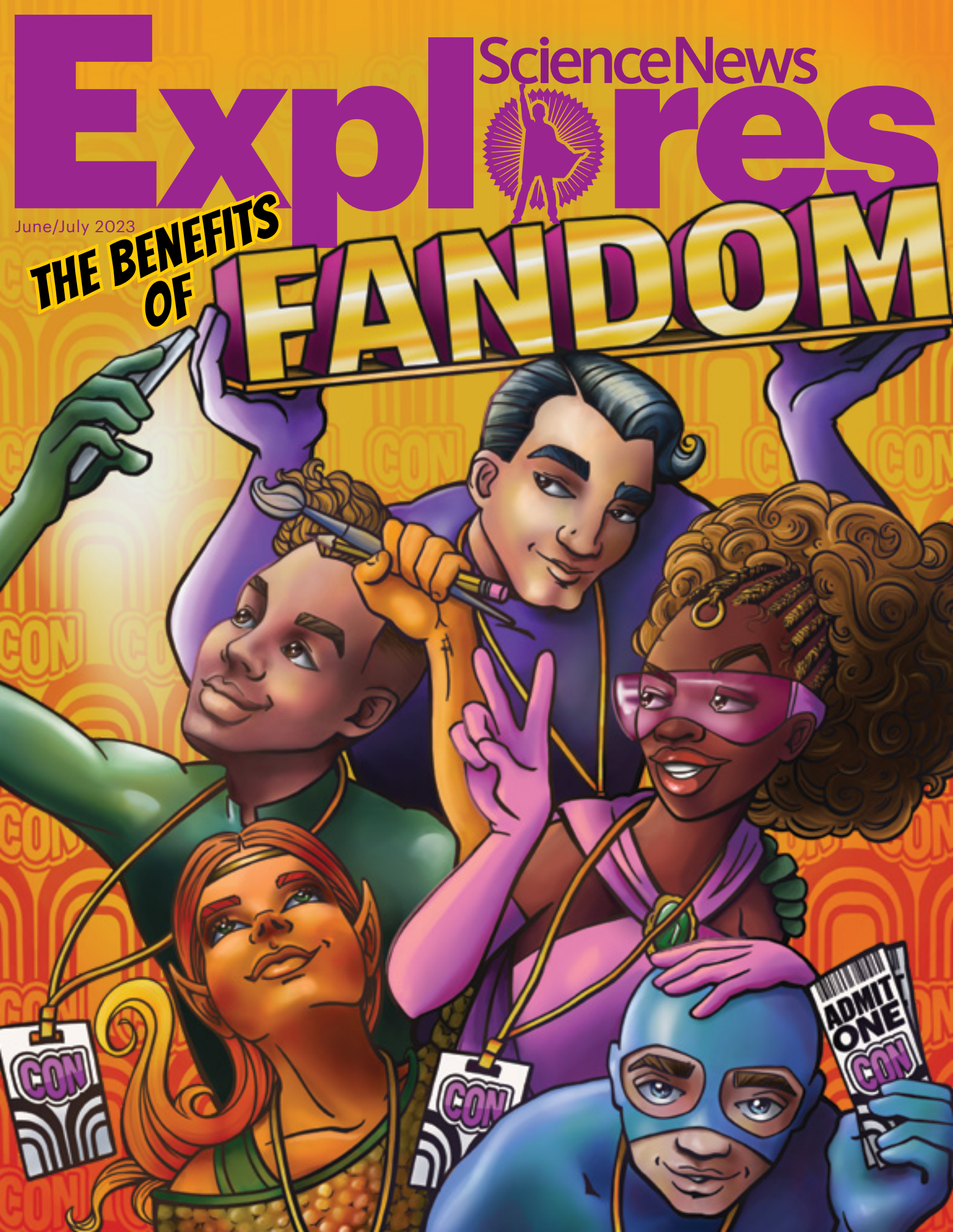
Science News Explores
June/July 2023

THE BENEFITS OF FANDOM



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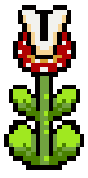

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Q How does brain freeze work?

— *Faith Y.*

A Brain freeze can strike after eating, drinking or inhaling something cold, such as ice cream. This intense headache usually lasts for a few minutes at most. Despite brain freeze being common, researchers aren't sure what causes it. But they have some ideas for what may be happening. Cold foods or air may aggravate cold-sensitive nerves in your palate — the hard plate on the top of your mouth. Or that tasty milkshake may force your body to widen blood vessels in your head. While this reaction is meant to help warm your mouth, it might also cause pain. Try eating cold treats slowly if you find yourself getting a brain freeze.

Q Why does hair turn lighter in the summer?

— *Emily Z.*

A Hair and skin both get their color from a pigment called melanin. Melanin also helps protect fragile proteins in your hair by absorbing radiation from the sun. That radiation — ultraviolet and visible light — breaks down the color pigments. Cells in your skin react by creating more melanin, giving you a tan. Human hair, though, cannot produce more melanin to protect it from the sun. Without added protection, radiation damages the hairs' protein and pigment. This leads to your hair getting lighter, or photobleaching. The sun is causing chemical and physical changes to your hair. That's why strands may get frizzy or brittle in summer, too. This phenomenon is more likely to be noticeable on the heads of people with light-colored blond or red hair than those with darker hair. Don't worry — you can protect your hair in summer by wearing a hat!

Q If you were at the center of the Earth, would you float? Because gravity is pushing at you from all sides.

— *Mason R.*

A "Yes! If you were at the center of the Earth, you would feel like there was no gravity at all and would float," says Jonathan Sorce, a physicist at the Massachusetts Institute of Technology in Cambridge. But it's because of gravity's pull, not push. "When you are on the surface of the Earth, all of the different parts of the Earth beneath you pull on you using gravity, causing you to feel like you are being pulled down toward the ground," Sorce says. "But if you were at the center of the planet, then the parts of the Earth above you would pull you up with exactly the same force as the parts of the Earth below you that pull you down. These two effects would cancel each other out, and you wouldn't feel any pull from the Earth's gravity."

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*

FIND OUT MORE USING THE QR CODES.

ANDY HEYWARD/SHUTTERSTOCK

PHYSICS

Friction controls how dominoes topple

Computer modeling reveals the physics behind the chain reaction

Dominoes may seem like just fun and games. But understanding how they topple? That's some serious science.

"It's a problem that is so natural. Everybody plays with dominoes," says David Cantor. He has a background in civil engineering and does research at Polytechnique Montréal in Quebec, Canada. He studied dominoes with his friend Kajetan Wojtacki, a physicist at the Institute of Fundamental Technological Research. That's part of the Polish Academy of Sciences in Warsaw.

The pair used a computer to model a row of dominoes collapsing. It's a chain reaction, where each falling domino topples into the next. And the speed of that cascade depends on friction, the team reported in *Physical Review Applied*. The friction happens in two places. Dominoes rub together as they collide. They also slide along the surface on which they stand.

The computer model showed that the fastest fall took place when slippery dominoes stood close together on a rough surface, such as felt. Slicker tiles meant less friction between dominoes, which meant less energy lost when the blocks hit each other. Sitting on a high-friction surface meant the tiles didn't slide too far back as they fell. Such backsliding would otherwise slow the cascading chain reaction.

The domino duo used math to describe these computer simulations. They came up with an equation that predicts the speed of collapse under different conditions. Its predictions matched the experimental results, too. Turns out, there's fantastic physics behind the satisfying spectacle.

— *Emily Conover*

ENVIRONMENT

An estimated 170 trillion bits of plastic are floating in the world's oceans

That's about 21,000 particles for each person on Earth.*

*PLOS ONE, *March 8, 2023*

NATULRICH; ROMAN MIKHAILIUK/SHUTTERSTOCK

EARTH

Climate change could mean fewer blue lakes

Algae that thrive in warmer water can tint lakes green or brown

About a third of the world's lakes are currently blue, according to the first worldwide tally of lake color. But if average air temps in summer rise just a few degrees, some of those crystal blue waters could turn a murky green or brown.

Lake color depends in part on what's in the water. Compared with blue lakes, green or brown lakes have more algae, suspended sediment and organic matter. That's according to Xiao Yang. A hydrologist, he works at Southern Methodist University in Dallas, Texas.

Yang was part of a team that analyzed the color of more than 85,000 lakes around the world. The researchers used satellite photos from 2013 to 2020. They then looked at local climates during the same time period. That can be tricky. For many spots on the globe, records of temperature and precipitation don't exist. The scientists had to piece together info from fairly sparse records to make climate "hindcasts." (That's the opposite of a forecast.)

Average summer air temperatures and lake color were linked, the researchers found. Lakes were more likely to be blue in places where summer temps averaged less than 19° Celsius (66° Fahrenheit).

About one out of every seven now-blue lakes in the study are near that temperature threshold. That means just a bit more warming might tip them away from blue. By 2100, scientists think Earth could average up to 3 degrees Celsius (about 5 degrees Fahrenheit) warmer than today. That rise could turn another 3,800 lakes green or brown. Why? Warmer water can boost algae growth, Yang says. And more algae can tint the water green-brown. Yang's team shared its findings in *Geophysical Research Letters*.

Studying 85,000 lakes may sound like a lot. Still, it's just a small share of the world's lakes. So it's tough to know how these results might apply everywhere. "We don't even know how many lakes there are in the world," says Catherine O'Reilly. An aquatic ecologist at Illinois State University in Normal, she worked on the study.

People often use lakes for drinking water, food or recreation. If the water is more clogged with algae, it could be unappealing for play. Or it might cost more to clean it for drinking. So, O'Reilly says, people might find less value in less-blue lakes.

But the color changes might not mean the lakes are any less healthy. "[People] don't value lots of algae in a lake," O'Reilly notes. "But if you're a certain type of fish species, you might be like, 'This is great!'"

Color also can hint at the stability of a lake's ecosystem. A change in hue might signal shifting conditions for the critters that live there. One benefit of the new study is that it gives scientists a baseline for spotting future changes.

"[The study] sets a marker that we can compare future results to," says Mike Pace. He's an aquatic ecologist at the University of Virginia in Charlottesville. He says: "That's, to me, the great power of this study."

—*Jennifer Schmidt*

Warmer summers may boost algae growth, tinting more of the world's lakes brown (inset) rather than blue.

FABIAN PLOCK; SHUANG LI/SHUTTERSTOCK

CHEMISTRY

Keep the creaminess, hold the ice

A new ingredient could prevent gritty ice crystals in ice cream

Ice cream researchers are testing a new way to keep this treat more cream-y than ice-y.

Ice cream contains tiny ice crystals. Those crystals grow as it sits in your freezer, explains Richard Hartel. He's a food engineer at the University of Wisconsin–Madison. If the crystals get too big, they make the treat coarse and gritty.

The ice crystals grow because of how a freezer slightly warms and cools over time. That cycle lets the ice melt a bit and refreeze. Smaller crystals melt more quickly and tend to reform as bigger, grittier-tasting ones. Only if the ice cream is kept *really* frigid, Hartel says — as in below –40° Celsius (–40° Fahrenheit) — will its ice crystals stay tiny.

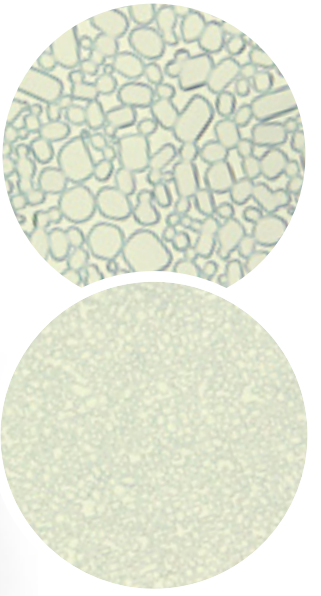
To help limit the crystals' growth, ice cream companies add substances called stabilizers. These are usually gums (such as guar or locust bean gum). Gums help but don't completely stop ice crystal growth. Once those crystals hit 50 micrometers (0.0002 inch) in diameter, the ice cream gets gritty.

Tao Wu is a food scientist at the University of Tennessee in Knoxville. He and his team are trying to find better ice cream stabilizers. They're testing cellulose nanocrystals, or CNCs, which are non-toxic and made from processed wood. CNCs may stick to the ice crystals and prevent them from growing.

In one experiment, the scientists added CNCs to a sugar solution (as an ice cream stand-in). After 24 hours, the ice crystals completely stopped growing. A week later, they were still no bigger than 25 micrometers. But a gum allowed the crystals to reach 50 micrometers in just three days. Wu's team reported its findings at the American Chemical Society meeting in San Diego, Calif.

CNCs need more research before they become common ingredients in food. Until then, you still have a good excuse to eat your family's ice cream quickly.

— *Anna Gibbs*



Ice crystals formed in a frozen sugar solution (upper right). Adding tiny crystals of cellulose before freezing kept the ice crystals from growing as large (lower right). Smaller ice crystals keep frozen treats (left) tasting creamy and smooth.

BAIBAZ/SHUTTERSTOCK; MIN LI

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

MAKING SPACE FOR OUTER

The next astronauts to walk the moon will be more diverse than the last ››

ARDEA-STUDIO/SHUTTERSTOCK

By **Lisa Grossman**

EVERYONE

Fifty years have passed since the last astronauts walked on the moon. Now, with the launch last year of Artemis I, NASA is finally preparing to send people back. This next generation of spacefarers will face new challenges. NASA expects them to stay on the moon longer and learn how to live there. This work will pave the way to send the first people to Mars.

NASA astronaut Zena Cardman (above, and right wearing a prototype space suit with astronaut Drew Feustel) was one of the first women to undergo training for a potential moon mission.

NASA/ROBERT MARKOWITZ

These new mission goals will require 21st century astronauts to have different knowledge, skills and temperaments than Apollo crews did. Fortunately, NASA is now picking from a much wider array of candidates.

NASA's Apollo missions in the 1960s and 1970s sent 24 white men to the moon. But thanks to social, political and scientific changes over the last 50 years, today's astronauts are more diverse in sex, race and field of expertise. NASA has declared that upcoming moon missions will include the first woman and first person of color. Some groups are even thinking about how to include people with disabilities in spacefaring.

This progress doesn't just broaden the pool of talent available for creating a more permanent human presence in space. Future lunar crews may reflect our lives on Earth more faithfully, opening space to everyone.

Meet the modern astronauts

NASA hasn't selected the next visitors to the moon yet. But there are only about 50 people to choose from. That includes at least 40 active astronauts and 10 astronaut candidates still in training. The members of that cohort come from a variety of backgrounds. The list includes medical doctors and military pilots. It also includes geologists, microbiologists, engineers and others. Of NASA's active astronauts, about 37 percent are women.

"The astronaut corps is, of course, NASA's most visible workforce," says Lori Garver. She was NASA's deputy administrator from 2009 to 2013. "Because of that, NASA has, I think, a responsibility to have an astronaut corps that reflects the nation."

Modern astronauts are already different from those of Apollo. For its first class of astronauts in 1959, NASA recruited only military fighter pilots. They all had to be shorter than 5 feet, 11 inches (1.8 meters) to fit inside NASA's space capsule. At the time, all military test pilots were white men. So, all astronauts were too.

NASA recruited its first class of "scientist-astronauts" in 1964. The move drew criticism from pilots. One was Eugene Cernan, who went to the moon on the Apollo 17 mission in 1972. In an interview, Cernan called science "a parasite" on the moon program. "Science is not the reason we learned to fly," he griped.

But according to NASA's mission report, Apollo 17 was "the most productive and trouble-free manned mission." It "demonstrated the practicality of training scientists to become qualified astronauts." Today, 42 percent of NASA's active astronauts have training in science or medicine. Their fields range from oceanography to physics.

What makes an astronaut

NASA's definition of "astronaut" doesn't actually require going to space. Once you've made it through the application and training process, you're a member of the astronaut corps. That's true whether you leave Earth or not.

The first step in applying is "underwhelming," says Zena Cardman. This geobiologist joined the astronaut corps in 2017. She has not yet been to space. "You submit a very short resume," she says. "Then you wait for a long time" for a response.

There are a few basic requirements to apply. First, you must be a U.S. citizen. You also need a

master's degree in science, engineering or math, plus two years of work experience. Pilots can swap out the work experience with 1,000 hours of jet-flying time. Candidates who make it through that first round travel to Houston, Texas, for a two-round interview process.

Astronaut Reid Wiseman offered more details in an August 2022 news briefing. "What we're looking for in these first few Artemis missions … first and foremost, is technical expertise," he said. A lot of those desired skills revolve around acquiring resources to support long stays on the moon.

Artemis III plans to send people to the lunar south pole as soon as 2025. That could be a good place to put a long-term base. The south pole has regions that will be in sunlight for the entire 6.5-day Artemis III mission. The light will help generate energy from solar power. The lunar south pole also has regions in permanent shadow. Those pockets hold water ice that future human settlements could use for water and fuel.

The goal of finding and using resources on the moon is part of why science backgrounds — especially in geology — are now more important for astronauts. But in the astronaut corps, everyone does everything, Cardman says. Her background is in geology and microbiology. But she's getting trained in engineering and aviation. Her test pilot colleagues, meanwhile, are learning geoscience.

Beyond technical skill, the next most important quality NASA looks for is: "Are you a team player?" Wiseman says. Working together was important on the Apollo missions. But those missions lasted 12 days at most. Up to three days were spent on the lunar surface. Astronauts on a weeks-long Artemis mission to the moon or a years-long mission to Mars will need to survive in stressful, isolated environments. Getting along becomes crucial to staying alive.

That's why the interview process includes teamwork exercises, Cardman says. Those activities mimic the kinds of situations astronauts might find themselves in.

The interview also involves medical screening. The details are not public. But "they really go quite in depth," Cardman says. There's no official requirement for any particular body type. Nor are there standards for physical fitness, such as running a mile in a certain time. "It's more functional," she says. As long as you can meet the mental and physical demands of a spacewalk, it doesn't matter how you get in shape.

NASA engineers (above) wear spacewalk backpacks with headlamps to practice collecting lunar samples in New Mexico. At the lunar south pole, some regions will be in permanent shadow.

NASA; BILL STAFFORD/NASA

Rethinking radiation risks

There's one more medical requirement for the next people to walk on the moon. They can't have already spent too much time in space.

Over time, exposure to the harmful charged particles that zip around space can increase a person's risk of cancer. For astronauts' safety, NASA limits how much radiation an astronaut can absorb over their career.

From 1995 until 2021, that limit depended on an astronaut's age and sex. Women were thought to have higher risks of dying from radiation-related cancers than men. So female astronauts were not allowed to fly as much. This may have unfairly limited female astronauts, says Erik Antonsen. This emergency physician and aerospace engineer works at Baylor College of Medicine in Houston. Antonsen notes that no openly transgender astronauts have flown. But he can't think of any medical issues that would hold them back.

In 2021, the National Academies of Sciences, Engineering and Medicine released a report urging NASA to change its radiation limit. The new limit amounts to about 400 days in orbit around the moon or 680 days on the lunar surface.

Since Cardman hasn't been to space yet, she's as far from NASA's radiation limit as she could be. Her cohort is beginning to fly missions to the International Space Station. They are likely candidates for Artemis III. Cardman herself could be the first woman on the moon.

She's modest about it. "I would be thrilled to go to the moon, of course," she says. "Depending on the timeline, who knows. But it's pretty exciting to know I work with the people who will be the first ones setting foot on the moon in half a century."

The new right stuff

Even though there are no official astronaut health standards, NASA does end up selecting the healthiest people, Antonsen says. But private spaceflight companies in the United States and space programs in other countries are expanding the pool of people who get to go to space. SpaceX and Blue Origin are already sending customers on space joyrides. Those companies might be more willing to take risks — or more focused on making money — than NASA is.

"The beautiful thing about this is, the goal is eventually to send just people," Antonsen says. "It's changing. And it should change."

SpaceX won't say how it chooses who it sends to space. But Antonsen suspects that some companies' only criteria for their customers will be "making sure they can walk up the stairs to get to the vehicle."

Even that might not be a barrier for long. Some organizations are exploring how disabled people can live and work in space.

"Disability inclusion affects how we design our spacecraft," says AJ Link. He's the communications director of the nonprofit AstroAccess. "If we can make [outer] space accessible, we can make any space accessible."

Sheri Wells-Jensen (upside down) and other AstroAccess ambassadors here float in a zero-gravity flight. This adventure in weightlessness was meant to test out what life would be like in space for people with disabilities.

The most recent class of NASA astronaut candidates, who are eligible for the Artemis mission to the moon, is much more diverse than their Apollo predecessors.

NASA

To show how disabled people's strengths could be useful in space, AstroAccess took the crew above on a zero-gravity flight. The team included linguist Sheri Wells-Jensen (back row, second from left), who is blind. She was surprised that her usual instincts worked differently in a weightless environment.

ASTROACCESS/ZERO G CORPORATION

AstroAccess has organized flights for disabled people on zero-gravity aircraft. Those flights aim to show that disabled people have strengths that could be useful in space. In October 2021, 12 people with various disabilities took a parabolic flight. (That's a flight where the plane takes repeating upward and downward turns to give passengers a few minutes of weightlessness.)

"It was wicked fun," says Sheri Wells-Jensen. She's a linguist at Bowling Green State University in Ohio. Wells-Jensen, who is blind, was one of the people on that flight. "I'm not a thrill seeker. I don't even like roller coasters," she says. But while weightless, she was "surprised by how not terrified" she was.

She was also surprised at how useless her normal instincts were. When feeling about as weightless as she would on the moon, a tiny hop sent her flying to conk her head on the ceiling. The plane was so noisy that her normal ways of orienting by sound didn't work. She felt like there was no up or down.

Learning how disabled people behave on spaceflights will help all astronauts in the future, regardless of disability, Wells-Jensen says.

"Space is a profoundly disabling environment. It's always trying to kill you," Wells-Jensen says. What happens if an astronaut loses their vision, whether temporarily or permanently, on the way to Mars? Or if the spacecraft lights go off? Or smoke makes it hard to see? Designing a spacecraft to be used by blind people could help all astronauts navigate those situations.

Likewise, if an astronaut loses use of their legs, knowing how people without certain limbs navigate a spacecraft will give them options. "For able-bodied people who acquire a disability in space, we're not just going to send them home," Wells-Jensen says. "How do we make sure they're safe and can still do their jobs?"

Wells-Jensen hopes that sending disabled people on weightless flights will raise awareness of how capable they are, too. "A disabled person could take a [space] flight tomorrow," she says. "I think at this point, the limiting factor is cultural, rather than technological."

The European Space Agency, or ESA, is also recruiting disabled astronauts. These "parastronauts" will help study the kinds of adaptations needed for disabled people to fly in space. This past November, ESA named its first parastronaut. His name is John McFall, and he's a British paralympic sprinter and orthopedist. His right leg was amputated after a motorcycle accident when he was 19.

Both ESA and AstroAccess argue that now is the time to consider accessibility in space. It should be done before future spacefaring vehicles are finalized. "Retrofitting is hard," Wells-Jensen says. "Building things the way you want them is much easier."

"We want to fundamentally change the way humanity goes to space," Wells-Jensen says. "We can't become a spacefaring species if only some of us can go."

This astronaut took a winding journey into space

Kjell Lindgren treated NASA crew members before joining their ranks

Kjell Lindgren wanted to be an astronaut for as long as he could remember. He spent much of his childhood abroad with his family on U.S. Air Force bases. The straightest path seemed to be serving as an Air Force test pilot. After all, many astronauts have come from that background. But Lindgren's dreams ended when he was diagnosed with asthma, a serious respiratory disease, after graduating from the U.S. Air Force Academy and enrolling in pilot training. The Air Force decided to medically discharge him.

So Lindgren pivoted to medical school, eventually specializing in emergency medicine. After new tests showed he didn't have asthma, though, he could again think of going to space. He first worked as a flight surgeon at NASA, treating crews preparing for spaceflight. And then, in 2009, he was selected as a NASA astronaut. He has since flown into space twice, performing more than 100 scientific experiments. Now he is a member of the Artemis Team, a group of scientists and astronauts working together to send people back to the moon in 2025. In this interview, he shares his experiences and advice with *Science News Explores*. (This interview has been edited for content and readability.)

— *Aaron Tremper*

Q How did you get where you are today?

A My passion for space came from reading science fiction and watching science fiction movies. I grew up as a *Star Wars* fan. Then, in the second grade, we watched the very first launch of the STS-1 space shuttle *Columbia* on April 12, 1981. And that's when this passion really grabbed me.

The number one thing that opened doors for me and established opportunities was just hard work. By working hard, I came across really cool opportunities that weren't necessarily on the path that I had dreamed of for myself.

Q What's one of your biggest successes?

A During my most recent mission, we had a research project that was very complex. We ran into several instances where we encountered obstacles, and it made things very difficult. We had to figure out a path forward. I tried to be a good teammate, a good leader and a good scientist by sharing my expertise. I think when it comes to tasks we're proud of, we immediately think of something that went smoothly. I think it's really gratifying, though, when we meet challenges and are able to overcome those.

It's a great lesson in resilience for when we encounter obstacles at school, at our jobs or even at home. We can choose to stay frustrated or depressed. Or we can see our obstacles as an opportunity to overcome a problem and work toward success.

NASA astronaut Kjell Lindgren (right) has made two trips into space. On his most recent trip aboard the International Space Station in 2022 (above, and inset with Bob Hines), he served as the commander for SpaceX Crew 4 for 170 days.

Q What's one of your biggest failures, and how did you get past that?

A Being medically discharged from the Air Force was a very challenging time. It obliterated this dream of not only becoming a pilot but really the dream of getting to serve as an astronaut at any point. I had to figure out what the next step was. I really had to lean on my family, friends and especially my faith to determine what the future was going to look like.

I am incredibly grateful to have these opportunities to live and work in space. I'm fairly certain that I would not be in this job today if I had become a pilot. What I once saw as a curse was truly a blessing. It was a lesson in recognizing that an obstacle may not be as bad as you think it is. How trying to have a great attitude and figuring out what is next on that path is really important.

NASA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WHY FANDOM FEELS GOOD — AND MAY BE GOOD FOR YOU

SCIENTISTS EXPLORE THE REASONS AND REWARDS OF FALLING IN LOVE WITH FICTION >>

By **Maria Temming**

New York Comic Con 2022 bustles with a huge cast of characters. One group of friends dressed like *Stranger Things* teens hangs out in the food court. Others decked out like characters from Super Mario and *Avatar: The Last Airbender* pose for photos. All around, fans sporting everything from Pikachu onesies to T-shirts and jeans wander through a sea of booths selling paintings, figurines or LEGO sets of fictional characters.

Every October, nerds of all stripes descend on the Javits Center in Manhattan for this festival of fandom. They show off homemade costumes, get actor autographs and more. No matter what type of fiction someone loves, they're bound to find fellow fans among these tens of thousands of people gathered to geek out about their favorite media.

Of course, attending a comic con is only one way to experience fandom, or be a fan, of fiction. Every day, people dissect new episodes of TV shows on social media. Fans build and maintain elaborate Wikis for books and movies. They create fan art of beloved characters and reimagine stories through fanfiction. Even casual fans devote time to rereading or rewatching series.

"We all are either fans or know people who are fans of a movie or a TV show or a book," says Cynthia Vinney. She's an independent pop-culture researcher and psychologist. She and other scholars are now taking a closer look at the widespread phenomenon of fandom. By studying the many types of media fans, they are gaining new insights into why people get so invested in fictional worlds. They're also learning about the benefits of fandom.

Falling into fandom

"People are drawn to fandom — no matter what it is that they're drawn to — for a lot of the same reasons," says Lynn Zubernis. She's a psychologist at West Chester University in Pennsylvania. "This is how our brains are wired," she says. "We get a lot of pleasure from indulging in the things that we love … and the intensity of those feelings is very reinforcing." Basically: "When we like something, that is immediately connected to us wanting more."

But people don't only become fans of fiction because it's fun. Research suggests that fiction also helps people make sense of the world around them. It can help them find inspiration. It also can offer insights into human nature and what gives our life purpose.

Many fans dress up, or cosplay, as favorite characters, such as these teens in costumes from the show Stranger Things.

HAVE YOU EVER GOTTEN SO ABSORBED IN A STORY THAT THE WORLD AROUND YOU JUST SEEMS TO FADE AWAY? THAT SENSE OF IMMERSION IS CALLED "TRANSPORTATION."

Comic conventions aren't just for comic fans. Left: Two fans show their love for video game characters Mario and Princess Peach.

ILLUSTRATIONS: SUNRISE ILLUSTRATIONS, KAPITOSH/SHUTTERSTOCK; FANS: M. TEMMING

Laramie Taylor is a communications researcher at the University of California, Davis. He asked 360 U.S. adults about why they were fans of their favorite media. People ranked how much they agreed with various statements. Some statements were about the fun of fiction, such as "my favorite series … makes me laugh." Others were about fiction helping people make sense of the world. For example, "my favorite series … has profound meanings or messages."

People agreed with both types of statements about equally. Taylor shared these results in *Psychology of Aesthetics, Creativity, and the Arts*. Clearly, people have a range of reasons to be fans of fiction — from casual fun to intellectual fulfillment. "But that doesn't really explain why this happens to some people and it doesn't happen to other people," Taylor says.

Fandom-prone people

The question of who's most likely to fall in love with a fictional world is still murky. But some research has connected personality traits to becoming a fan. One of those traits is empathy. That's the tendency to put oneself in another person's shoes. People with stronger empathy seem to get more invested in fictional characters, Zubernis says. That can lead to becoming a bigger fan.

The other personality trait affecting whether somebody becomes more of a serious fan is how much they tend to get absorbed in fictional story lines. Experts refer to this as "transportation." Some people are transported more easily than others. Such mental immersion can make stories feel more real. That, in turn, can foster fandom.

Taylor's research has shown some support for this. In a 2015 study, he did an online survey of nearly 400 fans of various media. He also surveyed about 160 *Star Trek* fans standing in line for a movie premiere. Both groups rated how much they agreed with statements such as "movies and shows often affect my mood." (That gauged each person's tendency for transportation.) People also rated how much they agreed with statements showing empathy. These included things like, "I often have tender, concerned feelings for people less fortunate than me."

People higher in empathy tended to be transported more readily. And that, in turn, was linked to being a bigger fan. Taylor shared these findings in *Psychology of Popular Media Culture*. But this study shows only that empathy, transportation and fandom are related, he cautions. Proving that certain traits *cause* stronger fandom would require studying people throughout the process of becoming fans.

Perks of fandom

There's a lot to like about being a fan. Fictional stories can offer a distraction from stress or a way to connect with other people. And thinking about such imaginary worlds may have very real benefits for mental health.

Take anticipation. Looking forward to stuff — be it a sequel or a new season — is a big part of the fan experience. And some research suggests that anticipating positive events can help relieve stress.

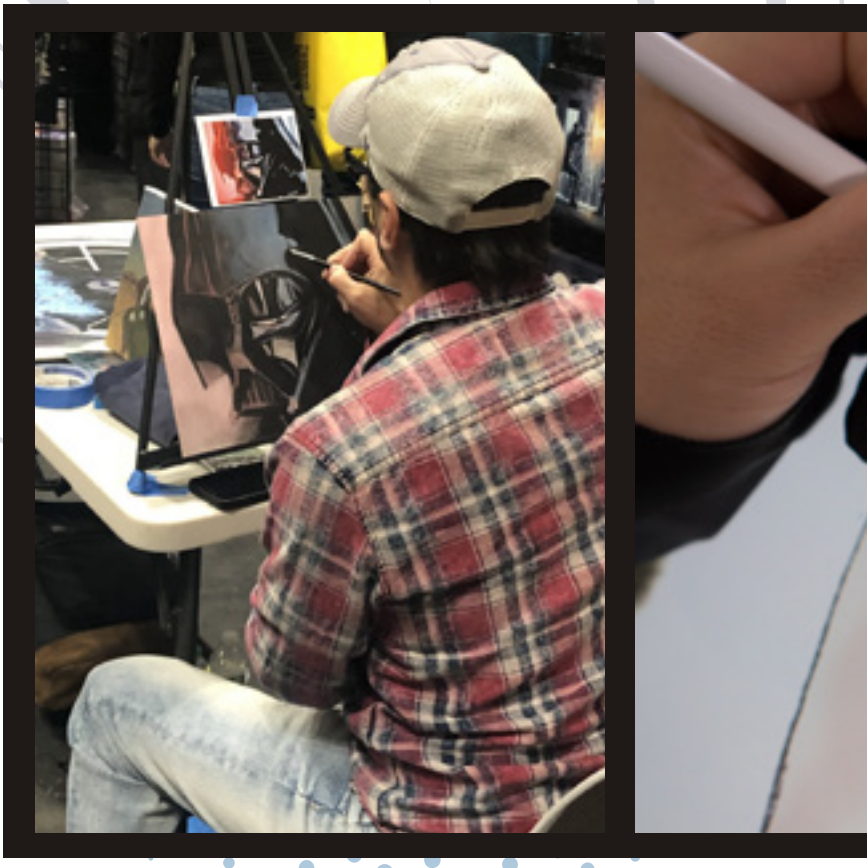
In one 2014 study, researchers recruited about 70 college students. About 30 were promised that at the end of the study they'd get to view some cartoons they were looking forward to. The other 40 were told they'd get some cartoons they were not excited to see. Then, everyone was told to prepare a speech in five minutes.

Having to prepare a speech made both groups of students feel worse than they did before. But those who were looking forward to seeing cartoons later reported more positive feelings both before and after their speech prep. Researchers shared these findings in the *Journal of Experimental Social Psychology*.

What's more, many fans do not just sit around waiting for new content to drop. They make fan art, write fanfiction, do cosplay and make fandom-related memes. "Whatever it is, if it's tapping into creativity and allowing self-expression, that's really good for people," Zubernis says. "It can be really wonderfully stress-relieving." Research also shows that spending time on such creativity can put people in better moods.

One 2016 study in New Zealand, for instance, tracked more than 650 young adults for around two weeks. Each day, participants reported how much time they had spent on creative activities such as playing music, painting or writing. Participants also shared how good or bad they felt each day and their level of "flourishing." That included elements such as having a sense of purpose in life and social connections.

People tended to have more good feelings on days after they spent more time than normal on creative pursuits. This was especially true for high-energy good feelings, such as enthusiasm or excitement. People also tended to report greater flourishing on days after they were especially creative. Researchers shared these findings in *The Journal of Positive Psychology*.



Finding identity through fandom

For some, the impacts of fandom go beyond mere mood boosts. Relating to fictional characters can help people learn about and embrace aspects of who they are. Fan communities can play a role, too. As such, "fandom can be part of identity development in a healthy way," Zubernis says.

Lauren McInroy has studied this among young LGBTQ+ people. McInroy is a social work researcher at Ohio State University in Columbus. Online fan communities, she notes, often produce creative works that add queer elements to media narratives. Many works of fanfiction and fan art, for instance, portray characters with LGBTQ+ identities.

Fans "are essentially taking [mainstream] content, remixing it and creating representational narratives with their own LGBTQ identities," McInroy says. This fan-made media, she says, "is a way to see a rich, complex queer story, and to sort of seek yourself out in the content." This network of creators and consumers can also offer young people an accepting community in which to explore queer identities.

McInroy looked at how fandom impacted the development of young people's queer identity. She and her colleagues surveyed nearly 5,000 LGBTQ+ people. All were ages 14 to 29 and living in North America. About 3,500 said they had participated in online media fan communities.

Seventy-two percent of those who were involved in fan communities online said this experience had contributed to the development of their LGBTQ+ identity. How? Many said that LGBTQ+ representation in fanworks expanded their knowledge of queer identities. Some had explored their identities by creating their own fanworks. Fan communities also offered opportunities to meet other queer people.

ILLUSTRATIONS: DOYANDESIGN, KAPITOSH/SHUTTERSTOCK; FANS: M. TEMMING

Have you ever drawn a picture of one of your favorite characters? That's fan art!

Those relationships helped young people feel like their queer identities were normal and valid. McInroy and her colleague Shelley Craig shared these findings in 2020 in *Psychology of Popular Media*.

Better together

Fan communities create supportive environments for many types of people. And that sense of community seems to be good for fans' overall well-being, says Stephen Reysen. He's a social psychologist at Texas A&M University–Commerce.

Reysen found evidence of this in his research. In one study, Reysen and his colleagues surveyed more than 200 college students with different fan interests. The survey measured such things as a sense of purpose in life, self-acceptance and having positive relationships with others. The survey also measured how much people identified as a fan of their favorite interest and how connected they felt with other fans.

In general, the more people felt a connection with other fans, the better their psychological well-being. This seemed to be because these people had more friends who shared their interests. Identifying as a bigger fan also was linked with greater well-being. But that link was not as strong as the one seen between fan connectedness and well-being. Reysen's team found similar trends in a survey of more than 2,800 people recruited from anime fan clubs and anime-related websites. The team published its findings in *Leisure Sciences*.

"It's really [a fan community] that leads to the well-being," Reysen says. "It's the connection with other human beings that really helps you." At least, that's what the researchers think is happening. A correlation between fan community and well-being doesn't prove the first caused the second. Maybe people with greater psychological well-being just tend to connect more with other fans.

But it would make sense for fandom friendships to promote well-being, Reysen says. "Belongingness and participating with groups, in general, in psychology research shows that you're happier."

That's not to say fandom is all sunshine and rainbows. "There are positives and negatives in everything, as well as your fandoms," Reysen says. Groups of fans, like all communities, can become embroiled in drama. TV shows get canceled. Book endings disappoint. But overall, fandom seems to be a normal, healthy and productive part of many people's lives. So, to all the teen media fans out there: Nerd on.

Research suggests that doing creative activities, such as making costumes or drawing, can boost mental health.

DRAWING: WIRESTOCK CREATORS/SHUTTERSTOCK; FANS: M. TEMMING

CHEMISTRY

Keep candy cool with evaporation

Use evaporation to keep chocolate from melting

By Science Buddies

On a hot summer day, your body is bound to sweat. That perspiration keeps you cool. As sweat evaporates off your skin, it carries heat away from your body. But can such "evaporative cooling" help other objects — such as chocolate candies — stand the heat? Let's find out!

OBJECTIVE

Discover how to use the evaporation of water to keep chocolate candy from melting.

EXPERIMENTAL PROCEDURE

1. Cut a paper towel into strips about 7.5 centimeters (3 inches) wide.

2. Lightly wet one paper towel strip by dripping water on it.

3. Tightly wrap one chocolate candy (still inside its wrapper) in the wet paper towel strip. Tightly wrap another chocolate candy in a dry paper towel strip.

4. Place the two candies side by side on a heatproof surface.

5. Place a glass upside down on the edges of the paper strips to keep the candies in place.

6. Hold a hair dryer about 20 centimeters (8 inches) above the candies.

7. Use the dryer to blow hot air on the candies for five minutes.

8. Observe how the paper towel strips have changed. Remove the paper towel strips and open the candy wrappers.

9. In a lab notebook, record what happened to the candy wrapped in the wet paper towel versus the candy in the dry paper towel.

10. Repeat steps 1–9 twice more with new candies and new paper towels.

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

SCIENCE BUDDIES

ILLUSTRATION BY STEVE MCCRACKEN

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 will 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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RADIATION
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PATPITCHAYA/SHUTTERSTOCK

TECHNOLOGY

Robotic pills may one day replace injections

This could be a more patient-friendly way to receive medicine

Do you hate getting shots? If so, you're not alone — and you may be in luck. Researchers are devising new, pain-free ways to deliver drugs, including a robotic pill. It's still in the early stages of development. But someday, such innovations could make delivering medicines more patient-friendly.

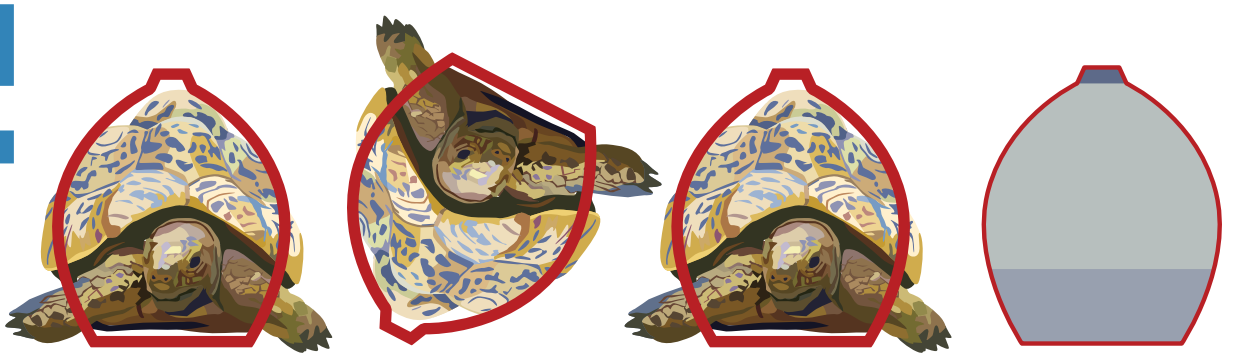
The robotic pill comes out of a lab at the Massachusetts Institute of Technology (MIT) in Cambridge. It holds a teeny, spring-loaded microneedle only about 3 millimeters (a tenth of an inch) long. Once swallowed, the pill injects medicine directly through the stomach wall.

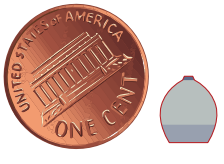
Unlike a normal shot, this needle prick shouldn't hurt, says Giovanni Traverso. He's a physician and biomedical engineer who specializes in the gut. He also helped develop the robo-pill at MIT. Stomachs can detect some sensations, such as the deep ache of a stomach ulcer. Or the discomfort of feeling bloated. But those sensations are "more related to stretch receptors," Traverso explains. The stomach lacks receptors to detect sharp pains, such as an injection.

Designing a pill that could reliably prick the stomach wall was a bit tricky. Once swallowed, the small but heavy device settles to the bottom of the stomach. In order to prick the stomach wall beneath it, the pill must land injector-side-down. To make that happen, the MIT team borrowed an idea from the leopard tortoise.

Contrary to popular belief, most tortoises can get back on their feet if flipped upside down. Leopard tortoises are aided by steeply domed shells. If one of them is flipped on its back, the shape of that shell helps it roll right-side up. That same shape ensures the new pill always lands upright, too.

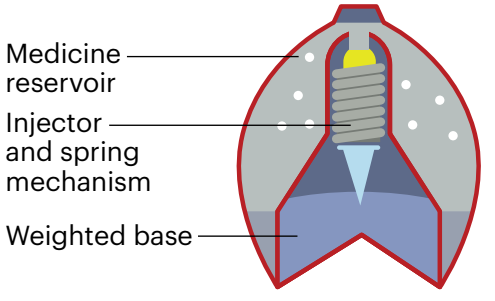
Robert Langer is a chemical engineer on the MIT team. "Watch," he says, as he drops a chickpea-sized robotic pill onto a table. It bounces, then rolls upright. "No matter how I drop it," he notes — and he drops it again — "it always lands the same way."





Actual size

The robo-pill's shape—similar to a **leopard tortoise**—plus a weighted base will roll upright when it lands.



But what makes the pill's tiny needle pop out to do its job? "Sugar glass," Langer explains. Hard and brittle, this material holds back a spring that is attached to the needle. In the stomach, that sugar starts to dissolve. "All of a sudden, the thing breaks," Langer says. This releases the spring, which jabs the needle into the stomach wall to inject medicine. It's possible to control when that happens by adjusting the sugar's thickness. The MIT team unveiled its design in 2019 in *Science*.

POTENTIAL PERKS AND PRICING

In new experiments, these robotic pills have delivered an mRNA-based medicine to mini-pigs. The researchers described their success in *Matter*. It was an important test for showing that this new class of medicines could be delivered in this way. (Pfizer's COVID-19 vaccine also relies on mRNA.)

The new robo-pills also have successfully delivered insulin in mini-pigs. Many people with diabetes must inject themselves several times a day with this hormone. Normally, insulin cannot be swallowed as a pill because it would break down in the stomach. The robo-pill gets around that problem by feeding insulin straight into the stomach wall.

This is a completely new way to deliver the drug, notes Bruno Sarmento. He works at the University of Porto in Portugal. Although he didn't work on the pill system, as a nanomedicine researcher he's interested in such projects. "We know now that it's possible" for a robotic system to reach the stomach and deliver injections, he says.

Sarmento worries that the new pill may be too expensive for widespread use. But Traverso says this could be offset by wasting less medicine. When normal pills are swallowed, the drug must pass through the stomach lining. "That's like going through a brick wall," Traverso says. It's very difficult without the help of a needle. And wasted drug is expensive — sometimes more expensive than the device.

One example is a drug used to treat diabetes. It's called semaglutide. "It's a giant seller for people with diabetes," Langer says. And when you give this medicine as a pill, he says, "you lose 99 percent of the drug." It passes through the body before it's absorbed. But the new robo-pill would ensure the drug makes it right through the stomach wall and into the bloodstream. In the end, that could save money.

After successful tests in animals, the robo-pill is now ready for human trials. The Danish pharmaceutical company Novo Nordisk, which works with the MIT team, started recruiting volunteers in March 2022.

— *Katie Grace Carpenter*

A self-righting turtle shell served as the inspiration for a new capsule-based system to release insulin. Animal tests show its microneedles can quickly release the hormone into the stomach lining.

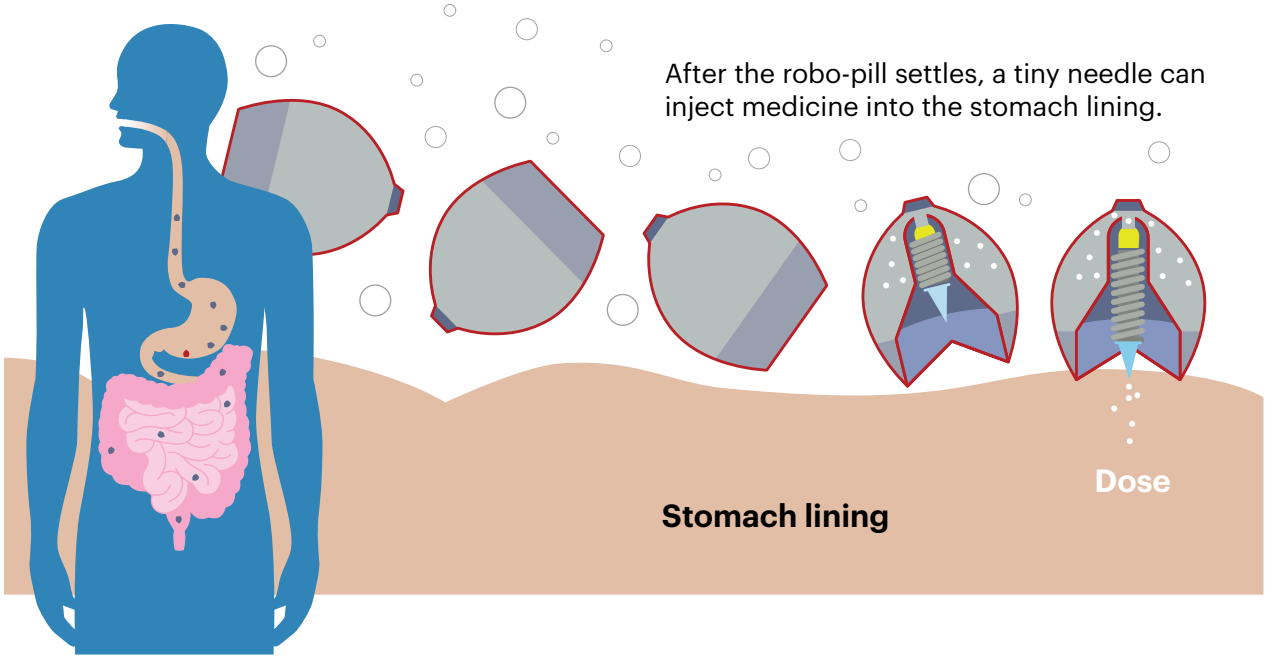


ILLUSTRATION BY STEVE MCCRACKEN

PLANTS

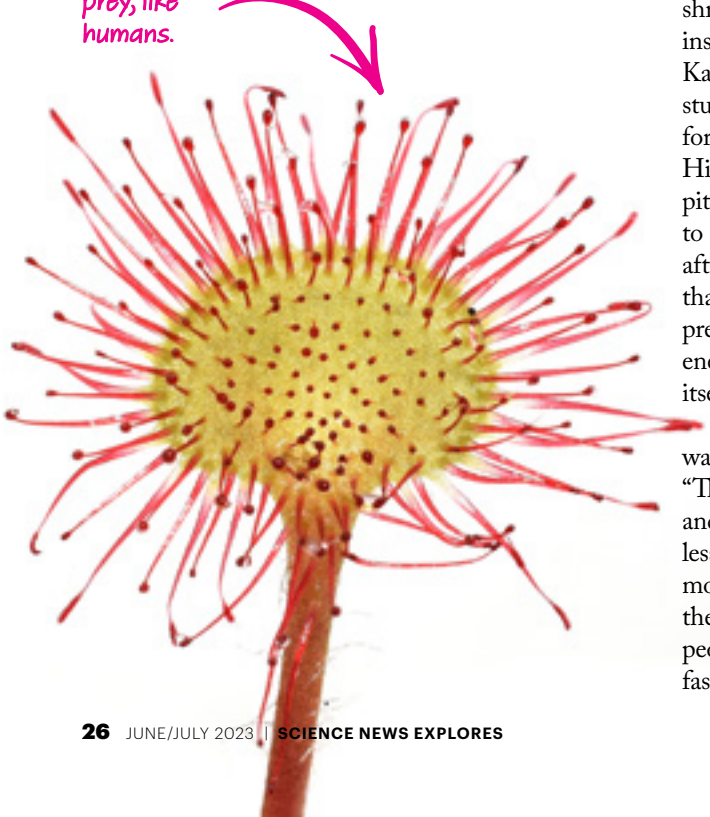
Could a plant ever eat a person?

Carnivorous plants can catch small animals, but a people-eater would need a major upgrade

There's no shortage of human-eating plants in popular culture. In the classic movie *Little Shop of Horrors*, a gigantic plant with shark-sized jaws needs human blood to grow. The Piranha Plants of the *Mario Bros.* video games hope to make a snack out of our favorite plumber. And in *The Addams Family*, Morticia owns an "African Strangler" plant with a pesky habit of biting humans.

Many of these villainous vines are based on real vegetation: carnivorous plants. These hungry flora use traps such as sticky leaves, slippery tubes and hairy snap-traps to catch insects, animal poop and the occasional small bird or mammal. Humans aren't on the menu for the 800 or so carnivorous plants known to science worldwide. But what would it take for a carnivorous plant to capture and consume a person?

A sundew's sticky secretions might be the most likely strategy to snare bigger prey, like humans.



HHELENE/SHUTTERSTOCK

DON'T FALL IN

Carnivorous plants come in many shapes and sizes. One common type is the pitcher plant. These plants lure prey into their tube-shaped leaves using sweet nectar. The lips of these "pitchers" have a slippery coating. Insects and sometimes small mammals that lose their footing on this coating plunge into a pool of digestive enzymes. Those enzymes break the animal's tissue down into nutrients that the pitcher plant absorbs.

Pitcher plants aren't equipped to make regular meals out of mammals, though. While larger species can trap rodents and tree shrews, pitcher plants mainly eat insects and other arthropods, says Kadeem Gilbert. This botanist studies tropical pitcher plants for Michigan State University in Hickory Corners. And the few pitcher plant species large enough to snare mammals are probably after these animals' poo rather than their bodies. Consuming this predigested material would use less energy than digesting the animal itself, Gilbert says.

A people-eating plant would want to save energy when it could. "The depictions in *Mario Brothers* and *Little Shop of Horrors* seem less realistic," says Gilbert. Those monstrous plants chomp, flail their vines and even chase after people. "It takes a lot of energy for fast movement."

Both of those fictional plants take cues from the real-life Venus flytrap, which, instead of sporting a pitcher, relies on jaw-like leaves to catch prey. When an insect lands on these leaves, it triggers tiny hairs that prompt the leaves to snap shut. Triggering these hairs produces electrical signals that use up valuable energy, Gilbert says. More energy is then needed to produce enough enzymes to digest the plant's prey. A giant flytrap would need massive amounts of energy to move electrical signals across its hefty leaves and also produce enough enzymes to digest a human.

Barry Rice says that the ideal man-eating plant wouldn't move. He studies carnivorous plants at the University of California, Davis. All plants have cells lined with a rigid cell wall, Rice notes. This helps give them structure but makes them "terrible at bending and moving around," he says. Real carnivorous plants with snap-traps are small enough that their cellular structure doesn't limit any moving parts. But a plant large enough to catch a person? "You'd have to make it a pitfall trap," he says.

Digesting a human may be more trouble than it's worth, though. The extra nutrients from undigested prey would promote the growth of bacteria. If the plant takes too long to digest a meal, the corpse could begin to rot inside the plant, Rice says. "The plant's got to be able to make sure it can take those nutrients out of there," says Rice. "Otherwise, you're gonna get a compost pile."

Pitcher plants use sweet nectar to lure prey to tumble into a pool of digestive enzymes.

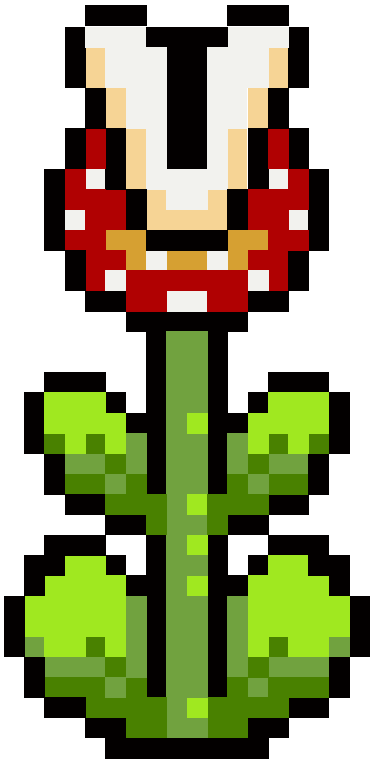
A STICKY AFFAIR

Pitcher plants and snap-traps, though, may offer humans too many chances to wriggle free. Large mammals could escape by simply thrashing about, says Adam Cross. He's a restoration ecologist at Curtin University in Perth, Australia, and has studied meat-eating plants. A person trapped in a pitcher plant could easily punch a hole through its leaves to drain the fluid and escape, he says. And snap-traps? "All you'd need to do is just cut or pull or tear your way out."

The glue-like traps of sundews, however, would prevent a person from fighting back. These carnivorous plants use leaves covered in tiny hairs and sticky secretions to capture insects. The best human-trapping plant would be a massive sundew that carpets the ground with long, tentacle-like leaves, Cross says. Each leaf would be covered in big globs of a thick, sticky substance. "The more you struggled, the more you would become enmeshed and the more your arms would be unable to function properly," says Cross. The sundew would subdue a person through exhaustion.

Sundews' sweet scents may entice insects, but that's probably not enough to lure humans into a trap. Cross recommends a fleshy, nutritious fruit or a reliable source of water. "I think that's the way to do it," says Cross. "Bring them in with something tasty, and then munch on them yourself."

— *Aaron Tremper*



Mario Bros.' **piranha plants (left) and the ravenous Audrey II from *Little Shop of Horrors* (top) take some cues from real Venus flytraps (right). But the fast chomping and big movements needed to take down a person would require too much energy for a real plant.**

PLANTS: ANAOUSS; TAWEESAK SRIWANNAWIT; KUTTELVASEROVA STUCHELOVA/SHUTTERSTOCK; POSTER: PICTORIAL PRESS LTD/ALAMY

PHYSICS

What is friction?

This force exists between any two surfaces in contact with one another

Friction is a familiar force in everyday life. It is the force felt between two surfaces when one attempts to slide against the other — whether or not they are moving. Friction always acts to slow things down. And it depends on only two things: the nature of the surfaces and how hard one presses against the other.

The material a surface is made from affects how much friction it creates. This is due to the "bumpiness" of each surface. Sandpaper, for instance, will create more friction than smooth metal.

The other factor that affects friction is how hard the two surfaces are pressing together. Very light pressure between them will result in only a small amount of friction. But two surfaces pressing together strongly will generate a lot of friction.

For instance, even two sheets of sandpaper rubbing together lightly will have only a little friction. That's because the bumps can glide over one another fairly easily. Press down on the sandpaper, though, and the bumps have a much harder time moving. They attempt to lock together.

This offers a good model for what happens even on the scale of molecules. Some seemingly slick surfaces will try to grab on to each other as they slide across. Imagine them as covered by microscopic hook-and-loop tape.

You can see friction's large-scale effect in earthquakes. As Earth's tectonic plates try to slide past one another, small "slips" cause minor quakes. But as the pressure builds up over decades and centuries, so does the friction.

Friction can also lead to dramatic fun, such as ice skating. Balancing all of your weight on skates creates a much higher pressure under their blades than if you were wearing regular shoes. This, in turn, melts the ice beneath your skates to create a liquid layer. And this thin layer of liquid allows your skate to glide — with very little friction — over the ice beneath it.

We feel the forces of friction every day as we walk, drive and play. We can lower its drag with a lubricant. But whenever two surfaces are in contact, friction will be there to slow things down.

— *Trisha Muro*

PEOPLEIMAGES.COM - YURI A/SHUTTERSTOCK

TYPES OF FRICTION

Friction is involved in many different motions, from sliding to cycling to swimming. And it can even be involved when something isn't moving at all.

ILLUSTRATION BY STEVE MCCRACKEN

ANIMALS

Sharks aren't as scary as they seem on TV

Shark Week programs lack research and give mixed messages

You can hear it in the eerie music. Or in the narrator's tone. Something bad is about to happen. On Shark Week, a week of documentary-style shows on cable TV, suspenseful sounds often cue terrifying tales of shark attacks.

But such incidents are rare, says Lisa Whitenack. She's a biologist and geologist at Allegheny College in Meadville, Pa. "You are more likely to get hit by lightning than to be bitten by a shark," she says. And as long as sharks aren't provoked, they usually leave people alone.

Whitenack and other shark scientists were concerned that the scary stuff on Shark Week was misrepresenting sharks. They also suspected that Shark Week didn't contain much science. She and her colleagues set out to gather data on their hypotheses. "Because that's what good scientists do," she says.

Her team watched 201 episodes of Shark Week. For each 40-minute episode, the researchers kept tabs on which species of sharks appeared, what was said about them and the research methods cited in the shows. The researchers shared their findings in *PLOS One*.

Shark Week often gave muddled messages. Over half of the shows gave both positive and negative messages about sharks.

"In some cases, we saw stuff that was just not true or was exaggerated," Whitenack says. "That creates fear." For instance, she recalls one episode of Shark Week that focused on possible encounters with a prehistoric shark. "The entire episode was fiction," Whitenack says. But many viewers missed a message about the show's staged events and thought the extinct creature could be alive today.

Many shark species are rare and endangered. Shark Week shows provide some information about sharks' roles in ecosystems and how to protect the animals. But the team found that only six episodes gave viewers ways to help sharks. "The messaging needs some work," Whitenack concludes.

Just like scientists, viewers should ask lots of questions. And they can fact-check what they've heard on TV. "Don't take it all at face value," Whitenack cautions. "Just because it's on TV doesn't mean it's true."

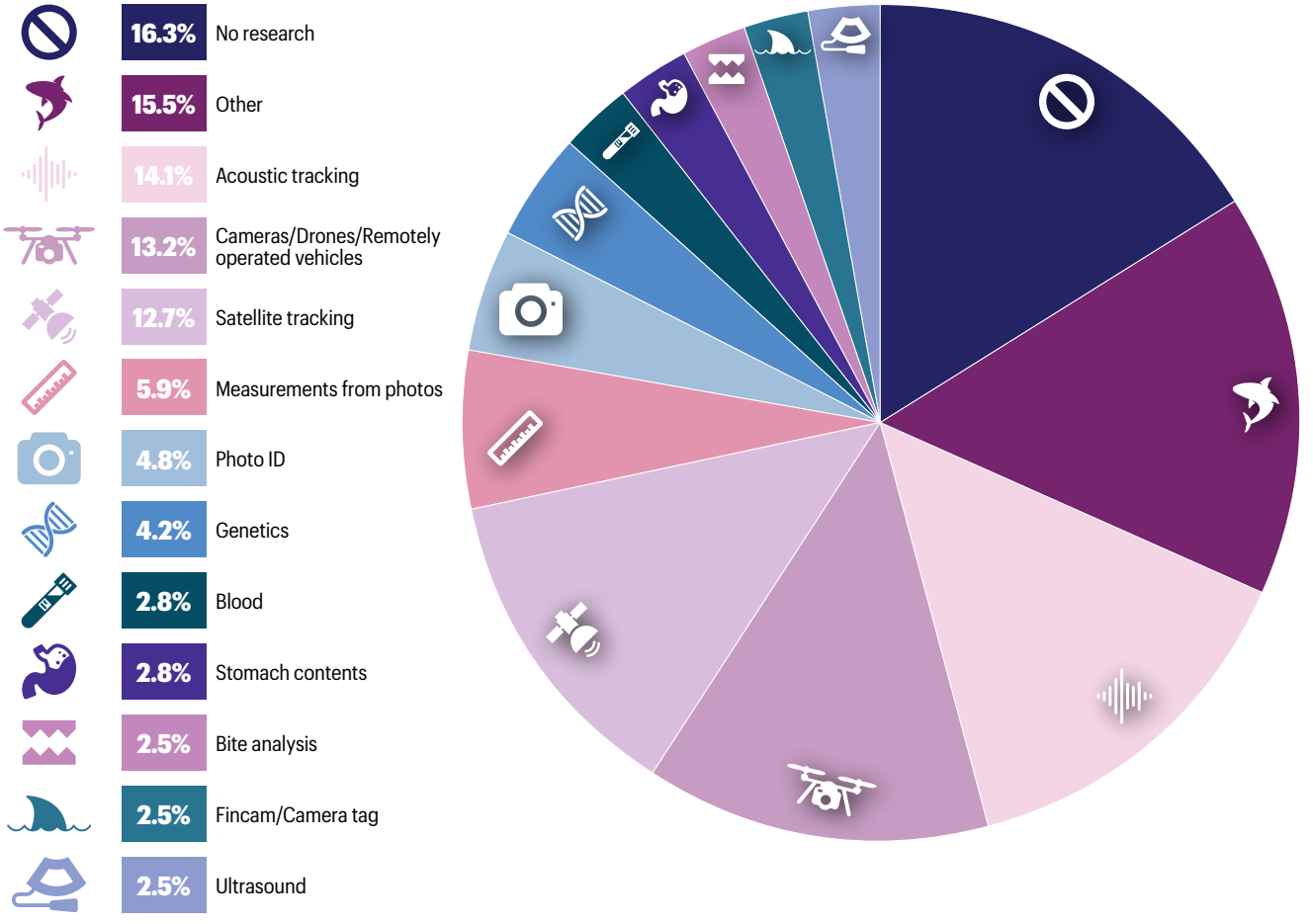
— *Carolyn Wilke*

Sharks may seem scary because of what's on TV or in movies. But you're more likely to be struck by lightning than to be bitten by a shark.

ALESSANDRO DE MADDALENA/SHUTTERSTOCK

RESEARCH METHODS FEATURED ON SHARK WEEK EPISODES

Researchers watched over 200 episodes of Shark Week, filling out a worksheet on each one. They tallied up all the research methods mentioned. The category "other" includes methods that were only used once, such as research that measured how sharks' muscles worked.



DATA DIVE

1. What is the largest slice of the pie chart?

2. Why does it matter that this is the most-cited method in Shark Week shows?

3. How many slices on the pie chart relate to the use of photos or videos? Add them up. What's the total percentage?

4. What sort of information about animals can researchers get from photos and videos? What kinds of information will they miss?

5. How many slices on the pie chart relate to measuring animals? What's their total percentage?

6. What is the percentage of methods that analyze samples — DNA, blood or stomach contents?

7. Which methods track where animals travel? What's the total percentage?

JULIA SALTZMAN; ADAPTED BY L. STEENBLIK HWANG

ANSWER

Sleeping glass frogs go into stealth mode

The animals make themselves harder to see by hiding away red blood cells

As tiny glass frogs fall asleep, about 90 percent of their red blood cells can stop circulating through the body. The cells all cram inside the frog's liver as the animal snoozes. That organ can disguise the cells behind a mirrorlike surface.

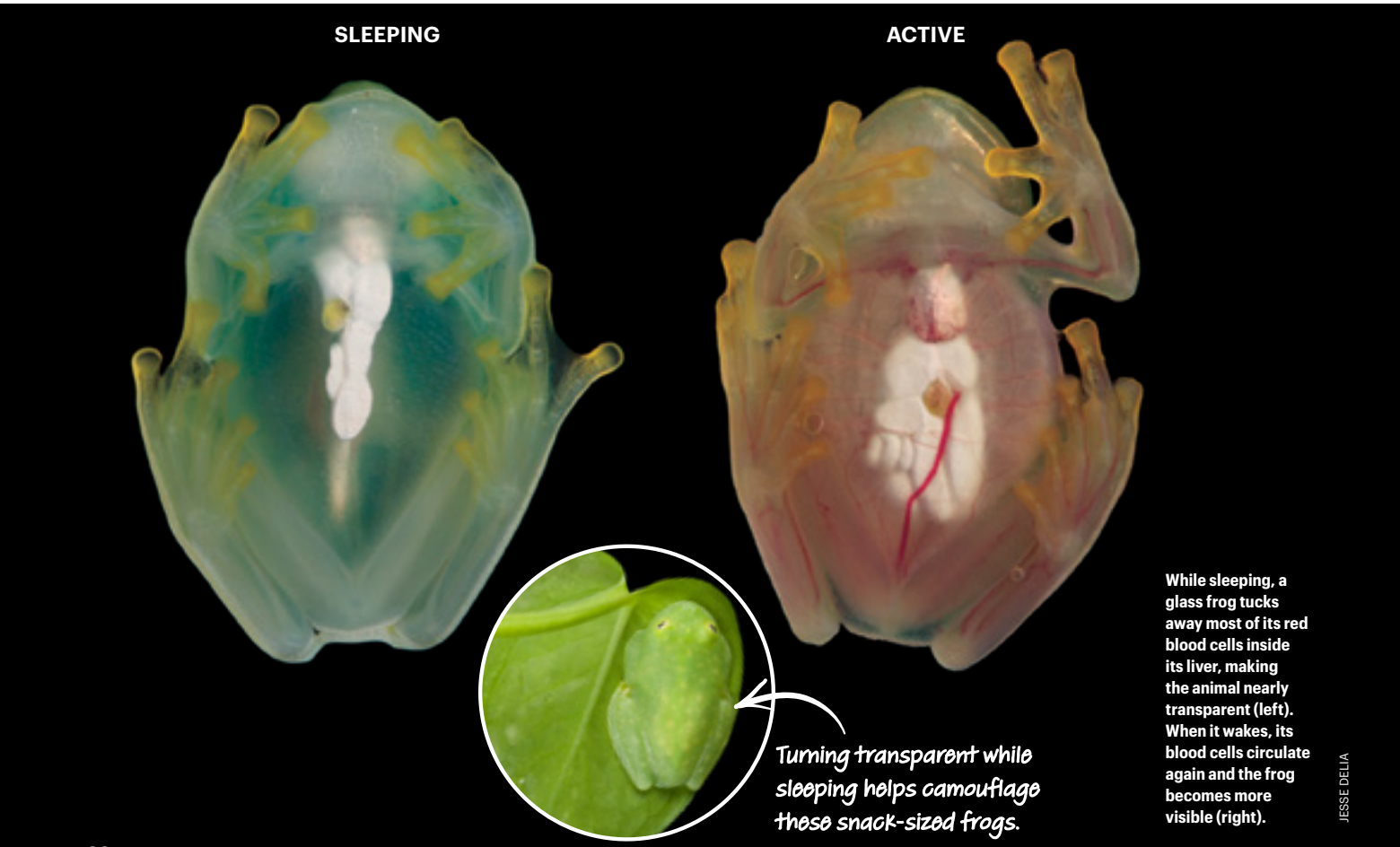
Hiding their red blood cells can make the animals two or three times as transparent. And being see-through matters a lot for the snack-sized frogs. They spend the day hiding like little shadows on the undersides of leaves.

"The heart stopped pumping red, which is the normal color of blood, and only pumped a bluish liquid," says Carlos Taboada. He works at Duke University in Durham, N.C., and studies how life's chemistry evolves. He's part of the group that discovered glass frogs' hidden cells and shared the findings in *Science*.

Catching red blood cells in the act inside living frogs proved to be a tough puzzle. With a regular microscope, the researchers couldn't see through the mirrorlike outer tissue of the liver. They also couldn't do anything that woke up the frogs. Otherwise, the red blood cells would rush out of the liver and into the body. Even putting the frogs to sleep with anesthesia kept the liver trick from working.

The researchers solved their problem with a technique called photoacoustic imaging. It can reveal hidden interiors thanks to subtle vibrations created by light striking various molecules.

— *Susan Milius*



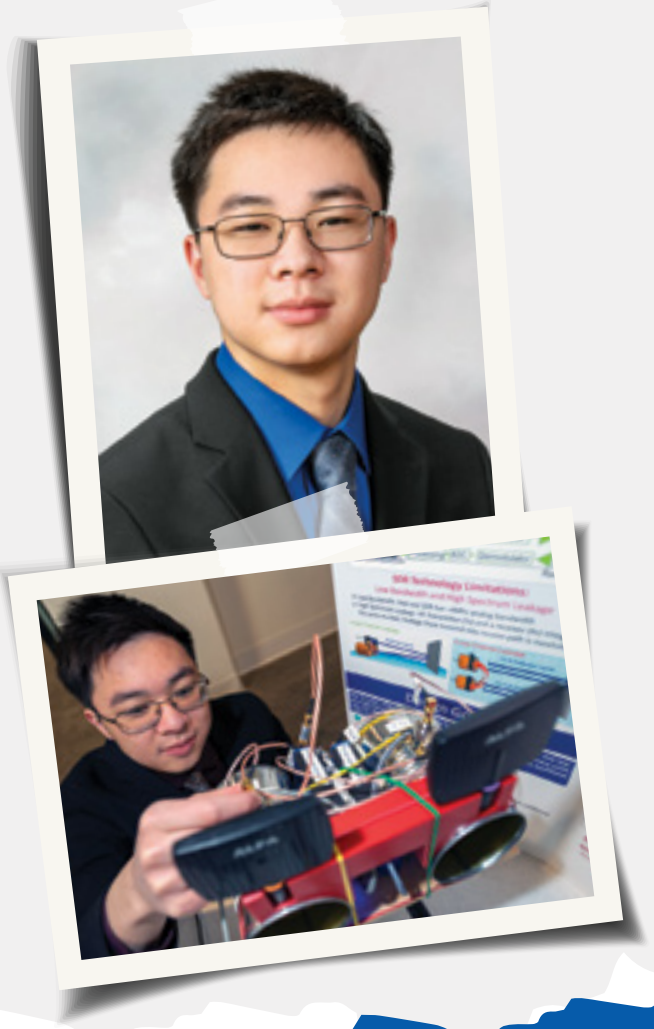
While sleeping, a glass frog tucks away most of its red blood cells inside its liver, making the animal nearly transparent (left). When it wakes, its blood cells circulate again and the frog becomes more visible (right).

JESSE DELIA

INSIDE THE MIND OF A YOUNG SCIENTIST

A winner of the Regeneron Science Talent Search — Society for Science's most prestigious competition — answers four questions about science

Science competitions can be fun and rewarding. But what goes on in the mind of one of these young scientists? Regeneron Science Talent Search (STS) 2022 2nd place winner Victor Cai shares some of his science dreams and advice.



Q Which sci-fi advancement do you wish we had by now?
A Although likely impossible, I'd love to see the Alcubierre warp drive become a reality. I've always been fascinated by the human capacity for imagination in striving to bend the laws of the universe and push the boundaries of what we once thought was possible.

Q Which scientist — alive or deceased — would you want to solve scientific mysteries with and why?
A With my passion in electrical engineering, I would love to work alongside Thomas Edison. I admire Edison's perseverance and his drive to improve society through his inventions. I hope to become a resourceful and creative engineer like Edison, who is talented at turning ideas into useful applications.

Q What would you invent if you had all the resources in the world?
A I would invent the Dyson sphere! Once we create efficient and sustainable solar panel and energy storage technology, a Dyson sphere would provide enough energy to propel us to ... higher civilization levels.

Q What advice do you have for young innovators?
A Don't be afraid to pursue ideas no one else has tried before. It is at these frontiers that the research really starts. Pursue what inspires you, find out where others have failed, and incorporate new perspectives that could shed light on useful insights and breakthroughs.

2nd Place Winner

Victor Cai

Victor, of Orefield, Pa., won for creating a short-range, narrow-bandwidth radar that calculates distance by transmitting two signals at different frequencies and then measures the phase difference between them. This short-range distance-sensing radar could one day help the visually impaired navigate spaces in their homes. Victor is now studying electrical engineering at Harvard University in Cambridge, Mass.

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