thought about his nephew, who had passed away a few years earlier. He suspected the boy may have had autism. One of Agbonika's mentors suggested his background with animals could help support such neurodivergent children. Agbonika loved the idea. "Why not look for ways to help other children like [my nephew]?"

Today, Agbonika runs the Dogalov HumAn Support Initiative. Based in Nigeria, Dogalov uses animals to help support neurodivergent children. Agbonika also studies animal welfare and behavior through the University of Pennsylvania in Philadelphia. Here, Agbonika shares his experiences and advice with *Science News Explores*. (This interview has been edited for content and readability.) — *Aaron Tremper*

Q What was one of your biggest challenges?

A Our first challenge was reaching children who could benefit from animal-assisted therapy. We considered working with children in their homes. But the stigma surrounding autism made it a daunting experience. Instead, we tried connecting with centers that work with these children. It took a while before any of them would listen to us, but one loved the idea. They offered to have us come talk to parents and stakeholders at an event. Another center gave us the chance to run a trial to see if it would work. We ended up getting tremendous results. That let us get our message out there. Many other people have now started showing interest.

Q How is autism viewed in Nigeria?

A Many decades ago, Nigerian children who were neurodivergent were viewed with limited understanding. It was thought that either the child or the parents were witches. That idea doesn't hold any longer. But that stigma has led to a lot of denial and so many negative perceptions. The main treatment in Nigeria and much of Africa right now is through accessible schools. The children receive therapeutic services and an education.

Q What is pet ownership like in Nigeria now?

A There are more dogs and pet enthusiasts in Nigeria than when I was a child. I still wouldn't

MADURA MAHANAMA/SHUTTERSTOCK; S. AGBONIKA

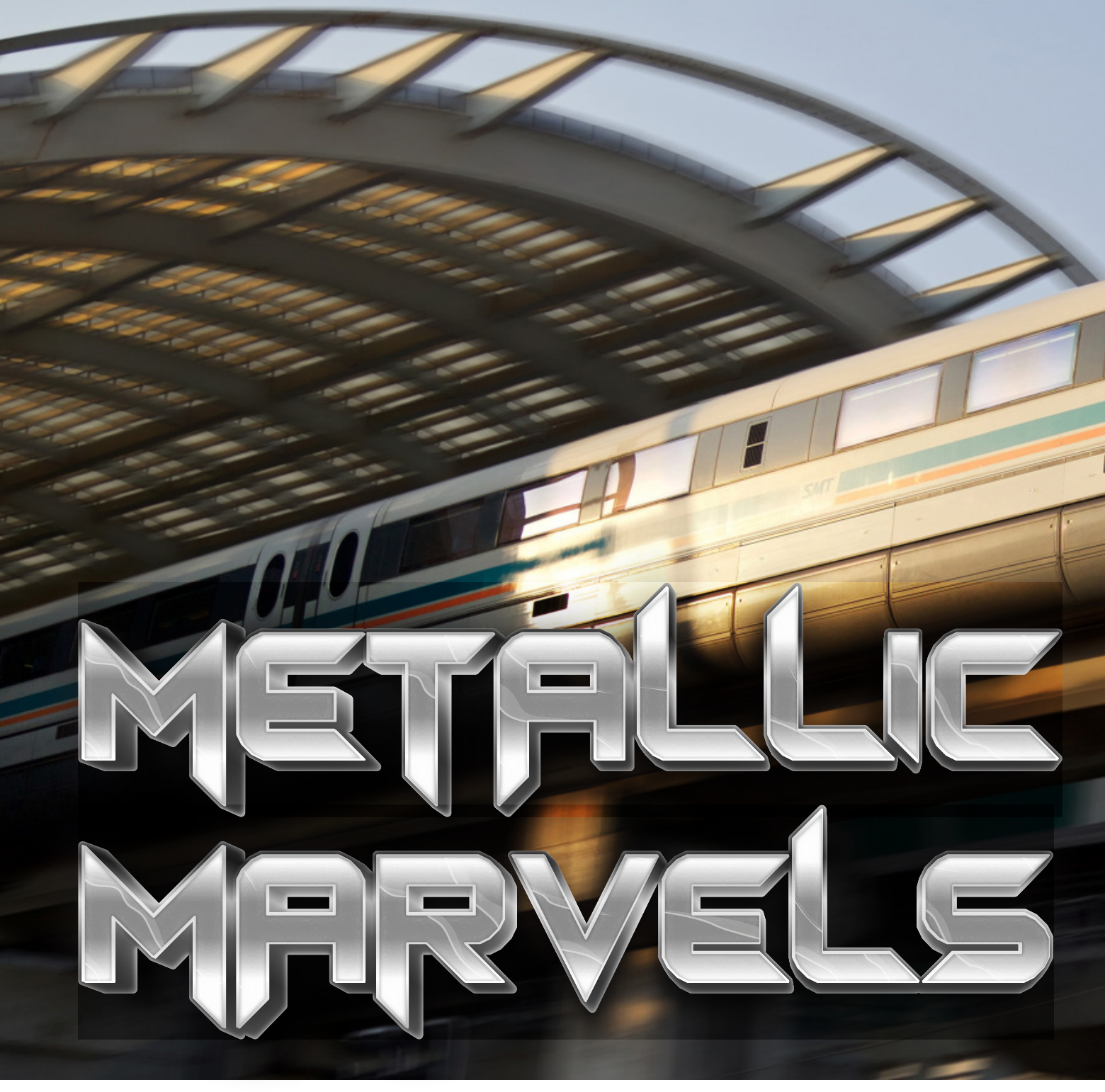
Agbonika finds that more Nigerians are choosing to own a pet dog compared with when he was a child. (Left image: Agbonika speaks at a conference. Right image: Agbonika sits with his own pooch, Tinkerbell, left, and his friend's dog, Snow, right.)

Sunday Agbonika credits his childhood dog with inspiring him to attend veterinary school. Today, he uses animals to help support neurodivergent children in Africa.

say the average Nigerian is a dog person or even an animal person just yet. But more people are growing to love the idea of having a trained dog.

Q What was one of your biggest successes?

A One of my biggest successes was receiving the Mandela Washington Fellowship for Young African Leaders in 2019. The program selects Africans to go to universities in the [United States] to learn leadership and team-building skills. The fellowship helped us build a relationship with the international community. People are now getting to see the work we're doing. I now have people here in Nigeria who are more willing to hear what we have to say.



METALLIC MARVELS

Several railways in China offer high-speed magnetic levitation (maglev) train service. The Shanghai Transrapid (shown) travels at speeds up to 430 kilometers (270 miles) per hour. The magnets needed for such systems rely on rare-earth metals. These 17 elements have a subshell of electrons that give these metals magnetic and luminescent properties.

Rare earths' hidden electrons make much of modern tech possible

CHRISTIAN PETERSEN-CLAUSEN/MOMENT OPEN/GETTY IMAGES PLUS; NACREATIVE ON FREEPIK

By **Nikk Ogasa**

A driving theme in Frank Herbert's epic space saga *Dune* is the mining of a precious natural substance called spice melange. This spice wasn't something to make food taste better. It granted people the ability to navigate vast expanses of the cosmos. It also became the basis of an intergalactic civilization. That was, of course, fiction. >>

Back here on Earth, in real life, a group of metallic elements has made possible our own technology-driven society. Called rare earths, these 17 elements are crucial to nearly all modern electronics. And demand for these metals has been skyrocketing.

Fifteen rare earths make up a whole row on most periodic tables. Known as lanthanides, they run from lanthanum to lutetium — atomic numbers 57 through 71. Also included in the rare earths are scandium (atomic number 21) and yttrium (atomic number 39). Those last two elements tend to occur in the same ore deposits as lanthanides. They also have similar chemical properties.

Rare earths play many roles in our modern lives. Cerium can serve as a catalyst to process crude oil into a host of useful products. Nuclear reactors rely on gadolinium. It captures neutrons to control the production of energy by a reactor's fuel.

But the most outstanding capabilities of rare earths are their luminescence and magnetism. We rely on rare earths to color our smartphone screens. They fluoresce to signal that euro banknotes are the real deal. Rare earths relay signals through fiber-optic cables along the seafloor. They also help build some of the world's strongest, most reliable magnets. These metals generate sound waves in your headphones and boost digital data through space.

More recently, rare earths have been driving the growth of green technologies, such as wind power and electric vehicles. They may even give rise to new parts used in quantum computers.

"They're everywhere," says Stephen Boyd. He's a synthetic chemist and independent consultant based in Dixon, Calif. When it comes to the uses of rare earths, he says, "The list just goes on and on."

Superpowers start here

Rare earths tend to be malleable, meaning they are easy to deform. These metals also have high melting and boiling points. But their secret power lies in their electrons.

All atoms have a nucleus surrounded by electrons. Those tiny electrons inhabit zones called orbitals. Electrons in the orbitals farthest from the nucleus are known as valence electrons. They take part in chemical reactions and form bonds that link atoms together.

Most lanthanides possess another important set of electrons. These "f-electrons" dwell in a Goldilocks zone. It's located near the valence electrons but slightly closer to the nucleus. "It's these f-electrons that are responsible for both the magnetic and luminescent properties of the rare-earth elements," says Ana de Bettencourt-Dias. She's an inorganic chemist at the University of Nevada, Reno.

When stimulated, rare-earth metals radiate light. The trick is to tickle their f-electrons, says de Bettencourt-Dias. An energy source such as a laser

MASSIMO BREGA/SCIENCE PHOTO LIBRARY; JOAQUIN CORBALAN P/SHUTTERSTOCK

The europium in embedded fibers in a Euro banknote (left) fluoresces under ultraviolet light (right). The UV light excites the europium's f-electrons, which then fall back into their ground state and release photons of visible light in the process.

beam can jolt one f-electron in a rare-earth element. The energy boosts the electron into an excited state. Later, it will drop back to its starting — or ground — state. As it does, the f-electron emits light.

Where do the 17 elements known as rare earths fit on the periodic table?

TURN TO PAGE 28 TO FIND OUT!

The rare-earth glow

After being excited, each rare earth reliably emits precise wavelengths (colors) of light, de Bettencourt-Dias notes. This allows engineers to carefully tune the electromagnetic radiation (light) in many electronics. Terbium, for instance, emits light at a wavelength of about 545 nanometers. That makes it good for creating green-glowing phosphors in the screens of TVs, computers and smartphones. Europium, which has two common forms, is used to make red and blue phosphors. Such phosphors can paint screens with most shades of the rainbow.

Rare earths also radiate useful invisible light. Yttrium is a key ingredient in yttrium-aluminum-garnet, or YAG, crystals. They form the core of many high-powered lasers. Engineers tune the wavelengths of these lasers by lacing YAG crystals with another rare earth. The most popular is a neodymium-laced YAG laser. These are used for a broad range of things — from slicing steel and removing tattoos to laser range-finding. And erbium-YAG laser beams are a good option for certain surgeries. They won't slice too deeply because their light is readily absorbed by the water in our tissues.

Beyond lasers, lanthanum is crucial for making the infrared-absorbing glass in night-vision goggles. "And erbium drives our internet," says Tian Zhong. He's a molecular engineer at the University of Chicago in Illinois. Much of our digital data travels through optical fibers as light. It typically has a wavelength of about 1,550 nanometers — the same as erbium emits. The signals in fiber-optic cables dim as they travel far from their source. Because those cables can stretch for thousands of kilometers (miles) across the seafloor, erbium is added to fibers to boost their signals.

The source of mighty magnets

In 1945, scientists constructed the world's first programmable, general-purpose digital computer. Its formal name was ENIAC. But scientists quickly nicknamed it the "Giant Brain." And that was apt. It weighed more than four elephants and covered an area roughly two-thirds the size of a tennis court.

Less than 80 years later, our smartphones boast far more computing power than ENIAC ever had. Society owes this shrinking of electronic technology in large part to the exceptional magnetic power of rare earths. And those f-electrons are the reason why.

Rare earths have many orbitals of electrons, but the f-electrons inhabit a specific group — or subshell — of seven orbitals. Each orbital can house up to two electrons. But most rare earths contain multiple orbitals in this subshell with just one electron.

Neodymium atoms, for instance, possess four of these loners. Dysprosium and samarium are two rare earths with five loner electrons. Crucially, those unpaired electrons tend to point — or spin — in the same direction, Boyd says. "That's what creates the north and the south poles that we classically understand as magnetism."

These lone f-electrons flitter behind a shell of valence electrons. That somewhat shields their synchronized spins from heat and other demagnetizing forces. And that makes these metals great for building permanent magnets, Zhong says.

The magnetic fields in permanent magnets, like the ones that hold up pictures on a fridge door, arise from the magnets' atomic structure. (Electromagnets, in contrast, need an electric current. Turn it off and the magnetism turns off, too.)

But even with their shielding, rare-earth magnets have limits. Pure neodymium, for example, readily corrodes and fractures. Its magnetic pull also starts to lose strength above 80° Celsius (176° Fahrenheit).

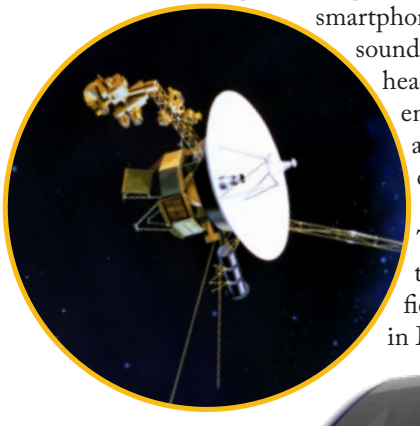
Mountain Pass (left), in southeastern California, remains the United States' only mine for rare-earth elements (inset), which are used in smartphones, wind turbines and electric vehicles.

So manufacturers often make alloys of rare earths with some other metals. This makes those magnets more resilient than if they had been made from rare earths alone, says Durga Paudyal. He's a theoretical physicist at Ames National Laboratory in Iowa.

This alloy approach works well, he adds, because some rare earths can orchestrate the magnetic fields of other metals. Just as weighted dice will preferentially land on one side, some rare earths — such as neodymium and samarium — exhibit stronger magnetism in certain directions. It's because the orbitals in their 4f-subshells are unevenly filled. This directionality can be used to coordinate the fields in other metals, such as iron or cobalt. The result: robust, extremely powerful magnets.

Super magnets have jobs

The most powerful alloy magnets are NIBs — a mix of neodymium, iron and boron. A NIB magnet can lift an object hundreds of times its own weight. More than 95 percent of the world's permanent magnets are made from this rare-earth alloy. These are the magnets that generate vibrations in smartphones and produce sounds in earbuds and headphones. They enable the reading and writing of data on hard-disk drives. They also create the magnetic fields used in MRI machines.



Adding a bit of dysprosium to these magnets can boost their heat resistance. Now they become a good choice for the rotors that spin in the hot interiors of the motors driving many electric vehicles.

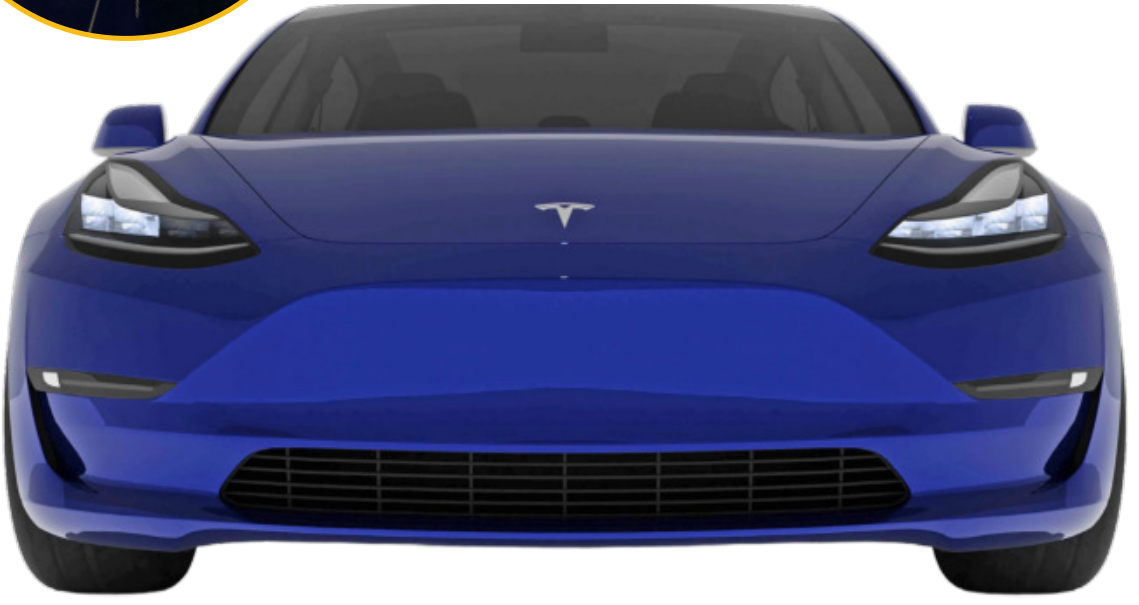
Developed in the 1960s, a samarium-cobalt alloy went into the first popular rare-earth magnets. Though slightly weaker than NIB magnets, samarium-cobalt ones have superior resistance to heat and corrosion. That makes them great for use in high-speed motors, generators, speed sensors in cars and airplanes — and in the moving parts of some heat-seeking missiles.

Samarium-cobalt magnets also form the heart of the devices used to boost signals emitted by most radar systems and communications satellites. Some of these rare-earth-based signal boosters are transmitting data from the Voyager 1 spacecraft. Launched in September 1977, that craft is the most distant human-made object — already more than 24 billion kilometers (15 billion miles) away (as of July 2024).

Recycling rare earths

Strong and reliable, rare-earth magnets are at the heart of many green technologies. These metals are found in the motors, drivetrains, power steering and many other parts used in electric cars. Tesla's use of neodymium-alloy magnets in its farthest-ranging Model 3 cars has sparked worries that magnet-makers may soon find it hard to get enough neodymium (which is mined largely in China).

Rare-earth magnets also replace gearboxes in many offshore wind turbines. They help boost the turbines' efficiency and cut their need for servicing.



Rare-earth elements can be found in human-made objects near and far, ranging from a Tesla Model 3 (left) to the Voyager 1 spacecraft (inset), the first spacecraft to reach interstellar space.

NASA/JPL-CALTECH; DODOTHABOI/SHUTTERSTOCK

Where are rare earths mined?

A small number of countries currently mine for rare-earth elements (shown). But rare-earth resources have been identified in many other locations, including Vietnam, Turkey and Greenland.

SOURCE: E. DEADY/GLOBAL RARE EARTH ELEMENT (REE) MINES, DEPOSITS AND OCCURRENCES/BRITISH GEOLOGICAL SURVEY 2021

And in 2022, Chinese engineers introduced "Rainbow." It's the world's first magnetically levitated train line to rely on rare earths. Its magnets enable the trains to float above their tracks without consuming electricity.

Rare earths may even soon advance quantum computing. Conventional computers store and record data as binary bits — 0s and 1s. Quantum computers instead use quantum bits. Also called qubits, they can occupy two data states at once. Crystals containing rare earths make good qubits, Zhong says, because their shielded f-electrons can store quantum data for long periods of time. One day, scientists might even manipulate the light-emitting properties of rare-earth qubits to share information between quantum computers. It could give birth to a quantum internet, Zhong says.

It's too early to predict exactly how rare-earth metals will boost the expansion of all these emerging technologies. But it's probably safe to say: Rare earths better not be too rare, because we're going to need a lot of them.

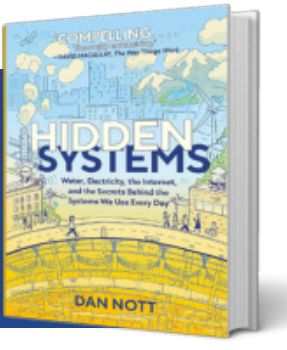
ANDREI MINSK/SHUTTERSTOCK; RANDOM HOUSE GRAPHIC

READ MORE

Hidden Systems:
Water, Electricity, the Internet, and the Secrets Behind the Systems We Use Every Day

By Dan Nott

Rare-earth elements are often the secret ingredient in the evolution of today's technology. With this graphic novel, explore the hidden history of the utility systems, like internet and electricity, that make our modern world possible.



PHYSICS

What's the speed of light in Jell-O?

You can find out using a laser pointer and a bit of math

By Science Buddies

When light passes from one material to another, it often bends, or *refracts*. The amount and direction that a light beam bends at the boundary between two materials depends on: (1) the angle at which the light hits that boundary and (2) the *index of refraction* of the two materials. A material's index of refraction depends on how fast light travels through it. This mathematical relationship is captured in an equation called *Snell's law*. Let's measure the refraction of laser light as it passes from air into Jell-O and use Snell's law to calculate the speed of light in Jell-O.

OBJECTIVE

Measure the speed of light in Jell-O using a laser pointer

EXPERIMENTAL PROCEDURE

1. Make a box of Jell-O in a square container. Let it set, then remove the Jell-O from its container.

2. Shine a laser pointer at one side of the Jell-O block.

3. Measure the angle at which the light beam hits the Jell-O, and the angle at which the beam refracts inside the Jell-O.

4. Use Snell's law (see snexplores.org/gelatinlight) to calculate the Jell-O's index of refraction.

5. A material's index of refraction is the speed of light in a vacuum divided by the speed of light in that material. Use this definition to calculate the speed of light in Jell-O.

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

SCIENCE BUDDIES

To avoid eye injury, be sure to only point your laser at objects — not people or animals.

LOVELY BIRD, PIXEL-SHOT/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. Can you find them all?

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

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BANANAS
BRAIN
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CHATBOT
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DIAMOND
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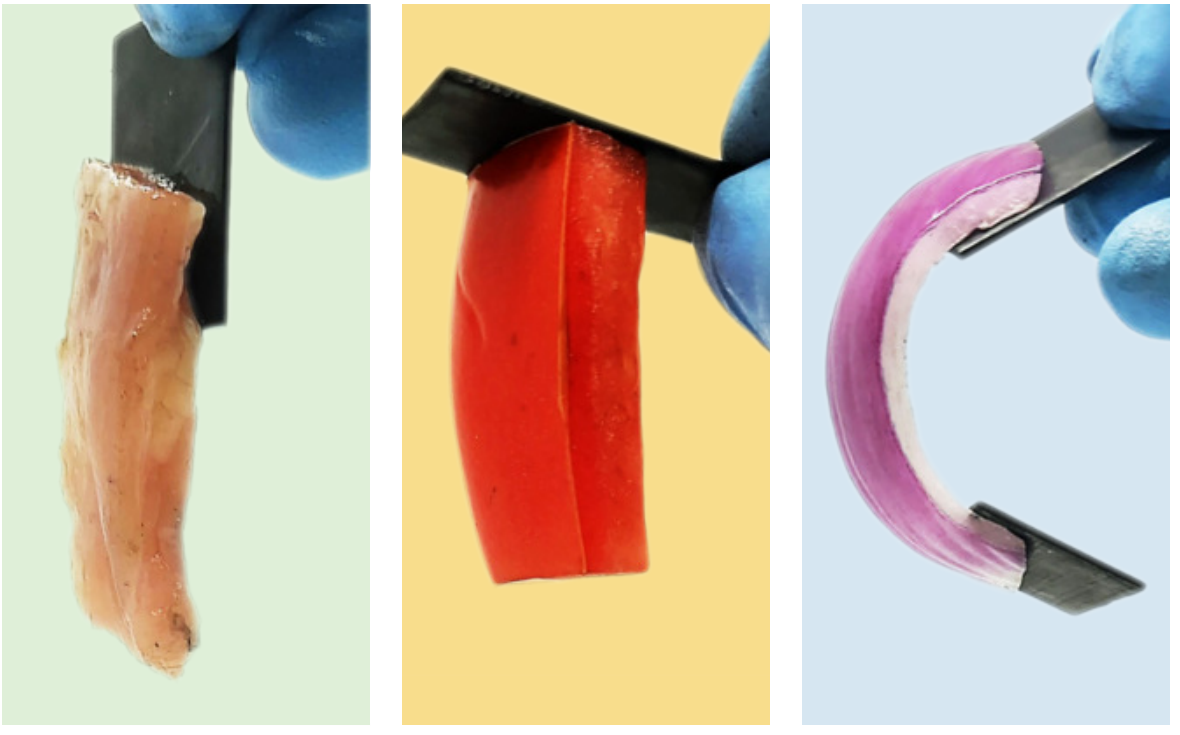
ELEMENT
GRAPHITE
HELIUM
KRYPTONITE
MAGNET
METAL
PLUTO
POLYMER
PRESERVED
QUBIT
RARE EARTH
REFRACTION
STATISTICS
THERAPY DOG
TIMEKEEPER
ULTRAVIOLET

PATPITCHAYA/SHUTTERSTOCK

TECHNOLOGY

Electricity can glue hard metals to soft materials

Playful experimentation in the lab revealed this shocking effect



A weak electrical current was able to glue metal pieces to a variety of soft tissues, including a piece of chicken (left), a tomato (center) and an onion (right).

SRINIVASA RAGHAVAN/UNIVERSITY OF MARYLAND

When you imagine a scientist, you might picture a serious-looking person peering into vials or frowning at equations. But not all science is serious. In a lab at the University of Maryland in College Park, researchers spend a lot of time playing around with different materials just to see what will happen. That fun, improvised exploration has led to some cool discoveries. One of the latest: A weak electric current can stick hard metals to soft gels and tissues.

The exact science behind this effect is still a mystery. But the unexpected find could one day lead to new types of batteries, move robots or attach medical implants to tissues inside people's bodies.

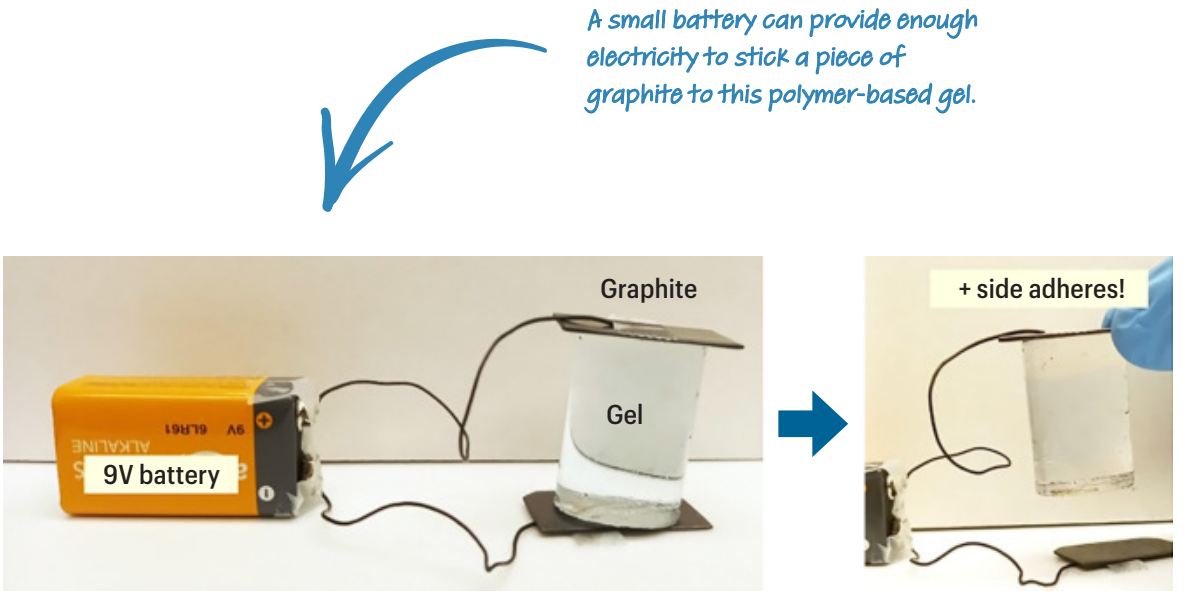
Chemical engineer Srinivasa Raghavan runs the lab that did this work. His group aims to create soft solids with unusual properties using household materials. Their Rapid Seal Wound Gel stops bleeding by knitting blood cells together. Another gel, made from Jell-O and cornstarch, forms a protective layer that can keep an egg from cracking if dropped.

"The way that we do research is not that different from how it would be done in a middle school or high school," Raghavan says. "We kind of, you know, mix things and see what happens."

STICKY SCIENCE

In 2021, the lab created a polymer-based gel that could be stuck to animal tissues. The researchers placed a piece of this gel on a slice of meat and applied a low-voltage electric current to the gel for a few seconds. When the current stopped, the gel and meat had been glued together. One day, surgeons might use a gel like this instead of stitches or staples to put patients' tissues back together, Raghavan says.

That experiment got other lab members thinking about ways



Although the team didn't use a battery in its experiment, one could be used to supply electricity, as shown here. A power source like this feeds an electric current through a wire attached to the top (positive) electrode. The current runs through the gel and out the bottom (negative) electrode. This piece of gel stuck to the positive graphite piece.

SRINIVASA RAGHAVAN/UNIVERSITY OF MARYLAND

to use electricity. Wenhao Xu, a chemist, decided to see if he could stick some graphite lying around the lab to a piece of gel by running a current through it.

He put two flat pieces of graphite — the stuff found in pencil lead — on opposite sides of a piece of gel. Then he clipped wires onto the graphite pieces and added 5 volts of electricity. That's the amount needed to charge a cell phone.

The graphite pieces acted as electrodes, moving electricity through the gel. Electric current ran into the gel through one piece — the positive electrode — and out through the other piece — the negative electrode.

When Xu tried to pull the graphite off of the gel, the negative electrode came off but the positive one was thoroughly stuck. Intrigued, Xu placed the other piece of graphite back on the gel and switched the wires so that the current ran through the gel in the reverse direction. When the current stopped, the gel came free from the first piece of graphite it had been stuck to. But now it was stuck to the other piece, which was now the positive electrode.

THE PLOT THICKENS

Xu next tried replacing the gel with other kinds of materials. He tested fruits, vegetables and different kinds of meat. He also used a variety of metals for the electrodes.

"Either one side sticks — the plus side sticks or the minus side sticks — or both sides stick," Raghavan says. "There's no rhyme or reason." Beef sticks to the positive, or "plus side," electrode. Pork sticks to the negative, or "minus side," electrode. Jell-O and banana stick to both pieces of metal. And some metals work with some soft materials but not with others.

The team shared its findings in *ACS Central Science*.

"There are lots of things we don't fully understand," Raghavan says. The electric field must somehow change the chemistry where the soft and hard materials meet. But the team doesn't yet know how or why.

"I find this work fascinating because of its simplicity," says Kevin Turner. He is a mechanical engineer at the University of Pennsylvania in Philadelphia who was not involved with the study. Turner is especially impressed the researchers could stick things together underwater, "which is something that is generally hard to do." Try using a piece of tape underwater — it won't stick. But the new study shows that electricity can get the job done for certain materials.

Members of the lab continue to play around and experiment. "Research should be fun," Raghavan says. You don't have to have special training or use special equipment to do science. "You [just] need to have a sense of curiosity."

— *Alison Pearce Stevens*

CHEMISTRY

Kryptonite's out-of-this-world glow is too good to be true

UV light helps Earth's minerals with their glow up

Found on the fictional planet Krypton, kryptonite (inset) holds the power to weaken Superman (above).

Superman is faster than a speeding bullet and more powerful than a train. His one weakness? Kryptonite, a radioactive mineral found on the fictional planet Krypton. A power stone that can sap the Man of Steel of his superhuman powers, kryptonite is often shown as a glowing green crystal.

Earth does have its own gleaming green minerals. Some are even radioactive. But these minerals don't glow on their own like kryptonite. Instead, ultraviolet (UV) light gives these crystals their inner light. There are over 500 kinds of these minerals.

The glow happens because fluorescent minerals contain excitable atoms known as activators. When UV light hits these atoms, their electrons gain energy. The excited electrons jump up to a higher energy state. As they lose energy, they return to their former position. Some energy is lost as invisible heat. The rest is emitted as visible light.

Most of the minerals seen glowing on their own in movies "wouldn't make much sense," says Gabriela Farfan. She is the gem and mineral collection curator at the Smithsonian National Museum of Natural History. That's in Washington, D.C. Fluorescent minerals need a steady energy source to keep them aglow. To keep their shine in a museum, for instance, these crystals are displayed with a UV lamp, says Farfan. Shutting off the lamp stops the glow almost immediately.

Some minerals phosphoresce. They continue to glow after they are removed from UV radiation. Their electrons stay excited for longer and release their energy more slowly.

In 2008, researchers found that one of the rarest jewels in the world has its own afterglow. It's the Hope Diamond, a deep-blue stone housed at the Smithsonian. (In addition to being quite large, the diamond is famed for its supposed curse.) Under UV light, researchers found, this precious gem emits a red glow lasting several minutes.

JORDI GRASIOT RUIZ - PHOTO/MOMENT/GETTY IMAGES; CUM OKOLO/ALAMY

In 2008, researchers found that this famous jewel phosphoresces a brilliant red under ultraviolet light.

Excited boron atoms give the famous jewel this fiery hue.

Phosphorescent stones probably wouldn't make good movie props, though. Some crystals can phosphoresce for days. But their shine is best viewed in dark settings. Seeing one glow in a lit room would be tricky, says Farfan.

AN EERIE GREEN GLOW

Though kryptonite may outshine glowing rocks here on Earth, our planet boasts minerals in similar shades of unearthly green. Many uranium-containing minerals come in bright colors, notes Farfan. Even without UV radiation, "they kind of look like they're poisonous," she says.

Flick on a UV lamp and some of these minerals fluoresce a bright yellowish-green. Lime-green autunite is a source of uranium used for nuclear power. It's also prized among rock hunters for its glow. Autunite fluoresces because of uranyl ions, says Ed Raines. He is the curator of the Mines Museum of Earth Science at the Colorado School of Mines in Golden. Uranyl consists of a positively charged uranium atom bonded to two oxygen atoms.

Autunite also contains water in its crystal structure. When autunite dehydrates, it gets converted to meta-autunite. This toxic mineral produces radioactive flakes. This dust can easily be rinsed off. It doesn't produce radiation strong enough to penetrate intact skin. But inhaling or swallowing these flakes can be harmful. "If you were to get [the flakes] on your hands and pick up your peanut butter and jelly sandwich and eat that, you could be in trouble," says Raines.

A REAL SUPERPOWER

Earth's glowing minerals won't stop a superhero in his tracks. However, fluorescence can help experts identify valuable stones and even catch forgeries.

"Gemologists use it every single day," says Farfan. Gemologists examine precious gemstones to determine their value. Cutting a stone for a piece of jewelry can make it hard to identify a gemstone by only its structure. Fluorescence gives gemologists tools to see features they can't see with their eyes alone.

Testing a stone with UV light can reveal heat treatments used to brighten stones or epoxy used to fill cracks. Fluorescence can help sort out human-made from natural gems. Under short-wave UV light, for instance, many synthetic sapphires fluoresce a chalky blue. Natural sapphire rarely does the same. And certain gems glow different colors when exposed to UV light. This can help determine if a rare gemstone is fake.

"If you're buying a very expensive piece of jewelry, you want to make sure that that actually is a sapphire [and] not a piece of glass," says Farfan.

KRYPTONIAN CONUNDRUMS

In 2007, researchers discovered a mineral with a similar chemical makeup as the kryptonite from *Superman Returns*. Called jadarite, this dull white mineral fluoresces pinkish-orange. News headlines dubbed it a real-life kryptonite.

But comparing kryptonite to any mineral found on Earth is impossible, says Raines. Chemistry, heat and pressure work in all sorts of ways to form minerals on and within a planet. Geologists would need to know the makeup of planet Krypton to figure out how these forces produce kryptonite.

And since no one has yet discovered a real-life counterpart to that fictional planet, kryptonite remains Superman's secret.

—*Aaron Tremper*

Excited uranyl ions make the mineral autunite fluoresce bright yellow-green. Each uranyl ion consists of a uranium atom bound by two atoms of oxygen.

At nearly 46 karats, the Hope Diamond (above) holds the record for the world's largest deep-blue diamond. It's on display at the Smithsonian Museum of Natural History in Washington, D.C.

WIRESTOCK, INC./ALAMY; JOHN NELS HATLEBERG; ALBERT RUSS/SHUTTERSTOCK

Your Guide to the **PERIODIC TABLE OF THE ELEMENTS**

Hydrogen: 74% of the universe is made of this

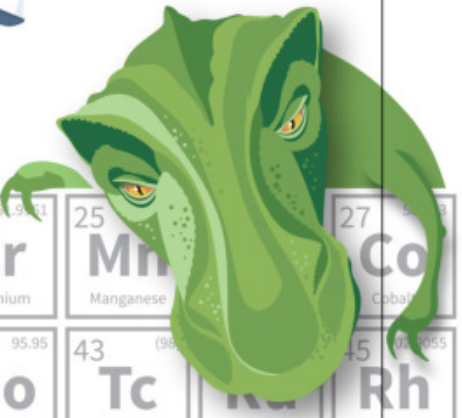
Potassium: Bananas give you a healthy dose of this

Calcium: Needed for healthy bones and teeth

Francium: There's only 30 grams of this on all of Earth

Titanium: A strong, lightweight metal found in airplanes and sunscreen

Iridium: A layer of this in the geologic record marks the end of the dinosaurs



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3 Li 6.938 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.011 Carbon	7 N 14.007 Nitrogen	8 O 15.999 Oxygen	9 F 18.998 Fluorine	10 Ne 20.180 Neon
11 Na 22.989 Sodium	12 Mg 24.304 Magnesium											13 Al 26.982 Aluminum	14 Si 28.085 Silicon	15 P 30.974 Phosphorus	16 S 32.06 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.948 Argon
19 K 39.0983 Potassium	20 Ca 40.078 Calcium	21 Sc 44.9559 Scandium	22 Ti 47.867 Titanium	23 V Vanadium	24 Cr Chromium	25 Mn Manganese	27 Co Cobalt										
37 Rb 85.4678 Rubidium		39 Y 88.9058 Yttrium	40 Zr 91.224 Zirconium	41 Nb 92.906 Niobium	42 Mo 95.95 Molybdenum	43 Tc (98) Technetium	Ru Ruthenium	45 Rh Rhodium									
55 Cs 132.905 Caesium	56 Ba 137.327 Barium	57-71 Lanthanoids*	72 Hf 178.49 Hafnium	73 Ta 180.948 Tantalum	74 W 183.84 Tungsten	75 Re 186.207 Rhenium	76 Os 190.23 Osmium	77 Ir 192.217 Iridium									
87 Fr (223) Francium	88 Ra (226) Radium	89-103 Actinoids*	104 Rf Rutherfordium	105 Db (268) Dubnium	106 Sg (269) Seaborgium	107 Bh (270) Bohrium	108 Hs (277) Hassium	109 Mt (278) Meitnerium									

Rare-earth elements (see page 18)

57 La 138.905 Lanthanum	58 Ce 140.116 Cerium	59 Pr 140.908 Praseodymium	60 Nd 144.242 Neodymium	61 Pm (145) Promethium	62 Sm 150.36 Samarium	63 Eu 151.964 Europium											
89 Ac (227) Actinium	90 Th 232.0377 Thorium	91 Pa 231.036 Protactinium	92 U 238.029 Uranium	93 Np (237) Neptunium	94 Pu (244) Plutonium	95 Am (243) Americium											

Uranium: Radioactive element used for nuclear power and bombs

Nickel, Copper, Zinc: Found in money

Helium: 24% of the universe is made of this

Carbon, Nitrogen, Oxygen, Phosphorus, Sulfur: Along with hydrogen, the most common elements in the human body

Noble gases that like to be on their own

Silicon: A common element in sand used to make glass and computer chips

Gallium: This metal melts in your hand!

Chlorine, Bromine, Iodine: These elements react with metals to form salts, like NaCl — table salt

Silver, Platinum, Gold: Jewelry!

Mercury: This metal is liquid at room temperature

These only exist in the lab

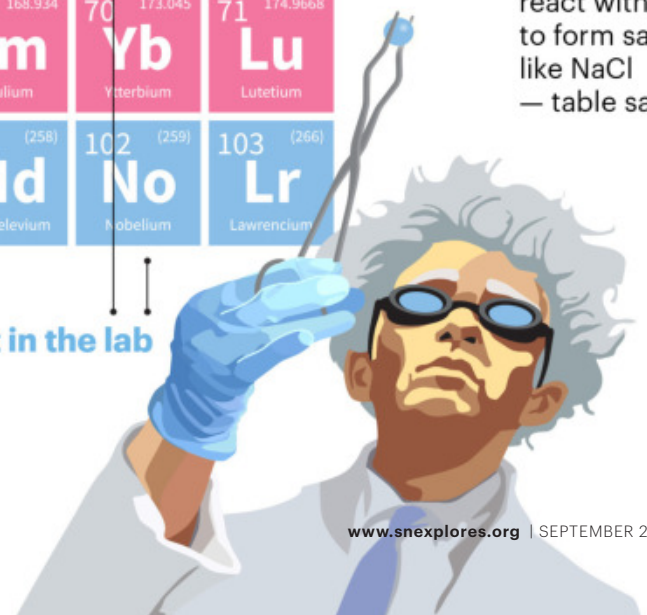


ILLUSTRATION BY STEVE MCCRACKEN

ARCHAEOLOGY

Human brains can last thousands of years

Some natural processes preserve the organs longer than others

When scientists find ancient preserved human brains, they often call their finds unique. But there may be brains hiding inside many excavated human skulls. New research suggests that human brains can resist decay for at least 12,000 years.

Alexandra Morton-Hayward is a forensic anthropologist at the University of Oxford in England. She led the study. She and her colleagues scoured four centuries of archaeology research papers for mentions of naturally preserved brains. They found over 4,400 brains reported from hundreds of dig sites.

The researchers sorted these brains into five types based on the processes that shielded them from rotting away. Some had been frozen or dried out. Others had been tanned, preserving the organ through the same process used to treat leather. This can happen when human remains react with chemicals found in bogs. Still other brains had been saponified. This process turns some of their fats into a fairly stable soapy substance known as grave wax. "It's really disgusting," Morton-Hayward says. "It smells absolutely terrible."

Nearly one-third of the brains didn't fall into one of these four types. In all these cases, all that remained of the body's once soft, squishy tissues was the preserved brain. Some unknown mechanism must have saved these brains from degrading, the team thought.

Brains preserved by this unknown process tended to persist far longer than the other types of brains. The oldest one was more than 12,000 years old. More than half of these specimens came from wet environments — sunken shipwrecks, the bottom of wells, lake beds and so on.

The research appeared in the *Proceedings of the Royal Society B*.

Based on studies of soft tissues from dinosaurs and other ancient creatures, the team hypothesized how the unexplored mechanism safeguards brains. Morton-Hayward suspects that aspects of the brain's chemistry and functioning during life preserve it after death. The types of proteins and lipids in the brain may be especially prone to linking up in a way that makes big, stable molecules.

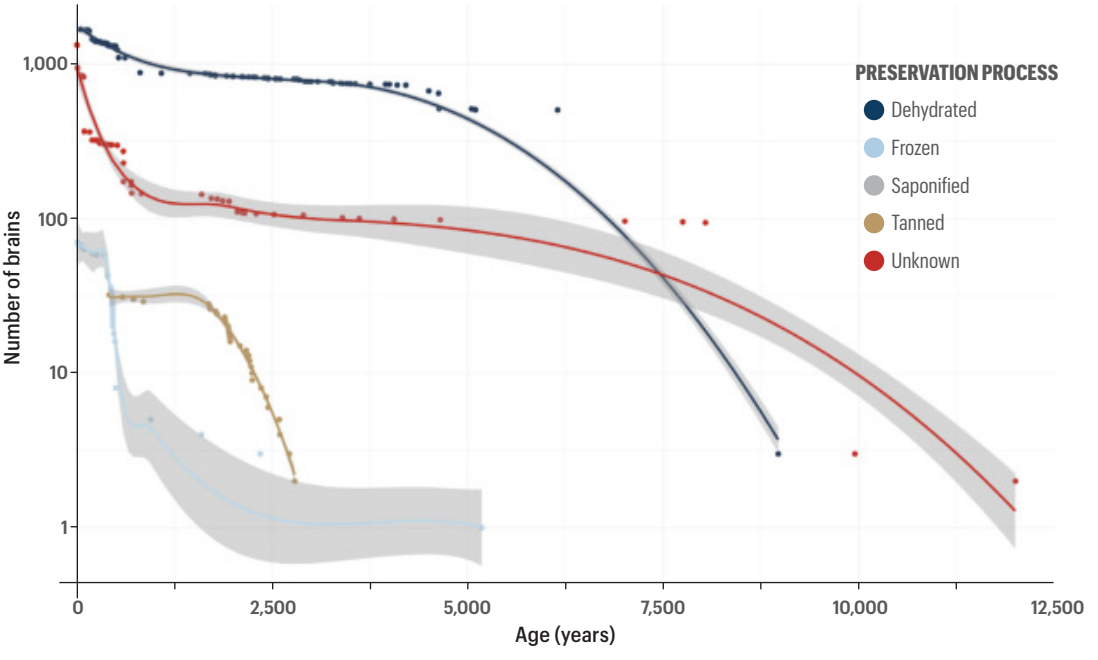
With the mystery preservation process at play, long-lasting brains may be more common than researchers realized. "I'd just love if other archaeologists were as excited as I was to go out to my next dig and gently rattle every skull," Morton-Hayward says.
— *Carolyn Wilke*

The folds of soft, wet tissue on a 1,000-year-old brain from Belgium (right) are stained orange with iron oxides.

A. L. MORTON-HAYWARD

Forensic anthropologist Alexandra Morton-Hayward holds up a 200-year-old brain that has been preserved in formalin.

Brain preservation



DATA DIVE

1. Which type of preservation accounts for the most brains?

2. What process or processes preserve brains for the shortest time?

3. How does the number of brains in the "unknown" category change with age?

4. How does the change in the number of "unknown" brains with age compare with that of frozen brains? How does it compare with tanned brains?

5. Where do you think frozen brains were found? What about dehydrated brains?

6. What is another way that these data could have been presented?

This graph shows the number of preserved brains of each type with different ages. The x-axis shows brains' ages in years, increasing from left to right. The y-axis shows the number of brains found preserved up to each age. This number includes all brains that are the age marked on the x-axis or older. (For instance, look at the data point for "unknown" brains at an x-axis value of about 7,000. It has a y-axis value of about 100. That means there are about 100 "unknown" brains that are about 7,000 years old.)

The farther archaeologists look back in time, the fewer preserved brains they generally find. So the number of brains of each type decreases as the age on the x-axis increases. The shape of the curve (the line that follows the points) shows how the number of brains found for each type drops off with increasing age. There weren't enough locations with saponified brains to draw trends about their changes with age.

MORTON-HAYWARD ET AL/PROCEEDINGS OF THE ROYAL SOCIETY B 2024

ANSWER

These cells help keep airways clear

They trigger coughs when they sense something headed for the lungs

Ever taken a gulp of water that goes down the wrong way? It probably made you cough. Cells in the lower throat may be helping you out.

For a long time, scientists didn't know exactly what drove this reflex. But they knew a quick reaction was important. Water or something else that doesn't belong "can cause airway damage," explains Laura Seeholzer. She studies the nervous system at the University of California, San Francisco. Such damage could even stop our breathing.

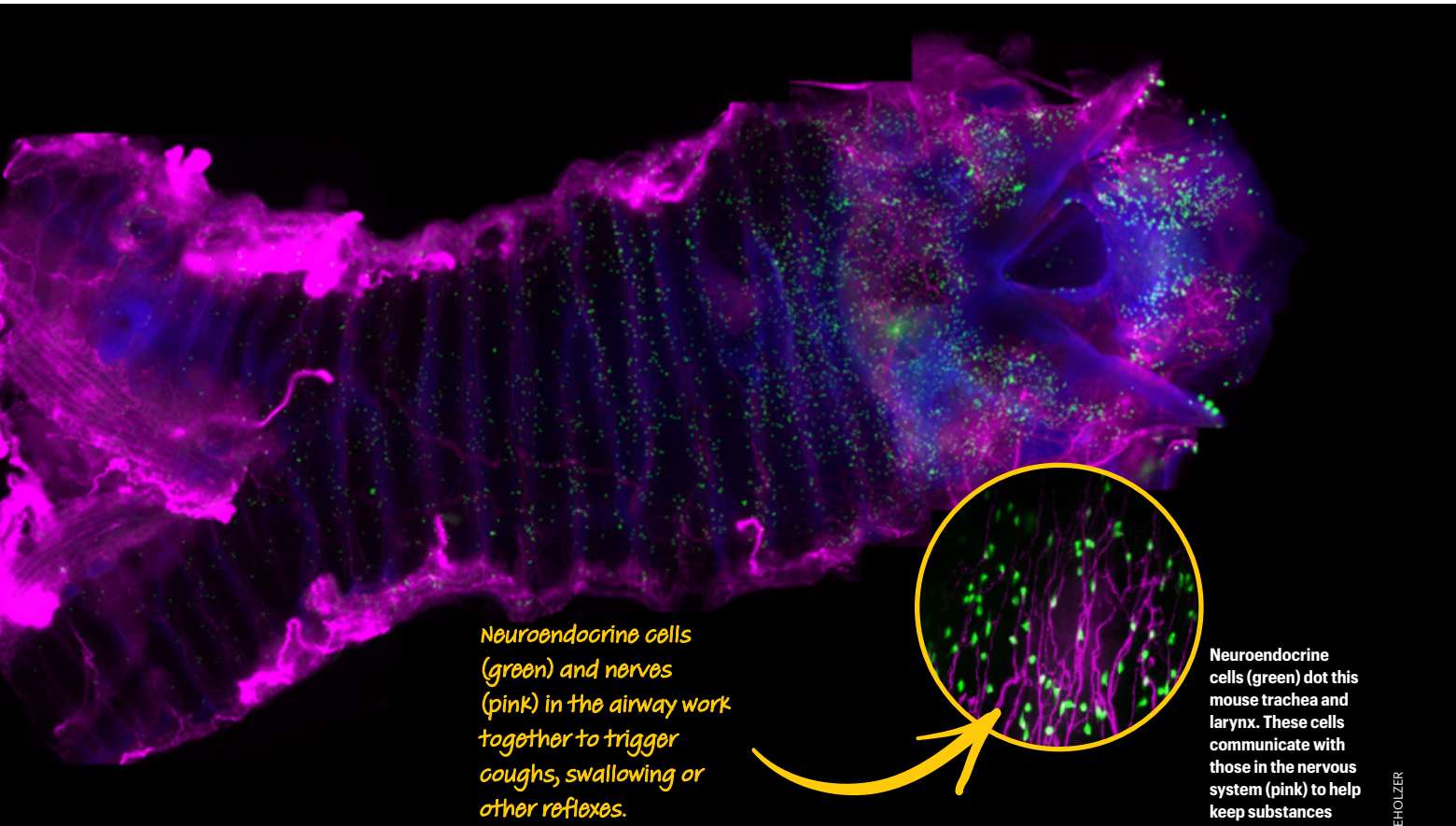
Seeholzer and a colleague, David Julius, studied neuroendocrine cells found in mouse airways. They grew the cells in the lab. The cells responded to water and acid, the team reported in *Science*.

Other experiments activated these cells in mice. When triggered, the neuroendocrine cells made the mice swallow and cough. This may help keep unwelcome things out of the lungs.

"This is not at all what I was expecting [these cells] to be detecting or doing," Seeholzer says. Neuroendocrine cells usually release hormones in the body.

But here, they act more like sensors. If they detect possible harm, they signal the nervous system to respond. That reflex could help protect us from harmful substances.

— *Nora Bradford*



Neuroendocrine cells (green) and nerves (pink) in the airway work together to trigger coughs, swallowing or other reflexes.

Neuroendocrine cells (green) dot this mouse trachea and larynx. These cells communicate with those in the nervous system (pink) to help keep substances such as water or acid from getting into the lungs.

LAURA SEEHOLZER

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? Aditi Avinash, winner of the Seaborg Award at the 2024 Regeneron Science Talent Search, shares her experience.

Q What inspired this project?

A Aditi recalls her freshman-year biology teacher talking about enzymes "and specifically about the Lactaid pill." That pill contains an enzyme to aid digestion in people with an intolerance to the lactose in dairy products. "That kind of got me curious as to why there wasn't a 'Glutaid' pill," she says. "I have a lot of friends who have celiac or are gluten intolerant. And a lot of people in my family are gluten intolerant."

Q How did this project challenge you?

A "A big thing is just my capacity to problem-solve," Aditi says. She describes herself as "an anxious planner" who likes to know exactly what's going to happen and when. But "every day of research is just so different," she says. "You can have a plan and a set schedule, but nothing really goes according to plan."

Q What resources helped you?

A "My research started off so incredibly simple ... reading different articles in my room and highlighting," Aditi says. Later, she got help from her science teacher and found a research mentor at a local university. "You have to remember that you are a high school student doing research," she says. "It's not a humbling or embarrassing thing to ask for help."

Seaborg Award winner

Aditi Avinash

Aditi, 18, dreams of creating a pill that lets people with celiac disease or gluten intolerance eat wheat. People with these conditions have a hard time digesting proteins in wheat known as gluten. For her project, Aditi tested three fruit enzymes that had been shown to break down gluten. Combining the chemicals made them even better at breaking down the proteins, she found. Aditi graduated from Rock Canyon High School in Highlands Ranch, Colo.

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EXPLORE
OUR SOCIAL MEDIA

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