Science News Explores

September 2022

LYING WILL STEAL YOUR BRAINPOWER

MONSTROUS MAMMALS

HONEYBEES FEND OFF HORNETS WITH POOP

MAKE YOUR GAMING GREENER

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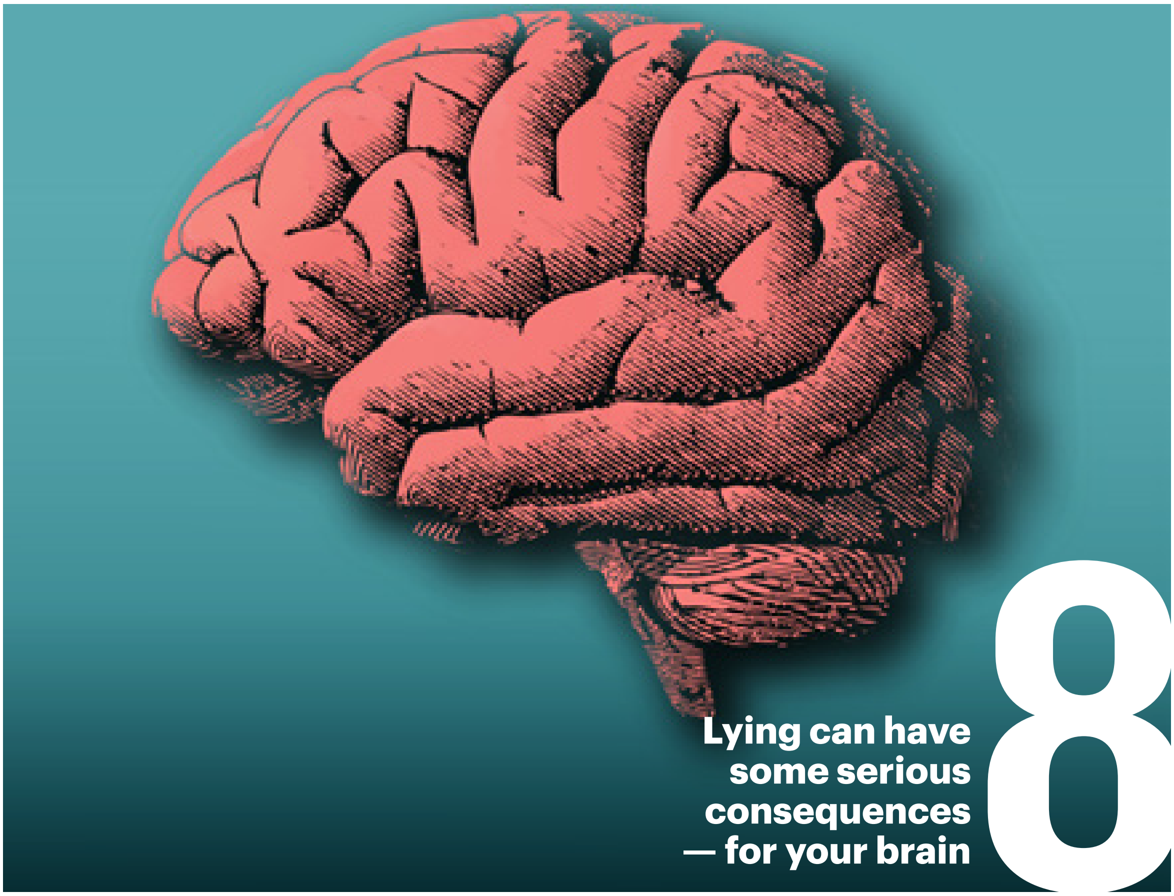
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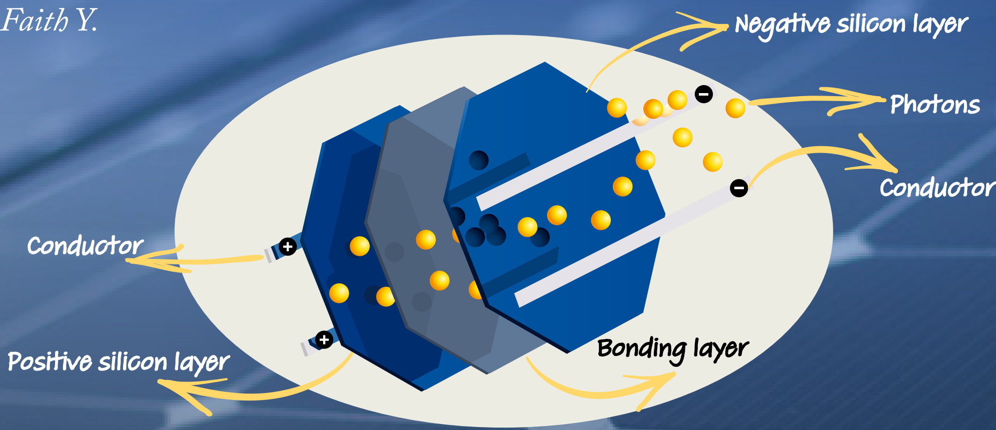
Q How do solar panels work?

— *Faith Y.*



A Inside a solar panel, positively charged slices of silicon are connected to negatively charged slices. Those silicon layers are sandwiched between metal plates, which conduct electricity. When particles of sunlight — or photons — strike a solar panel, they can knock electrons off atoms in the silicon. Those negatively charged electrons tend to flow toward the negative silicon layer. Meanwhile, the positively charged empty spaces left behind by those electrons move toward the positive silicon layer. The metal plates on either side of the silicon sandwich collect those negative and positive charges. If a wire is hooked up between the two metal plates, it can provide a path for the negative electrons at one plate to flow toward the positive empty spaces at the other plate. Such a flow of electrons creates an electric current. And an electric current can be used to supply electricity to other devices.

Q Why do scientists use rats in their labs?

— *Máté B.-H.*

A Different animals can help scientists answer different questions, says Anne Kwitek. Kwitek works with rats at the Medical College of Wisconsin in Milwaukee in studies of how genes affect heart disease and obesity. Rats are one of the more common lab animals, though, because they have bodies that work in ways similar to ours, she says. This makes the critters great test subjects for learning more about how our own bodies work and how various treatments might affect us. Rats are small and adaptable, and can handle a variety of scenarios and living situations. This makes them easy to care for and study in a lab. Rats are also smart, learn quickly and love to be around others. Kwitek has found that their calm, curious natures make them easier to work with than mice, which tend to be less social. "And their lifespan is … pretty short," Kwitek notes. That makes them a lot easier to study than a human.

Q How many light-years away is the closest habitable planet?

— *Sasha D.*

A The star closest to our sun, Proxima Centauri, may host a planet with the right conditions for life. That world, Proxima b, is in its star's habitable zone. In other words, the planet is just close enough to Proxima Centauri for liquid water to exist on its surface. That's important because all life as we know it needs liquid water. Proxima Centauri is about 4 light-years away (more than 250,000 times the distance from the Earth to the sun). But habitable-zone planets are not the only promising places to look for life. Jupiter's moon Europa and Saturn's moon Enceladus might have liquid oceans beneath their icy surfaces that could be teaming with life. So, the first known habitable world could be right here in our own solar system.

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Sarah Zielinski
Editor, *Science News Explores*

SPACE

A star called Earendel is the most distant ever seen

Its light took nearly 13 billion years to reach Earth

A lucky lineup has revealed a star that started shining before the universe's one billionth birthday. If confirmed as a solo star, it would be the most distant one ever seen. Its light traveled some 12.9 billion years across space before it reached Earth, researchers reported in *Nature*. Studying this early starlight could help researchers learn more about what our 13.8 billion-year-old universe was like when it was very young.

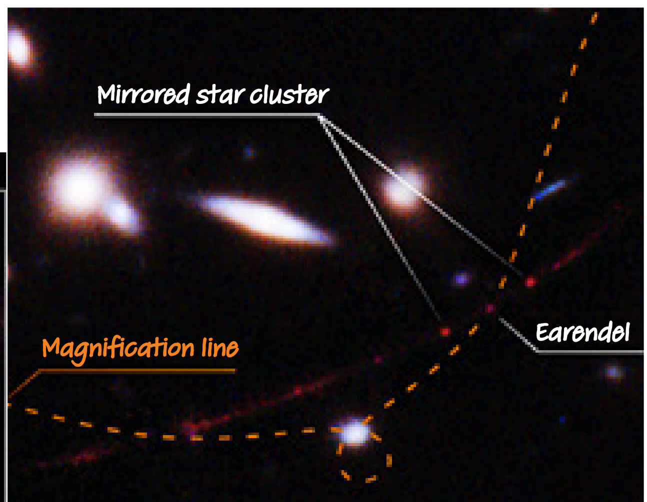
"These are the sorts of things that you only hope you could discover," says Katherine Whitaker. She is an astronomer at the University of Massachusetts Amherst. She did not take part in the new study.

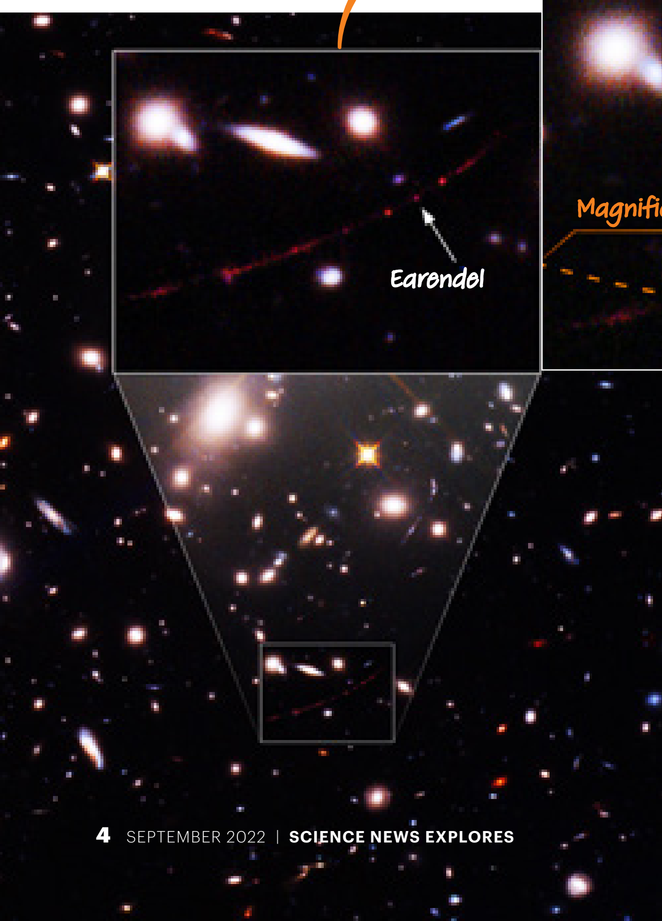
In images of one galaxy cluster, a group of astronomers from around the world noticed a long, thin red arc. That team includes Brian Welch from Johns Hopkins University in Baltimore, Md. The team realized that the arc was made of light from a galaxy located even farther away than the ones they were studying. The light from this background galaxy had been stretched, warped and magnified.

Atop that red arc, the researchers found one bright spot they think is too small to be a small galaxy or a cluster of stars. "We stumbled into finding" this ancient star, Welch explains.

His team now estimates that the starlight they spotted was from only 900 million years after the Big Bang. The Big Bang was the birth of our universe, when all matter, light, and even space itself expanded incredibly fast.

Earendel was shining only 900 million years after the Big Bang, researchers say. It is visible because a cluster of galaxies magnified its light.





The newfound object appears in images of a cluster of galaxies taken by the Hubble Space Telescope. A single cluster contains many galaxies. These galaxy clusters can bend and focus light that comes from things even farther away. They can also magnify the light from those objects, which makes dim distant objects appear brighter. Such a bending of light is known as gravitational lensing.

Welch and his colleagues nicknamed the newfound object "Earendel." That comes from an old English word meaning "morning star" or "rising light." They think this star is at least 50 times as massive as the sun. But the researchers need more information before they can confirm that it's just one star or a group of two or more.

— *Liz Kruesi*

SCIENCE: NASA, ESA, BRIAN WELCH/JHU, DAN COE/STSCI; IMAGE PROCESSING: NASA, ESA, ALYSSA PAGAN/STSCI

MICROBES

Kitchen sponges are bacteria's dream home

Microbes thrive in all those nooks and crannies

Ask bacteria where they'd like to live, and they'll answer: a kitchen sponge, please.

Damp, airy and loaded with food scraps, sponges are a microbe paradise. They contain as many as 54 billion bacteria per cubic centimeter (one sixteenth of a cubic inch)! Bacteria loves sponges because they provide just the right number and size of living spaces, researchers report in *Nature Chemical Biology*.

Like people, bacteria prefer different levels of interaction with their peers. Some are social. Others are more loners. Lingchong You wondered if separating different types of microbes would affect how they interact. You is a synthetic biologist at Duke University in Durham, N.C. Medium levels of separation maximize the number of bacterial types living in a community, he and his team now report. Those medium levels are similar to the structure of a sponge.

The researchers worked with many strains, or types, of a bacterium called *E. coli*. The team placed the strains onto plates with six to 1,536 tiny wells. A well is a compartment on a plate used to grow microbes. Each well acted like a party room, You says. Bacteria were randomly assigned to the wells. The party went on for 30 hours. Then the team tallied the number and types of bacteria on each plate.

On a plate with only six compartments, each of the parties would probably get a similar mix of characters. There, only the social bacteria would likely survive. Those that don't get along well with others might die. But on the plate with 1,536 compartments, each microbe would probably end up alone. Unable to schmooze with other bacteria, the social ones might perish.

A medium number of compartments should maximize the odds that a microbe attends the party it prefers. In the end, some will die. Some will live. It depends on which party a microbe attends. But some members of every type of bacteria could survive — and preserve the diversity of the whole community.

Kitchen sponges offer an ideal number of large and small holes as compartments for bacteria. That provides a range of varying-sized parties that should make more of the microbes happy. So the researchers hypothesized that kitchen sponges would host a diverse mix of bacteria. Sure enough, their tests showed that sponges are home to a diverse bacterial community. And it's more diverse than the communities found in liquid cultures. (Those cultures are a common method of growing bacteria in a lab.)

"Sponges are not really well-suited for kitchen hygiene," says Markus Egert. He is a microbiologist at Furtwangen University in Villingen-Schwenningen, Germany. He was not involved in the study. "There's hardly any sterile surface at home. But [in terms of microbes] the kitchen sponge is probably the most densely populated item at home."

The good news is that it's easy to solve the problem. Dish brushes are a much safer alternative. And if you love your sponge, don't use it for meat juices, which may have harmful microbes. No need to invite bad bacteria to the party.
— *Anna Gibbs*

W. SCOTT MATTHEWS

ANIMALS

Honeybees fend off deadly hornets by decorating hives with poop

The odd behavior is called fecal spotting

Giant hornets from Asia can quickly kill off an entire honeybee hive. But bees have found one stinky way to fend off these predators. Their tactic: smearing the entrance to their hives with animal dung.

Honeybees are known for collecting pollen, nectar and tree sap. So Gard Otis was puzzled to find strange, brown spots the size of poppy seeds encrusting beehives in Vietnam, a country in southeast Asia. When a beekeeper told him the smear was buffalo dung, Otis was astonished. "I had never, ever, ever heard of honeybees collecting dung," he says. Otis is a retired ecologist who studies insect behavior. He used to work at the University of Guelph in Ontario, Canada.

Some hive entrances were "totally coated with poop," says Heather Mattila. She's a honeybee biologist at Wellesley College in Massachusetts who also worked on the research. Asian honeybees use this stinky door decoration to protect their hives from a giant hornet, *Vespa soror*. Otis, Mattila and their colleagues shared this finding in *PLOS ONE*.

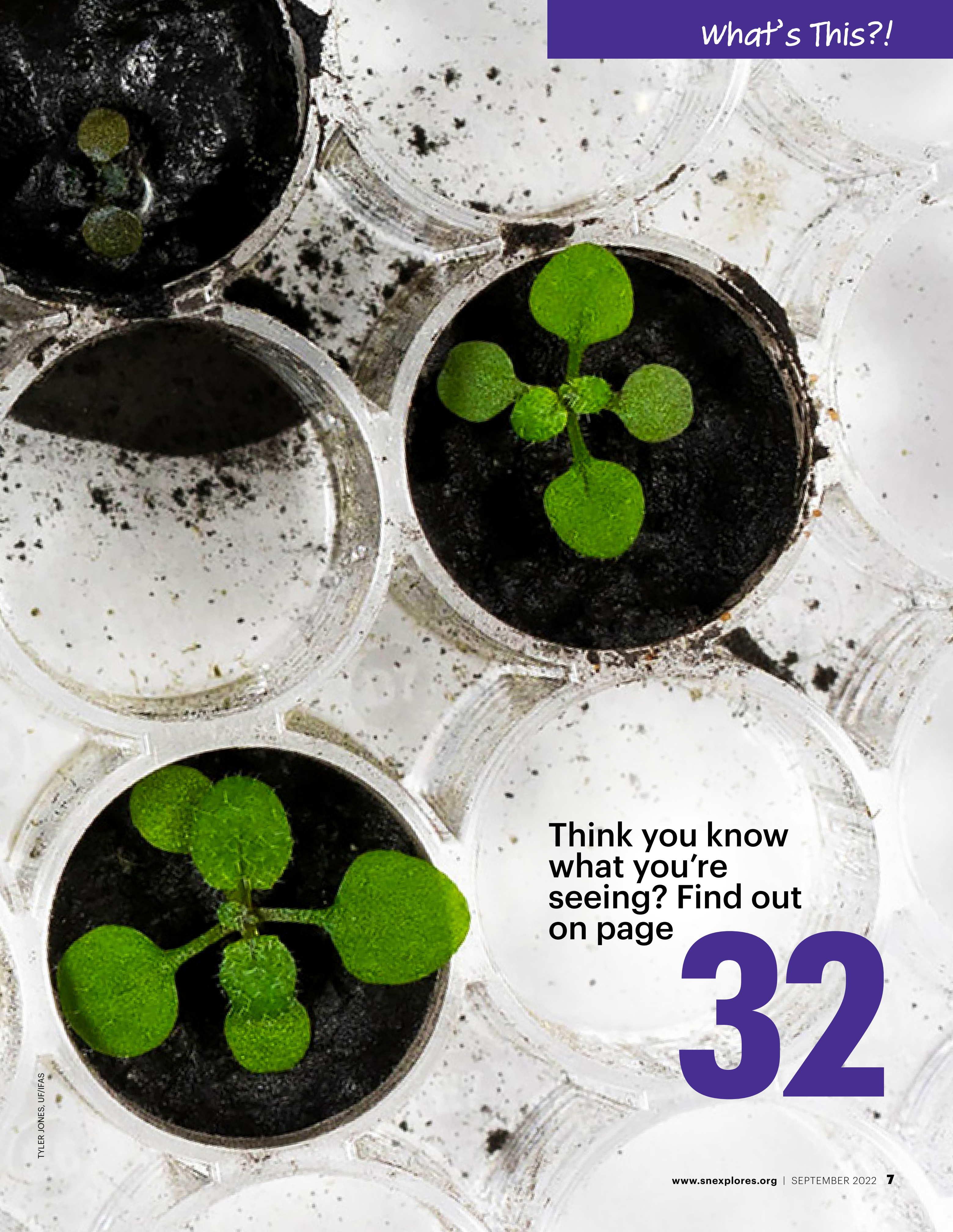
To confirm that bees collected poop, the researchers gathered dung from chickens, water buffalos, pigs and cows. They placed piles of the feces near beehives. Then they waited.

"We called it the dung buffet," says Mattila. "It was gross. We were sitting there in really hot weather beside large piles of animal poop. It didn't smell good," she says with a laugh.

The insects collected mouthfuls of dung and then made a beeline back to their hive. There, they pasted small blobs and specks of dung around hive entrances. It kind of looked as "if you took cookie dough and threw it at the wall," Mattila says. The researchers call this behavior "fecal spotting."

Tests showed that *V. soror* spent about 77 to 81 percent less time at hives with moderate or heavy spotting than those that were lightly spotted. The hornets also spent 94 percent less time chewing at filthy hive fronts. This suggests that a dirty doorway keeps hornets from trespassing on the hive. — *Asher Jones*

H. MATTILA



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

TYLER JONES, UF/IFAS

LYING WON'T STRETCH YOUR NOSE, BUT IT WILL STEAL BRAINPOWER

Even little fibs can have serious consequences — and some of them might surprise you >>

By **Avery Elizabeth Hurt**

ILLUSTRATION BY STEVE MCCRACKEN

Most of us have told a lie at one time or another. Some lies are harmful. Others — like the ones here — are mostly harmless. Still other lies, such as those used to protect other people, may even be created with the best of intentions. But no matter what kind of lie you tell, it takes a surprising amount of brainpower to pull it off.

Using up that brainpower can be costly. The brain drain it causes just might prevent you from performing some task or skill that's important to you. And, of course, lying can have unwanted social impacts, too.

People lie for different reasons. Sometimes they do it to make themselves look better. Sometimes they lie to get out of trouble. Often, people will tell a fib to keep from hurting another's feelings.

Overall, most people don't lie very much, says Timothy Levine. He's a psychologist at the University of Alabama at Birmingham. Levine studies deception. And he's done a lot of research on when and how much people lie.

Most people value honesty and want to be truthful, his research has shown. In one of Levine's studies, almost three quarters of people rarely lied. And of all the lies reported in the study, 90 percent were harmless "white lies." It makes sense that many people value honesty. If you're an honest person, people will trust you more. And trust is important. "By being honest with people, you build up social capital," Levine says. Social capital is goodwill among people in a group or community.

However, Levine's research also shows that while most people don't lie often, a few lie a lot. The top one percent of liars, according to Levine's research, tell more than 15 lies per day. Some chronic liars are insecure. Others may lie about their accomplishments because they're conceited or overly impressed with themselves. Still others lie to take advantage of people — perhaps even to cheat them or to steal from them.

Some lies are well-intended. You know those small lies you might tell to make someone feel good? Scientists call them "prosocial lies." Maybe you tell your parents that you loved the sweater they gave you for your birthday (even though you were really hoping for a new video-game console). That's a prosocial lie. There's little risk to you in telling it, and it makes your parents feel good.

Still, there are times that lies told to benefit others may cause the liar great harm. These are known as altruistic lies. During the Holocaust, some people told such lies to the Nazis about where Jews were hiding. The liars knew they could be killed if their falsehoods were discovered, but they took this risk in hopes of saving others. Clearly, some altruistic lies can be quite risky.

Your new haircut looks great!

I can't come to your party because I have to help clean out the garage.

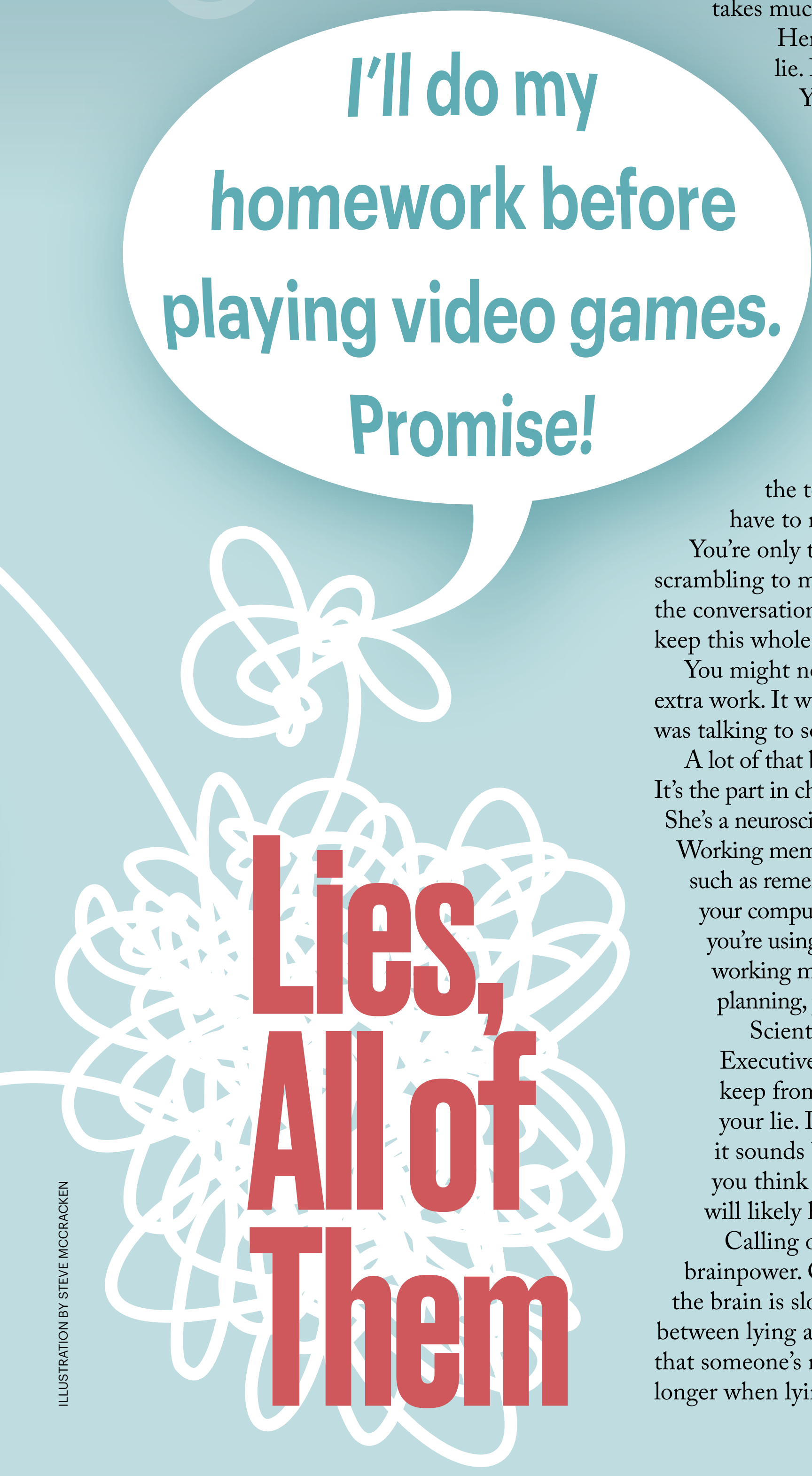


ILLUSTRATION BY STEVE MCCRACKEN

Lies, All of Them

Hard work

When you tell the truth, your brain doesn't have to do anything out of the ordinary. You think of what you want to say, and you say it. Lying takes much more work.

Here's an example of what goes into a seemingly simple lie. Imagine you're late to class and the teacher asks why. You decide to lie. You now have to either come up with a story on the spot or remember the story you made up as you were rushing to class.

So you say: "I had to stop by the library and pick up a book."

Your teacher asks: "The book I assigned last week?"

Immediately, you must decide how to respond — and quickly. If you say yes, the teacher might ask to see the book. Or she might expect you to read from it in class. So, you have to imagine these possibilities. You might say: "No. It was a different book."

Now you have to be ready with another title in case the teacher asks which book you checked out. And you have to make sure it's a book the school library actually owns.

You're only two sentences into the lie, and already you've been a) scrambling to make up a story; b) thinking about the various directions the conversation might take; and c) figuring out what you need to say to keep this whole lie from falling apart.

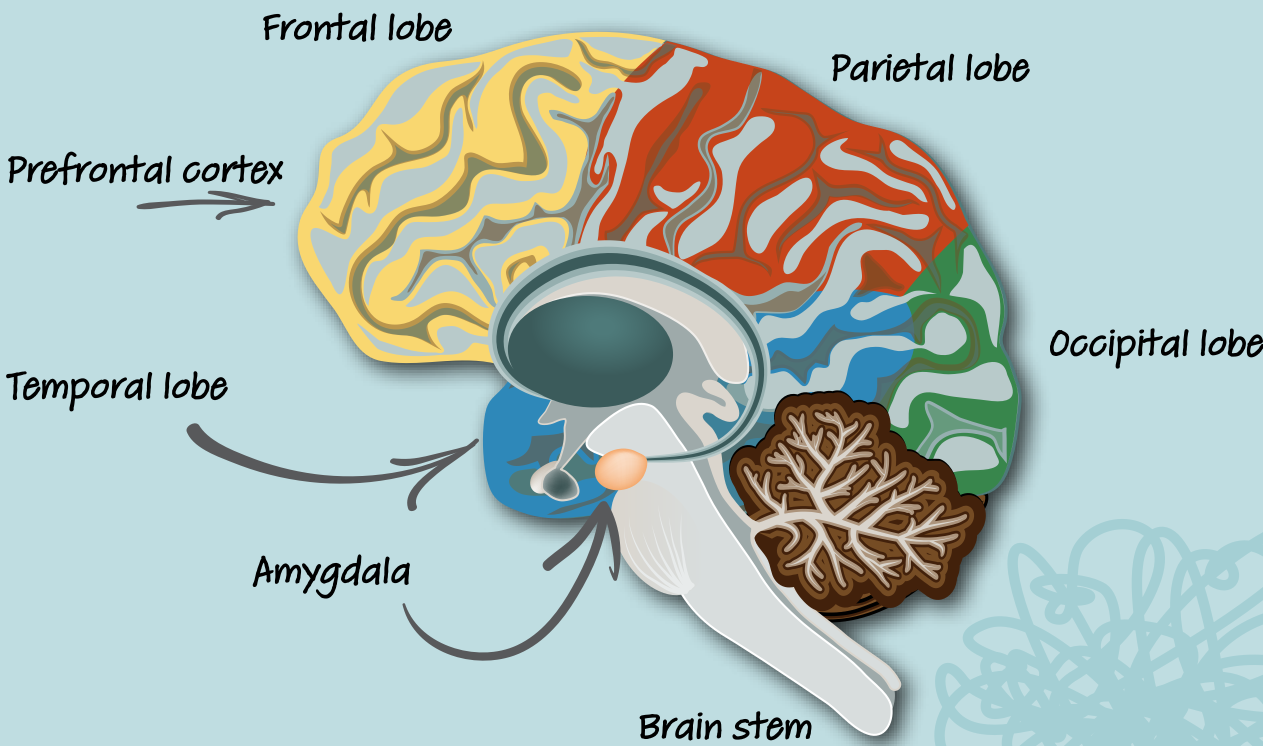
You might not be aware of it, but you just gave your brain a ton of extra work. It would have been far easier just to have told the truth: "I was talking to some friends outside the gym and lost track of the time."

A lot of that brain work is done in a region called the prefrontal cortex. It's the part in charge of working memory, explains Jennifer Vendemia. She's a neuroscientist at the University of South Carolina, in Columbia. Working memory keeps something in mind just for a little while — such as remembering instructions for how to play a game. It's a bit like your computer's clipboard. It stores things for only a short while as you're using them. It doesn't put them in long-term storage. Besides working memory, the prefrontal cortex also takes care of tasks such as planning, problem-solving and self-control.

Scientists describe these as "executive function" tasks. Executive function comes into play when you use self-control to keep from blurting out the truth or some fact that would expose your lie. It helps you recall all the details of a lie to make sure that it sounds believable and you don't slip up. Executive function lets you think a step or two ahead to make sure the lie you're telling will likely hold up to questioning.

Calling on your executive function this way also uses up a lot of brainpower. One study done by researchers in Belgium found that the brain is slower and more likely to make mistakes when it shifts between lying and truth-telling. Vendemia's research has also shown that someone's mental workload will be heavier and their reaction time longer when lying.

ANATOMY OF THE BRAIN



Expensive lies

Spending so much brainpower trying to keep a story straight means there's less available for other things — like solving math problems or remembering who invented the printing press. Lying is especially hard for young people, says Vendemia. The prefrontal cortex is not fully developed until around age 25. So younger people have fewer resources there to begin with. When the prefrontal cortex is busy with tasks related to lying, she notes, it now has a harder time doing other tasks that require planning, self-control or working memory. Those things might include planning a study schedule or using self-control to keep from drinking too much soda.

Lying to avoid getting into trouble — for being late to class, say — is pretty much a one-and-done. You're not going to have to keep up that lie about going to the library for very long. Yes, you wasted some mental resources, but just that one time. Some lies, however, never stop. These are what Vendemia calls "lifespan lies."

Spies, for instance, spend their entire lives lying about who they are. Someone with a difficult home life might lie to keep others from finding out — and that lie could go on for years. Pretending to be something you're not almost every hour of every day is mentally draining. And the toll it takes can be long-lasting, says Vendemia. "Over time, this kind of lying actually causes you to use up the brain resources you need for thinking."

Lying has social consequences, too, explains Victoria Talwar. She's a psychologist in Canada. Working at McGill University, in Montreal, Quebec, Talwar studies the development of lying in children. People generally value honesty and don't like liars, she says. So if people view you as untrustworthy, it can be bad for your relationships.

BRAIN FUNCTIONS

Frontal lobe
This area controls decision-making, emotions and behaviors and helps us respond appropriately in social settings.

Prefrontal cortex
Located in the frontal lobe, the prefrontal cortex is in charge of working memory. But it's not fully developed until age 25.

Parietal lobe
The parietal lobe helps the brain process senses, such as taste and pain. It also helps us read and do math.

Occipital lobe
This part at the back of the brain interprets information from the eyes.

Temporal lobe
Functions of this section include memory, recognizing objects and faces, processing sounds and understanding language.

Amygdala
These almond-shaped structures are located in the temporal lobes. They help process emotions.

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“Being able to tell the truth to a friend is rewarding. It feels good.”

– Victoria Talwar

RAWPIXEL.COM/SHUTTERSTOCK

Even the kindest of prosocial lies can sometimes be risky. A recent study looked into these and found they often backfire. When you give insincere compliments, for example, you may make your friends feel good — at first, anyway. But do it often enough, and they’ll soon learn that they can’t trust your compliments. That makes those compliments meaningless.

That’s why Talwar often warns parents not to give false praise to their children. “If you do,” she points out, “you undercut the value of honest praise. You lose credibility.”

Get used to it

Neil Garrett is a neuroscientist at the University of East Anglia, in Norwich, England. Emotions have an effect on how willing people are to be dishonest, he finds. He points to one study where students were given a medicine (known as a beta blocker) that dampens their emotions. These students were more likely to cheat on an exam than those who didn’t get the medicine. That may be because the medicated students felt less of the fear or anxiety that usually comes with dishonesty.

Garrett was part of a team that decided to look at the relationship between lying and activity in the amygdala. It’s a part of the brain that processes emotions.

These researchers wondered, do our emotions adapt to lying? In other words, do our brains get used to lying? To test that, the team recruited volunteers to play a game in which they could make money if they lied to a partner. The researchers scanned the players’ brains as they played to track activity in the amygdala.

At first, the amygdala was very active when someone lied to make more money. As the lies went on, however, activity in that part of the brain started to drop. And as the amygdala’s activity fell, the players lied even more.

This brain effect may be similar to the way our sense of smell adapts to a strong odor, Garrett suspects. Enter a newly painted room and you might notice an overwhelming scent of fresh paint. But after a few minutes, you may not notice it much. Emotions might work this way, too, Garrett says. The emotion you feel when you lie might be fear or anxiety — a warning of the dangers a lie might bring. Or it might be a slight twinge that tells you it’s wrong to lie. Whatever it is, Garrett’s team showed that the more you lie, the less you feel those uncomfortable emotions.

In other words, lying gets easier the more you do it.

An honest culture

Nearly all cultures value honesty, Talwar says. And, she adds, there are things people can do to help create a culture that reinforces the value of honesty.

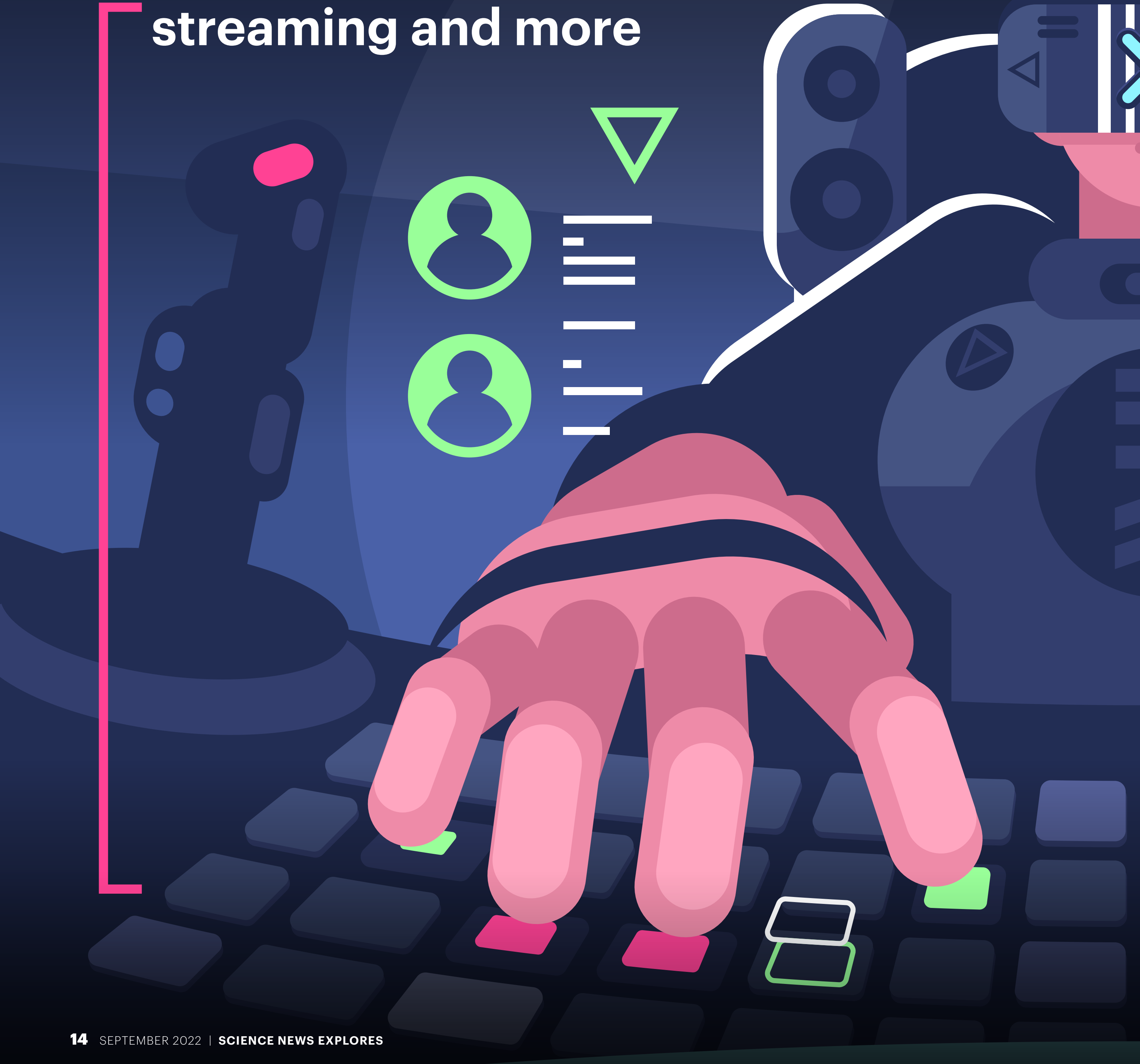
Finding ways to support your friends while still being truthful is one strategy. “When people’s friends are truthful with them,” she says, “it creates a culture of honesty among them.” And that, she argues, “will build stronger friendships.”

It also helps when lying has consequences. People who have never had to face consequences for their lies are more likely to lie, explains Vendemia. People tend to lie less when they know they’ll be called out for those falsehoods. However, punishing people for lying is less important than rewarding them for telling the truth, she says. This is especially important, she adds, when people share important truths about themselves. Sometimes those can be the hardest truths to tell. “Being able to tell the truth to a friend is rewarding,” she says. “It feels good.”

Most people know lying is generally bad and can have serious consequences. Science is now revealing ways in which dishonesty also can impact the brain and your ability to build the trust on which strong relationships depend.

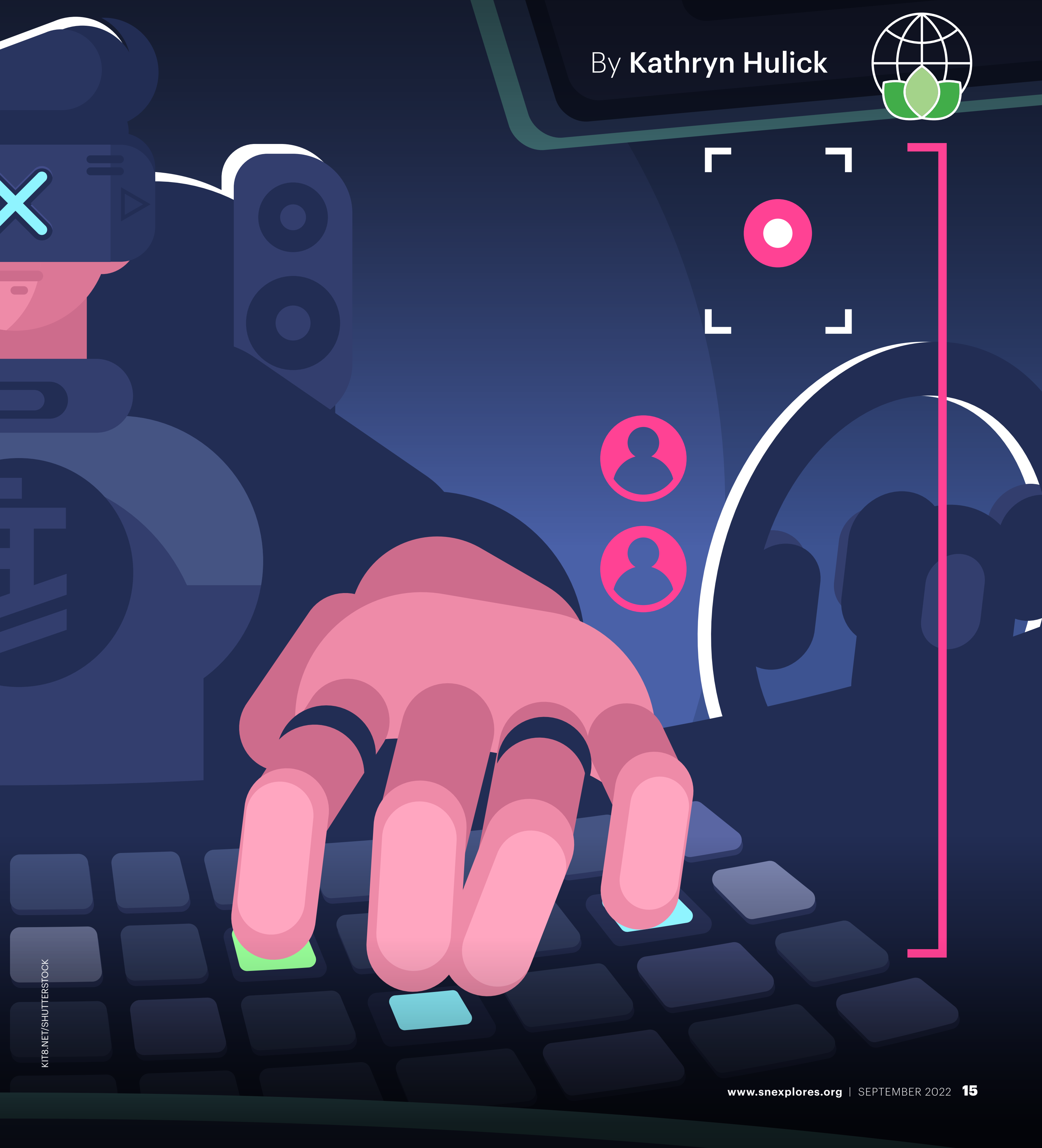
GREENING YOU

How to reduce your energy impact when gaming, streaming and more



R DIGITAL LIFE

By **Kathryn Hulick**



KIT8.NET/SHUTTERSTOCK

Back in eighth grade, Nathaniel Mills grabbed some tools and sat down in his bedroom. A computer lay open in front of him, filled with components he had installed himself. It was time to add another part. "Building a computer is essentially LEGO for adults," he says.

This was back in 2014. At the time, he had wanted a powerful computer he could use to play video games like Skyrim. So he was upgrading his old one.

Unlike most gamers, though, he wasn't just thinking about fast gameplay and movie-quality images and sound. He was also thinking about energy. He wondered, could he build a great gaming computer that also used less electricity than usual?

The answer was yes. At the time, a typical gaming computer used about the same amount of energy as three refrigerators. By the time Nathaniel was done, his used little more than a third that much. But the computer was still fast and fun to play on.

Even if you're not a gamer, you likely spend hours every day texting, watching videos and more. It takes electricity to run your devices. But that's not the only energy involved. The networks that carry signals to and from your devices also consume electricity. So do the distant data centers that house and process most of the content and apps you use. And it takes electricity to manufacture the devices themselves.

In most countries, electricity mainly comes from power plants that burn fossil fuels, such as coal or natural gas. That combustion spews harmful emissions that worsen climate change. So the more devices you own and the more you use them and connect to the internet or the cloud, the more emissions will be produced and the bigger your impact on the climate will be.

But how much impact does an evening of Fortnite or TikTok actually have? It's complicated. Some digital activities or ways of connecting use more energy than others. Like Nathaniel, you can make choices that reduce the amount of energy you use — while still having fun. Let's find out how.

N. MILLS

Video gaming in the United States eats up around **$6 BILLION WORTH** of electricity each year.

That energy use affects the climate as much as an extra **2.3 MILLION CARS** driving around for a year.

HOW TO SAVE ENERGY WHEN GAMING

» Turn off anti-aliasing, which smooths images

» Delete old games and apps to avoid energy-intensive updates

» Put your system in sleep mode when you're not using it

CHECK OUT WWW.GREENINGTHEBEAST.ORG FOR MORE ADVICE

Green gaming

Running a video game, especially one with realistic graphics, is the most energy-intensive thing a personal computer can do, notes Ana Cardoso. She is a researcher at the Copenhagen Centre on Energy Efficiency in Denmark. A gaming computer uses around six times as much energy each year as a typical computer does.

When you play a realistic video game, the computer's graphics processor (GPU) constantly creates an entire virtual world. It must render, or draw, all the shapes, textures, light and shadows in real time. A PS5 can do 10 trillion calculations per second, or 10 teraflops. An Xbox Series X reaches 12 teraflops. And a graphics processor for a high-end gaming PC? That may exceed 100 teraflops. Meanwhile, the central processing unit, or CPU, also must quickly calculate the physics of the world so things interact realistically.

Such powerful processing tends to need a lot of energy. If your computer's processors are working extra hard, the machine may get warm or even hot to the touch, says Cardoso. You can literally feel the computer pulling a lot of energy.

Video gaming in the United States eats up around $6 billion worth of electricity each year. That energy use affects the climate as much as an extra 2.3 million cars driving around for a year. In California, where Nathaniel's family lives, gaming uses up more electricity than all of the dishwashers in the state.

Where did these numbers come from? It all started with Nathaniel's project. His father, Evan Mills, is a scientist who studies energy efficiency at Lawrence Berkeley National Laboratory (LBNL) in California. Today, Nathaniel is a student at Reed College in Portland, Ore. While he was still in high school, the father-son pair teamed up to make that first gaming computer as energy efficient as possible.

They started with a regular gaming computer. Then, one by one, Nathaniel replaced its parts with new, more energy-efficient ones. After each substitution, the pair measured how much electricity the computer used while rendering the same journey through a virtual scene. With each new part, the computer's energy usage fell. But did the scene look any different? "Definitely not," Nathaniel says. The visual quality never changed.

The upgraded computer had less impact on the environment. It also cost a lot less to run. And it ran cooler and more quietly.

Over the next few years, as Nathaniel finished high school, he helped his dad and his dad's colleagues at LBNL set up a "Green Gaming Lab." It measured the energy usage of 26 different gaming systems, including PCs, consoles and even virtual-reality equipment. The team tested 37 different games on these systems, including FIFA17 and Skyrim. Energy usage varied a lot. But in general, high-end desktop gaming computers use more energy than most laptops. And game consoles tend to use less than either.

Left: Nathaniel Mills built an energy-efficient gaming computer when he was a teenager. He says that most people don't really need the most expensive, most powerful parts. You can have a great gaming experience and use less energy.

IAMCLAU STUDIO/SHUTTERSTOCK

The invisible cloud

Another energy issue is how you connect to the internet. Let's say you're watching a movie on Netflix. You may watch it on a TV plugged directly into the internet through a cable. Or you may stream it over Wi-Fi to your laptop or mobile phone. "That cranks up the power needed to watch it," says Kerry Hinton. Now retired, this engineer used to work at the University of Melbourne in Victoria, Australia. There, he studied energy use by telecommunications systems.

The battery in a laptop or phone sips much less electricity than a television. So why do they sap so much power? The difference is in the way the movie gets to you. It takes a lot of energy to send data over a Wi-Fi network. "That's the killer," says Hinton.

Wi-Fi hotspots and mobile towers "just blast energy out." They work this way so we can connect whenever we want. Whether one person or 100 use the connection, keeping the network up and running takes the same energy. With Wi-Fi, Hinton suggests, "share whenever you can." Public Wi-Fi is more energy efficient than a private network. (Be aware, though, public Wi-Fi isn't secure. So don't share any private information while on public Wi-Fi.)

Phones, tablets, smartwatches and many laptops only use Wi-Fi, Bluetooth or mobile networks to connect. And they connect all the time, in ways we might not even realize. Many apps and games rely on cloud computing. This means that the

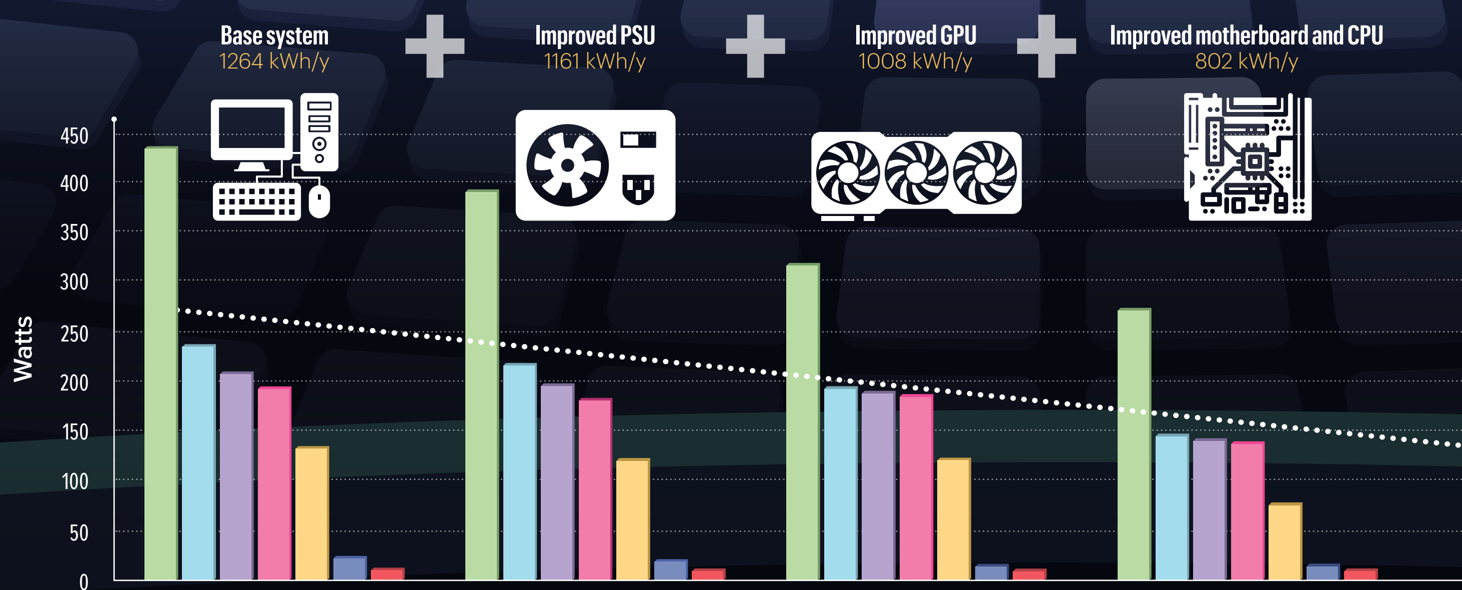
> *We're running out of new ideas. [Clean energy] is the next big challenge.*
> *— Kerry Hinton*

computer processing needed to run the app or game happens at distant data centers. The app's data live in data centers, too. Data centers are buildings filled with powerful computers and equipment to keep those computers cool.

The Green Gaming Lab team found that cloud-based gaming uses more energy than games that run on a home system. Even basic computer tasks, such as typing a document, require more energy when you work on the cloud. Why? When working online, a device continually communicates with the data center.

And it's more than just that communication. "Almost all data is stored in multiple copies," Hinton says. So if something happens to one data center, another one can take over. If you upload one photo to Facebook, the company stores four copies. And users upload 350 million new photos there every single day! When photos are new and people are most likely to look at them, data centers keep them on discs that spin all day, every day. That constantly uses energy. As the photos age, they get moved to storage that isn't immediately available, so it draws less energy. But as soon as someone wants an old

Measured Changes in Power and Energy Profiles with Progressive Efficiency Improvements to a Single Gaming Computer



EVAN MILLS

photo again, it goes back onto a spinning disc. Videos take up even more space than photos, so fewer of them fit onto one spinning disc. “Please don’t add to the population of cat videos,” says Hinton.

The future demands energy

Farming with drones is one example of the internet of things, or IoT. Drones, robot assistants, smart watches, sensors that monitor the air and other connected devices will make our world smarter and “make life a lot easier for everybody,” says Hinton. But he notes that “‘Smart’ is not free,” as he titled one research paper. It takes energy to run the internet of things.

Hinton’s team estimated how much energy a smart home will need to run all of its systems. This might include smart locks, smart light switches, smart appliances, surveillance cameras and a central hub to manage everything. A typical smart home would consume around 30 percent more energy every year than a regular home.

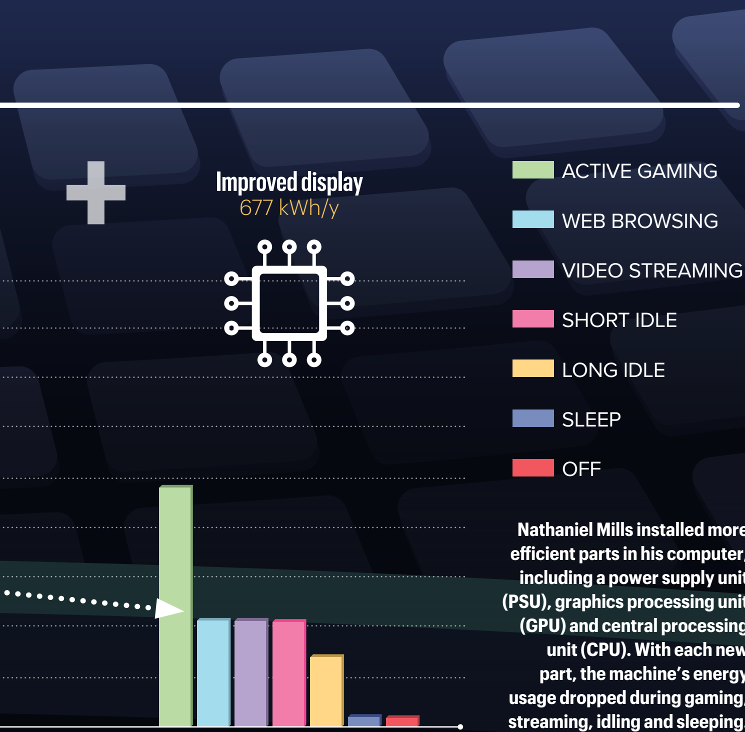
That may seem surprising, since one benefit of a smart home is that it will automatically turn off things like heat and lighting when you’re not using them. That should save energy. However, to be ready to respond to your commands, smart systems must be active and listening. That requires keeping a Wi-Fi or Bluetooth connection on all the time. And this will be “just chewing up power,” notes Hinton.

Engineers could design these systems to go into sleep mode. But impatient people might not want to put up with a short delay to wake up the devices. Thankfully, people are not switching to smart homes as fast as Hinton and other experts thought they might. So there is still time to design IoT devices to use energy in more efficient ways.

The fact remains, however, that humanity has a voracious appetite for technology and data. Data use keeps rising exponentially. That drives up energy use, too. Engineers have found ways to make computers, data storage and transmission more efficient. But they can’t keep up the pace forever. “We’re running out of new ideas,” says Hinton. He thinks finding a way to power our technology with clean energy is “the next big challenge.”

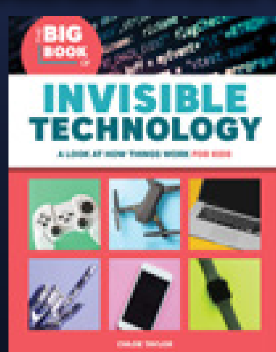
But you can help. Because new devices cost energy to make, think twice before switching to a new phone when your old one still works. In general, you should use your devices “as long as possible,” says Roland Hischier. He is an environmental expert at the Swiss Federal Laboratories for Materials Science and Technology in Dübendorf.

And when you aren’t using your TV, game system or computer, turn it off. “It’s that simple,” says Hischier. If you find yourself watching YouTube for no reason or scrolling through TikTok mindlessly, think about the energy you’re using. Instead, you could read a book or go outside.



Nathaniel Mills installed more efficient parts in his computer, including a power supply unit (PSU), graphics processing unit (GPU) and central processing unit (CPU). With each new part, the machine’s energy usage dropped during gaming, streaming, idling and sleeping.

Read More



The Big Book of Invisible Technology: A Look at How Things Work for Kids
— by Chloe Taylor

Sure, you use Wi-Fi all the time — but do you know how it works? Learn more about everything from the internet to drones in this handy, DIY tech guide.

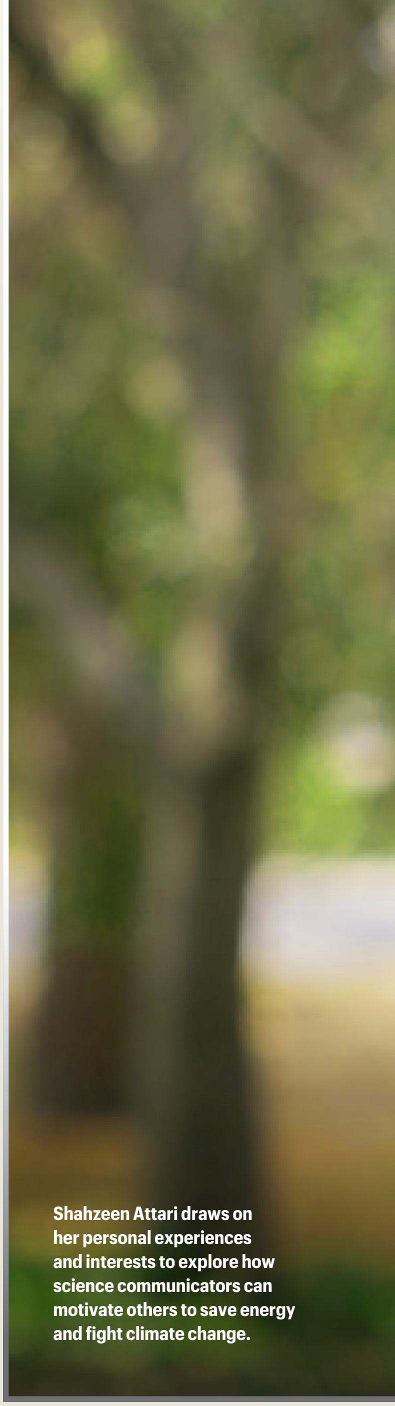
This scientist wants to motivate you to fight climate change

Science fiction helps Shahzeen Attari reimagine what our future could look like

Talking about climate change, energy and conservation is tough. The science can seem complex. So people need to communicate information clearly. Even when they do that, their audience does not always listen. Biases, attitudes and experiences can color their perceptions. Even when people do listen, they may not believe what they hear or want to make changes in their own lives.

Shahzeen Attari studies how people respond to information about climate change. As a scientist at Indiana University Bloomington, she also explores other aspects of how people choose to use energy, water and other resources. Her work is interdisciplinary research. In her case, it involves multiple fields of psychology, engineering and environmental science.

Attari was born in Mumbai, India. She grew up, however, in Dubai. It is part of the United Arab Emirates in the Middle East. She came to the United States as a college student and has lived there since then. In this interview, Attari shares her experiences and advice. (This interview has been edited for content and readability.) — *Kathiann Kowalski*



Shahzeen Attari draws on her personal experiences and interests to explore how science communicators can motivate others to save energy and fight climate change.

Q What inspired you to pursue your career?

A Growing up in Dubai, I saw how a desert was quickly transformed into a metropolis, or major city. This happened over a very short time span of about 10 years. So I realized growing up that humans have a very strong and direct impact that can transform nature.

Later, I volunteered for the Nature Conservancy and worked in interdisciplinary science labs. All these things changed the way I thought about problems. Since then, I've been working systematically, trying to understand how people think about climate change and the actions needed to address the problem. And I want to know how we can effectively communicate with people about those topics.

Q What do you do in your spare time?

A I go on long hikes with my dog, Savannah (above, inset). She's a hound dog from a shelter. She flies through the woods. She has even found a couple of rare timber rattlesnakes. She sniffs them and then runs away.

I also love reading science fiction. A lot of these stories talk about the future and different

COURTESY OF S. ATTARI

societies. I love getting lost in the fantasy of these different worlds. They help us reimagine what our world could look like. So now I've started a whole new line of research, trying to get people to think about the future. What do they want the future to look like? And what steps can the world take now to shape a better future?

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

A I wish someone had told me that failure is okay. As researchers, we get rejected all the time — from getting grants, publishing papers, working on projects and more. Every time you fail, you just have to pick yourself up and start running again.

And I learned this through my mentors in college: Follow the questions you want answered, based on your background and personal interests. As a scientist, you can learn a lot by talking to people. And if something is not in your tool basket, learn from people around you who know about those tools. Keep following the questions until you answer them.

And if no one's done it before, that's kind of cool, too.

Try This!

CHEMISTRY

An explosive experiment

How to blow up a classic chemistry demonstration

By Bethany Brookshire

It's a science fair staple: the baking soda volcano. The volcano's foamy rush is the result of a chemical reaction between two solutions, an acid made with vinegar and a base made with baking soda. This simple demonstration is easy to do. And it's not too difficult to turn it into a science experiment.

HYPOTHESIS

More baking soda will produce a larger explosion.

METHOD

1. In a clean, empty 2-liter soda bottle, mix 100 milliliters (mL) of water, 400 mL of white vinegar and 10 mL of dish soap. Add a few drops of food coloring if you want to make your explosion a fun color. Weigh your bottle with its mixture.

2. Place the bottle outside on a sidewalk, driveway or porch. (This reaction is safe, but it will kill grass.)

3. Mix 10 mL of baking soda with 40 mL water. Pour the mix into the 2-liter bottle as quickly as you can and stand back!

4. When the explosion is done, weigh your bottle again. Clean out the bottle — or use another bottle — and repeat four more times.

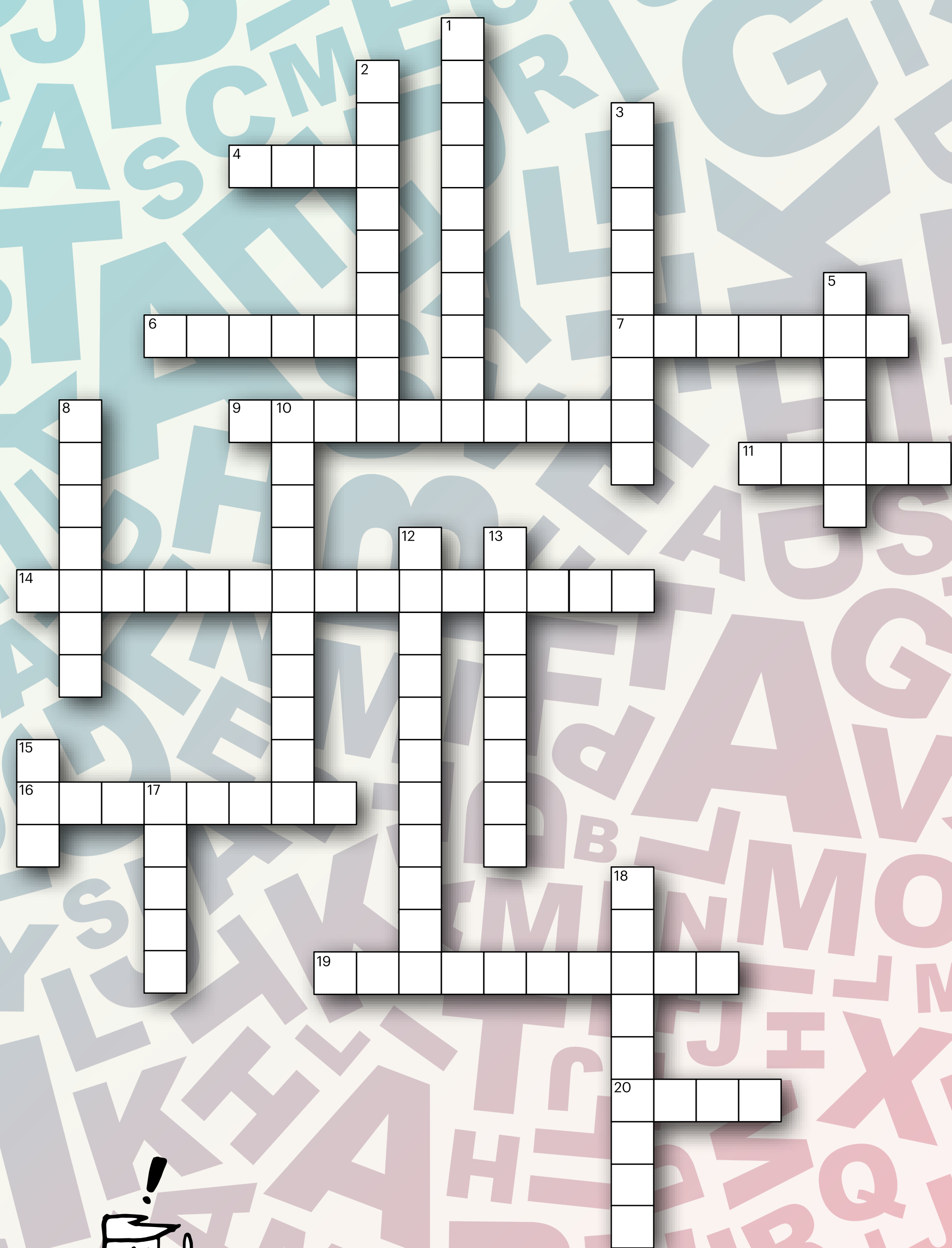
5. Repeat the experiment five more times using 50 mL of baking soda and 50 mL water, and five additional times using 100 mL of baking soda and 5 mL water.

WEAD/SHUTTERSTOCK

DID YOUR DATA SUPPORT YOUR HYPOTHESIS?
Find out how to analyze your data and more at snexplores.org/volcano-chemistry.

Crossword

If you're having trouble figuring out the answers to the clues below, make sure you read all the stories in this issue. Check your work by following the QR code at the bottom of the page.



ACROSS

4 Stinky bee protector
6 Kitchen cleaner-upper
7 Model volcano ingredient
9 Star-finding scientist
11 From or relating to the moon
14 Largest known land mammal
16 Processor of emotions
19 Sickening bacteria
20 Teller of untruths

DOWN

1 The burning of fossil fuels
2 Unit of distance in space
3 Plant eater
5 Energy-intensive pasttime
8 Birth of the universe
10 Sun-powered electricity maker
12 Green pigment
13 Planet in the habitable zone
15 Lab rodent
17 Slang for environmentally friendly
18 Wood polymer

BEKULNIS/SHUTTERSTOCK

TECHNOLOGY

This sun-powered system provides water and electricity

The new machinery could help remote and dry regions

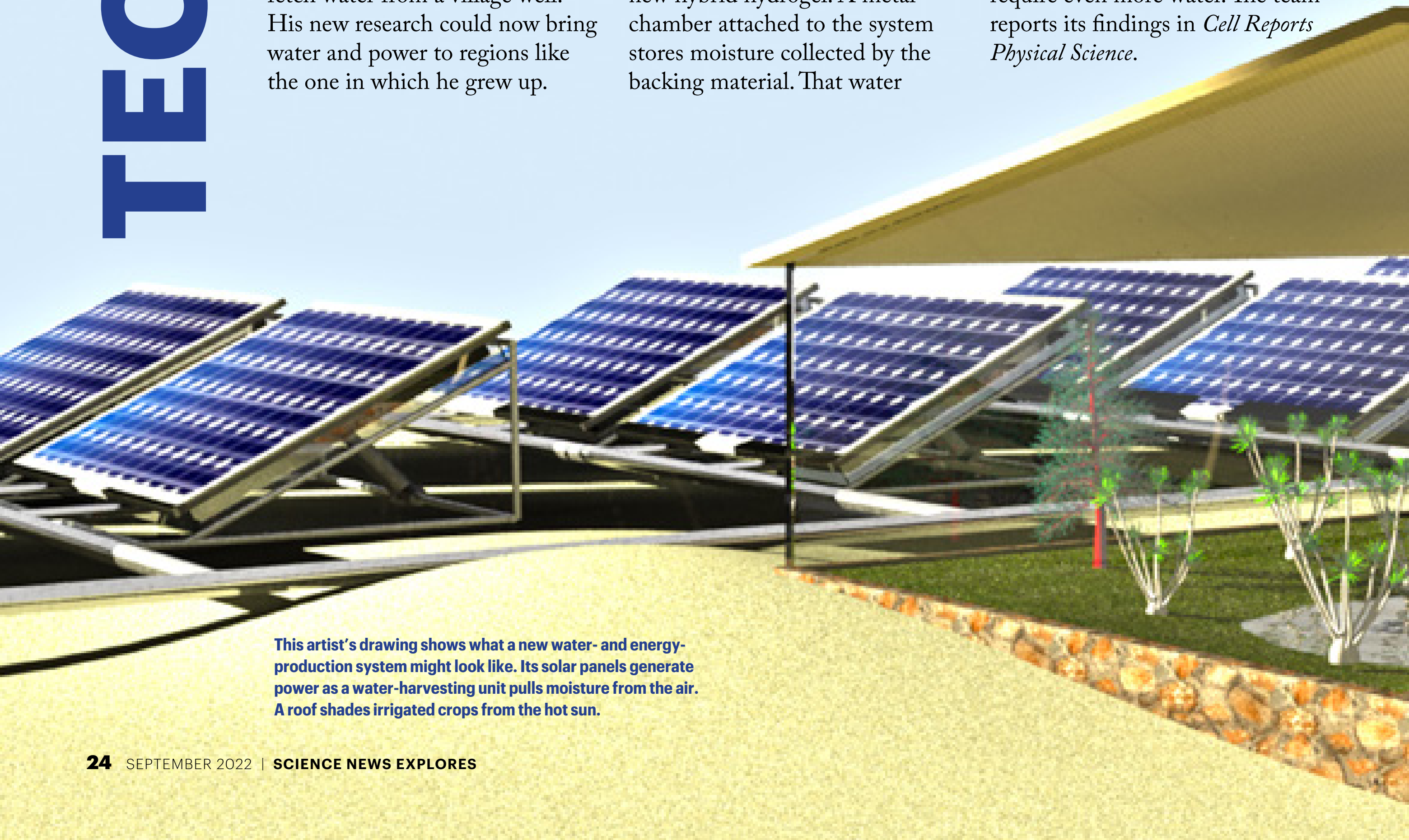
Clean water and energy. People need both. Sadly, billions of people around the world have no reliable access to either. But a new system can provide these resources — and should work anywhere, even in remote deserts.

Peng Wang is an environmental scientist who has been spearheading the new system. His childhood inspired its development. Growing up in Western China, Wang's home had no tap water, so his family had to fetch water from a village well. His new research could now bring water and power to regions like the one in which he grew up.

Wang works at King Abdullah University of Science and Technology, or KAUST. It's in Thuwal, Saudi Arabia. Wang is part of a team that has been working to make solar panels more efficient. Solar panels convert energy from the sun into electricity. Along the way, the team also developed a water-based gel, or hydrogel. When combined with a salt, this new hybrid material can harvest fresh water out of even seemingly dry air.

Wang's team used solar panels to catch the sun's rays and make electricity. They backed each of those panels with the new hybrid hydrogel. A metal chamber attached to the system stores moisture collected by the backing material. That water can be used to cool down the solar panels, allowing the panels to put out more power. Or the water can quench the thirst of people or crops.

Wang and his colleagues tested the system under the hot Saudi sun in a three-month trial. Each day, the device collected an average of 0.6 liter (2.5 cups) of water per square meter of solar panel. Each solar panel was about 2 square meters (21.5 square feet) in size. So, a family would need about two solar panels per person to meet the drinking water needs for everyone in its household. Growing food would require even more water. The team reports its findings in *Cell Reports Physical Science*.



This artist's drawing shows what a new water- and energy-production system might look like. Its solar panels generate power as a water-harvesting unit pulls moisture from the air. A roof shades irrigated crops from the hot sun.

The new system can run in one of two modes. In the first, it uses the moisture it collects to cool the solar panels. (Cooler panels can convert sunlight to electricity more efficiently.) Or the collected water can be used for drinking and growing crops. Opening or closing a chamber under each solar panel determines how it uses its collected water.

The solar panel–cooling mode "is similar to human sweating," explains Wang. "We sweat in order to reduce our body temperature in hot weather or when we do exercise." The water in sweat carries away heat from our bodies as it evaporates. Likewise, the water stored on the back of the solar panels can absorb some heat from the panels as it evaporates.

This mode cooled the solar panels by up to 17 degrees Celsius (30 degrees Fahrenheit). This boosted the panels' power output by 10 percent. In this mode, someone would need fewer solar panels to meet their power needs.

In the system's water-collecting mode, water vapor condenses out of the hybrid hydrogel as droplets that drip into a storage chamber. This mode still boosts the solar panels' power output, but just a little — by some 1.4 to 1.8 percent.

During the trial, Wang's team used their device to grow a crop called water spinach. The researchers planted 60 seeds. With shade from the hot summer sun and daily water pulled from the air, almost all the seeds — 19 out of every 20 — grew into plants.

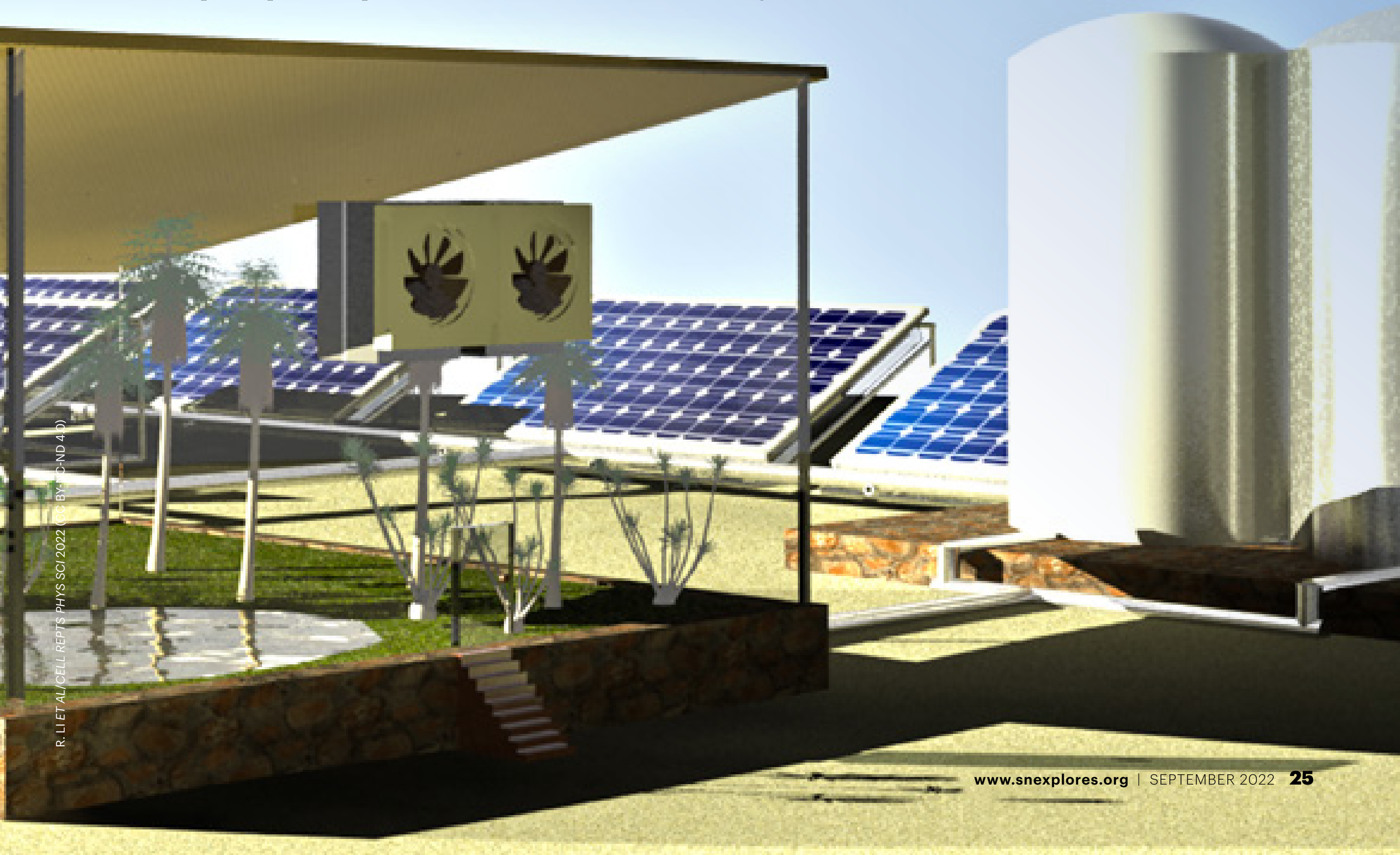
"It's an interesting project," says Jackson Lord. He's an environmental technologist and renewable-energy consultant with AltoVentus in San Francisco, Calif. Earlier in his career, he studied harvesting water from the air while working for X-The Moonshot Factory, based in Mountain View, Calif.

Speaking of the new system, Lord notes that it "can produce clean water anywhere." But he thinks this type of system is better suited for making drinking water than growing food. There usually isn't enough water in the air of dry regions to grow big fields of crops, he explains.

Still, Lord adds, it's important to build systems like this that tap into unused resources — whether that's drawing water from the air or harnessing excess heat to do useful work. And since the system boosts the power of a regular solar panel, he says its ability to collect water for drinking or growing crops could be thought of as a bonus to use when needed.

Wang notes that this invention is still in the early stages. He hopes to work with partners to improve the system and make it available around the world.

— *Laura Allen*



R. LI ET AL/CELL REPTS PHYS SCI 2022 (CC BY-NC-ND 4.0)

ANIMALS

Monstrous mammals would break the body rules

Our imaginations have no limits — but body size does

Giant mammals stomp through our imaginations. Clifford is a big red dog. Jack climbs a beanstalk to meet a giant. *Ella Enchanted* goes to a giant couple's wedding. In Disney and Pixar's *Turning Red*, Mei turns into a red panda the size of a grizzly bear. And if you think that's big, wait until you see her mom. But giants don't terrorize our real lives. Why? It has to do with heat.

Mammals can only get so large on land, explains Felisa Smith. She's a paleoecologist — someone who studies ancient ecosystems — at the University of New Mexico in Albuquerque. In theory, she says, if animals were only limited by the amount of weight their legs could carry, a four-legged animal could get as large as 109 metric tons (120 short tons). That's a bit larger than a 737 airplane or the largest dinosaurs to ever roam the planet. But there's no real use in being that massive. "Your legs would have to be so big to support your body that you couldn't move," Smith says.

Today's largest land mammals — male African bush elephants — are tiny in comparison. They average only a measly 6 metric tons (almost 7 short tons). *Paraceratherium*, the largest known land mammal, topped out at around 16 metric tons — well below that supposed 109-metric-ton limit. Thundering across Europe and Asia some 30 million years ago, it looked a bit like a cross between a giant rhinoceros and a huge horse.

Blame heat for land mammals' (relatively) small stature. Mammals are endotherms. They have to keep their bodies at a constant warm temperature. They digest food to generate energy to stay warm. Today's reptiles, in contrast, are ectotherms. Their body temperature varies with the environment. This means reptiles can't be active in the cold like mammals. But they also save a lot of energy by not generating their own heat. "If you take a reptile and mammal of the same size, the mammal needs 10 times more energy than the reptile does," Smith says.

The biggest land animals are all herbivores. They get their energy from plants, which get their energy from the sun. And to consume enough plants to get really big, an herbivore needs a huge home range, Smith says. Each individual *Paraceratherium* needed so much space that it would have to travel

In *Turning Red*, a girl named Mei turns into a huge red panda when she experiences strong emotions. Real red pandas are about the size of a house cat.

An African elephant (top) has big ears filled with blood vessels to help the mammals release heat into the air. Heat is a big limit on mammal size. The biggest land mammals to ever live, *Paraceratherium* (bottom), topped out at only 16 metric tons, much smaller than a blue whale, the largest animal ever.

long distances to find a mate. The species munched its way across most of Europe and Asia — all of North America would not have been big enough.

But really big herbivores risk generating too much heat. These animals have to break down lots of tough, fibrous plant material. Gut bacteria break down the plants in a process called fermentation. The mammal gets the energy it needs, but fermentation also creates heat. "You have this internal fermentation chamber that is actually producing energy and heat … and then you're endothermic. It's kind of a disaster," Smith says. Get too hot, and the mammal will die. So it has to release that extra heat.

Body modifications can help. African elephants, for example, have evolved huge ears. Blood vessels in those ears help dump heat into the air. Elephants can even wave their ears back and forth, creating their own breeze to whisk the heat away. They also have very little hair, so heat doesn't get trapped close to their skin.

There are other reasons why being big just isn't all that practical. Monstrous size also means monster appetites, whether an animal is eating plants or something else. Clifford the big red dog would go through a lot of dog food. The giants would need to eat a lot of snacks. And all of them would probably be constantly trying to stay cool.

In *Turning Red*, Mei turns into a giant red panda. Real red pandas are much smaller — about five kilograms (11 pounds) on average. Red pandas also live in trees, which means they can't get too giant. And while Mei might find a home in the California redwoods, there would never be a tree big enough to support her mom. Her red panda form is as tall as a stadium. And the pair of red pandas would easily eat all the trees and bamboo bare. "There's no way [a huge red panda] could sit and eat bamboo or whatever. It would starve to death," Smith says. "Unless it's sneaking hamburgers on the side."

— *Bethany Brookshire*

FROM TOP: BILDAGENTUR ZOONAR GMBH/SHUTTERSTOCK; WARPAINTCOBRA/ISTOCK/GETTY IMAGES PLUS; LIFESTYLE PICTURES/ALAMY

PLANTS

How photosynthesis works

Plants make sugar and oxygen with the power of water, carbon dioxide and sunlight

Take a deep breath. Then thank a plant. If you eat fruit, vegetables, grains or potatoes, thank a plant too. Plants and algae provide us with the oxygen we need to survive, as well as the carbohydrates we use for energy. They do it all through photosynthesis.

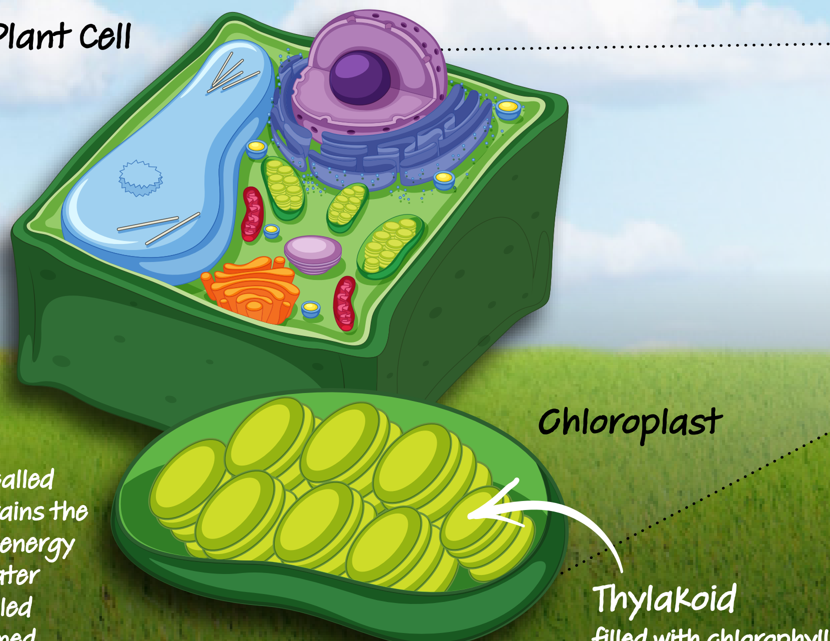
Photosynthesis happens through a long series of chemical reactions. But it can be summarized like this: Carbon dioxide, water and sunlight go in. Glucose, water and oxygen come out. (Glucose is a simple sugar.) There are two processes that make this happen: The "photo" part refers to reactions triggered by light. "Synthesis" is the making of the sugar.

Both processes happen inside a chloroplast. This is a specialized structure, or organelle, in a plant cell. The structure contains stacks of thylakoid membranes. Those membranes are filled with chlorophyll, a green pigment. This pigment absorbs energy from sunlight in wavelengths we see as blue and red. That's why we see plants as green. Green is the wavelength plants reflect, not the color they absorb.

When light enters a leaf, its energy excites a chlorophyll molecule. That starts a process that splits a molecule of water. The oxygen atom that splits off from the water instantly bonds with another, creating a molecule of oxygen. The chemical reaction also produces two other molecules: ATP and NADPH. Both of these allow a cell to store energy.

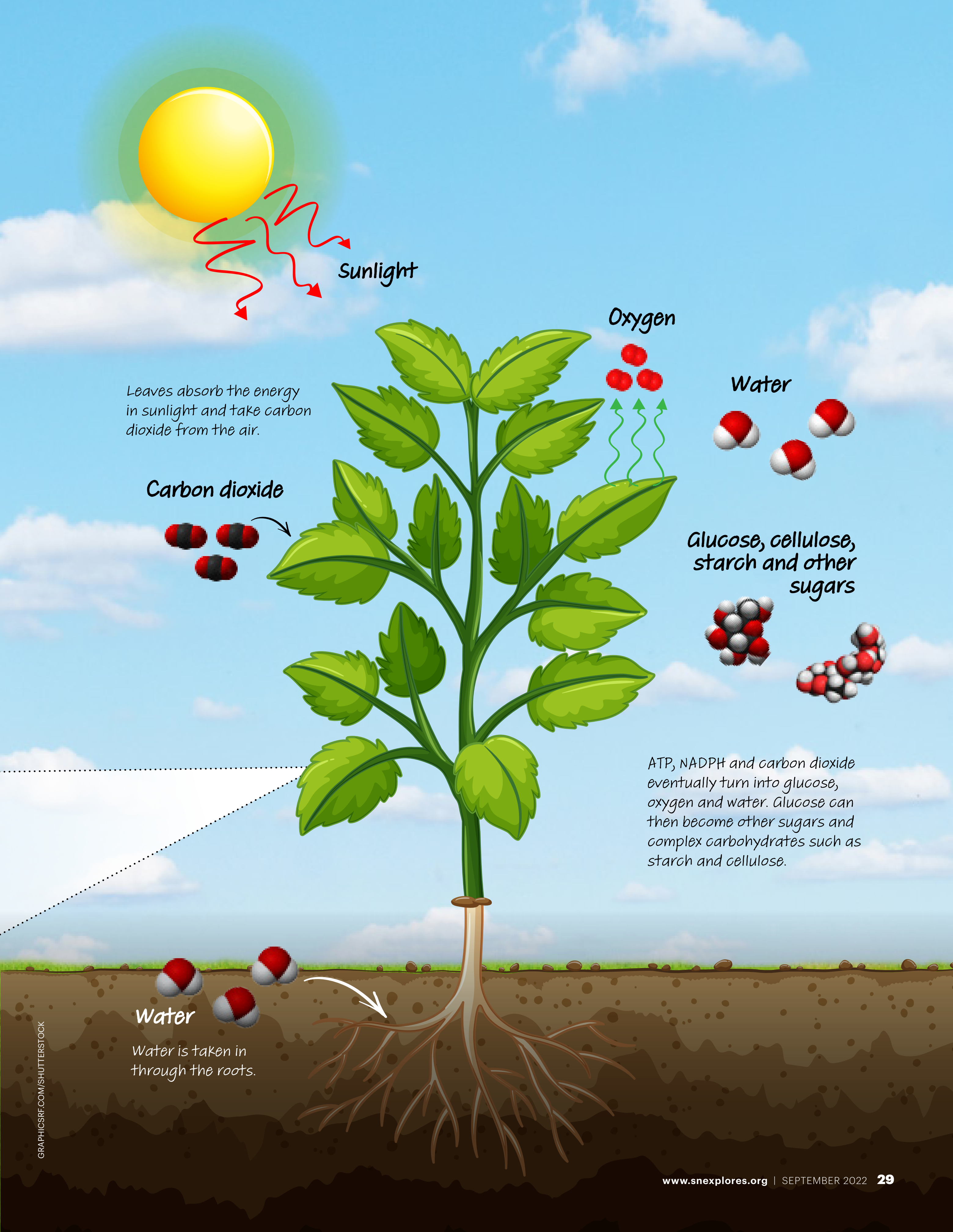
In the synthesis part of photosynthesis, ATP and NADPH, along with carbon dioxide, split and combine until the process eventually ends up with glucose, oxygen and water. The oxygen and water go out into the atmosphere. And the glucose molecule goes on to bigger things. It can become part of the cellulose in cell walls or large molecules of starch, or transform into other sugars — such as fructose — that make our food taste sweet.

— *Bethany Brookshire*



Plant cells have special organelles called chloroplasts. Each chloroplast contains the pigment chlorophyll, which absorbs energy from sunlight. In the chloroplast, water sheds its oxygen, and two energy-filled molecules (ATP and NADPH) are formed.

JAN PHANOMPHRAI/SHUTTERSOCK



GRAPHICSRF.COM/SHUTTERSTOCK

MATERIALS

These wooden knives are super sharp

Modifying wood may make a renewable material that can stand in for steel and plastic

An age-old material has gotten a hardcore makeover. Researchers have modified wood to make a renewable substitute for plastic and steel. Carved to make a knife blade, the hardened wood is sharp enough to easily slice through steak.

People have built with wood for thousands of years. "But we found that the typical use of wood barely touches its full potential," says Teng Li. A mechanical engineer at the University of Maryland in College Park, Li applies physics and materials science to design. He and his colleagues developed the hardened wood.

Materials such as diamonds, metal-containing mixes known as alloys and even some plastics are very hard. They aren't, however, renewable. So Li and other scientists have been trying to make hard materials from living things, such as plants, which are both renewable and degrade easily.

Wood contains the natural polymers cellulose, hemicellulose and lignin. These polymers give wood its structure. Chains of lightweight and strong cellulose, in particular, make a skeleton of sorts for the wood. Li's team came up with a way to enrich the wood in that cellulose. They then squashed the wood with a machine that applied a lot of pressure.

After the wood was dried out with heat, Li says it became so hard that a fingernail couldn't easily dent it. The researchers then soaked the wood in oil to make it water-resistant. Finally, the team carved this wood into knives, either with the wood grain parallel or perpendicular to a knife's edge. The scientists described this method in the journal *Matter*.

The researchers compared their knives with commercial steel and plastic knives. They also made a nail from the treated wood and used it to hold together three wooden boards. The nail was strong. But unlike steel nails, the wooden nails won't rust.

— *Carolyn Wilke*

Removing some of wood's lignin — one of its natural polymers — and squashing it makes a hard material. That wood now can be carved into a knife that will slice through steak, as shown here.

B. CHEN

TESTING FOR HARDNESS

In the Brinell hardness test, a ball of a superhard material called carbide is pressed against the wood, denting it. The resulting Brinell hardness number is calculated from the size of the dent in the wood. **Figure A** shows the test results for natural wood (tan) and hardened wood (yellow) that had been treated with chemicals for 2, 4 and 6 hours. From the hardest of those woods, the researchers made two wood knives that they compared with commercial polymer and steel table knives (**Figure B**).

To measure sharpness, they pushed the knives' blades against a plastic wire (**Figure C**). In some tests they pushed straight down (cutting without sliding) and in others they used a sawing motion (cutting with sliding). Sharper blades require less force to cut the wire.

FIGURE A

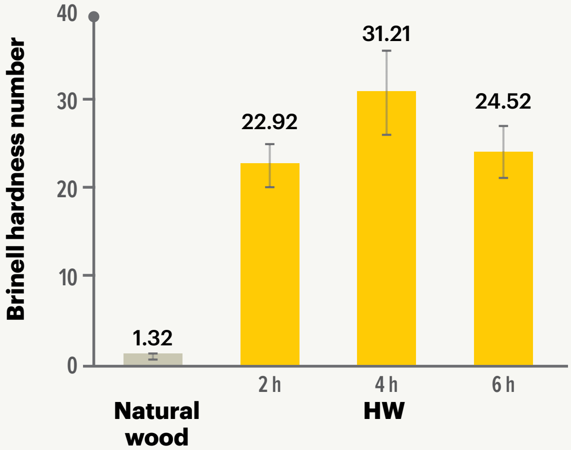


FIGURE B

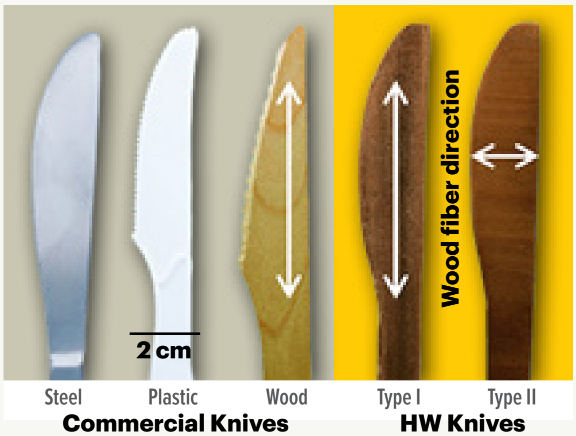


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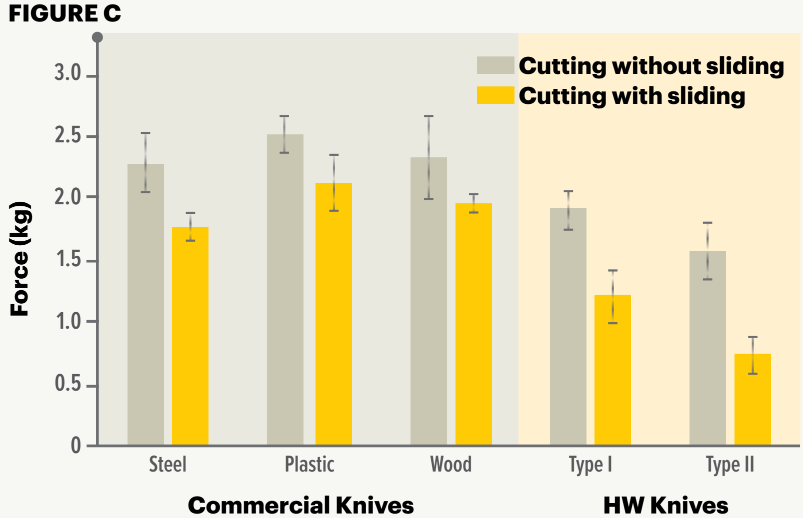
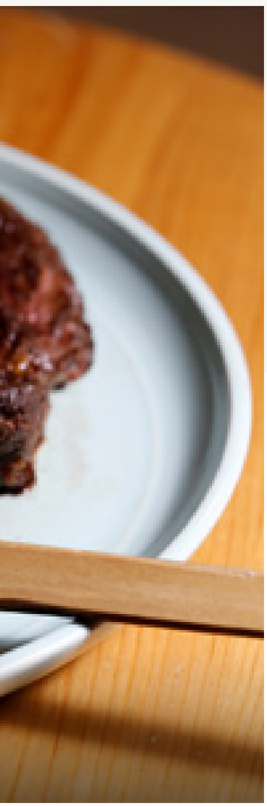
FIGURE C





DATA DIVE

1. Look at **Figure A**. What treatment time gives the hardest wood?

2. How does the hardness change from 4 hours of treatment time to 6 hours?

3. Divide the hardness of the hardest wood by the hardness of the natural wood. How much harder is the hardened wood?

4. Look at **Figure C**, which shows the force required for each knife to cut a polymer wire. Sharper materials require less force (less pushing) to cut. What is the range of force values for commercial knives?

5. Which knives are the least sharp? Which knives are the sharpest?

6. Which motion, sliding or no sliding, requires more force to cut? Does this fit with your experience cutting vegetables or meat?

ANSWER

The first plants ever grown in moon dirt have sprouted

But farming on the moon may be difficult

That's one small stem for a plant, one giant leap for plant science.

In a tiny, lab-grown garden, the first seeds ever sown in lunar dirt have sprouted. This small crop was planted in samples returned by the Apollo missions roughly 50 years ago. And its success offers hope that astronauts might someday grow their own food on the moon.

But there's a catch. Plants potted in lunar dirt were far scrawnier than those grown in volcanic material from Earth. Moon-grown plants also grew more slowly than those nourished in earthly material. These findings suggest that farming on the moon would take a lot more than a green thumb. Researchers shared the results in *Communications Biology*.

Some scientists, though, aren't daunted by the challenges revealed by this first attempt at lunar farming. Richard Barker studies how plants could grow in space at the University of Wisconsin–Madison. "I'm optimistic," he says. "There's many, many steps and pieces of technology to be developed before humanity can really engage in lunar agriculture. But having this particular dataset is really important for those of us that believe it's possible."

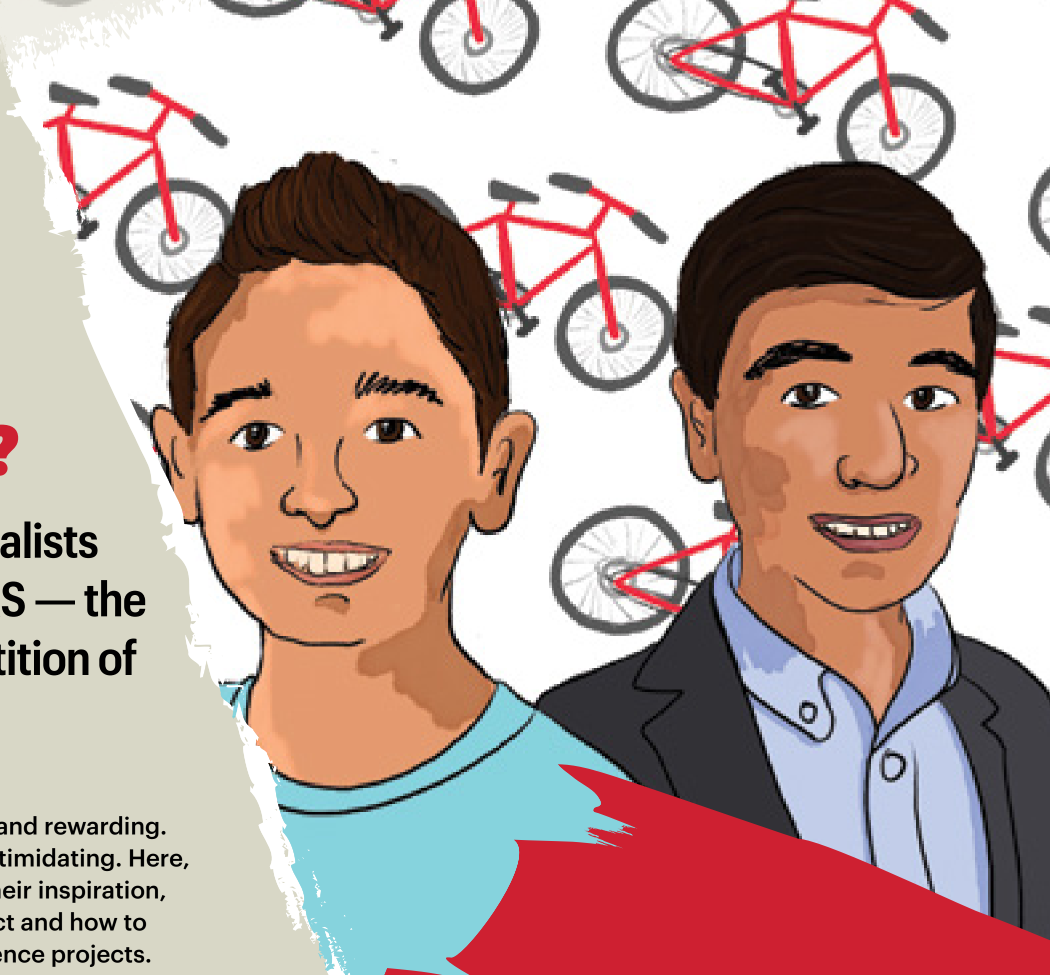
— *Maria Temming*

This thale cress plant sprouted from a seed potted in lunar dirt that was collected by Apollo astronauts.

TYLER JONES, UF/IFAS

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

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



Science competitions can be fun and rewarding. But for many, they also can be intimidating. Here, Avi Patel and Ansh Sehgal discuss their inspiration, what they enjoyed about their project and how to take the first step with your own science projects.

Q What inspired you to pursue this project?
A "Many years ago, I visited a shelter for blind people in India," says Ansh. There, he saw a little girl approach a milkman and asked if she could ride his bike. "She was very fascinated about how he rode the bike," Ansh recalls. Avi had a similar experience while volunteering at a summer camp for blind people when he was 10. After sharing those stories with each other, Ansh and Avi decided to team up to help visually impaired people ride bicycles.

Q What was your favorite part of this project?
A The most rewarding part was figuring out why they couldn't get their program to work, Avi says. "We got so frustrated," he recalls. "It took us an entire day to figure it out." The problem? A single line of extra code that caused the entire system to fail. "After that we had a pretty good laugh," Avi says. For Ansh, one of the best parts was getting feedback on their project from someone who was visually impaired.

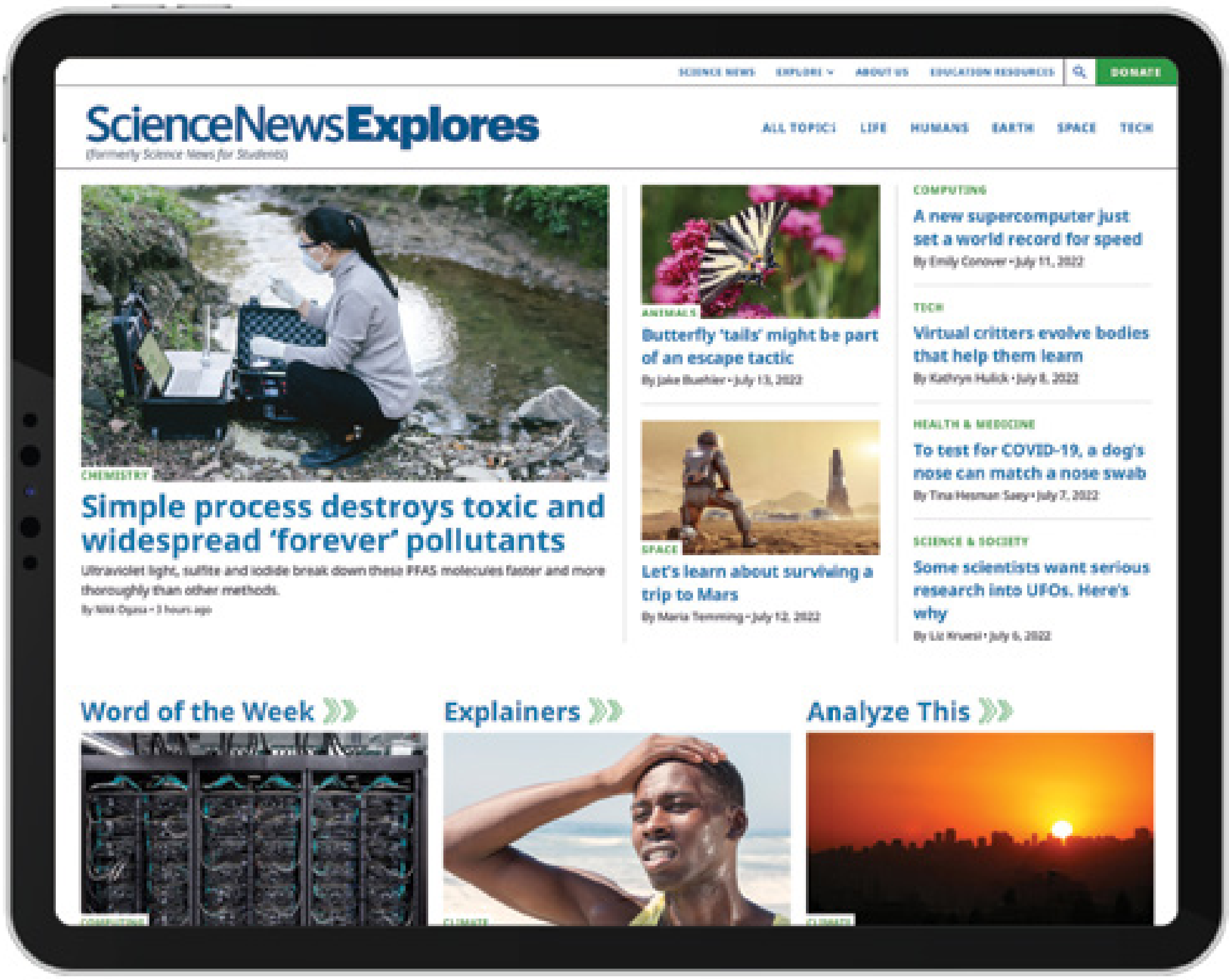
Q What would you tell a kid who wanted to start a science project?
A "I think kids should mainly seize every opportunity that they get, whether it's in STEM or outside of STEM," Ansh says. After all, you never know when you might discover a new passion.

2021 Broadcom MASTERS Finalist

Avi Patel and Ansh Sehgal

Avi and Ansh, both age 13, built a program together to help visually impaired people ride a bicycle. A device on a sighted person's bicycle sends instructions to a visually impaired person's bike about when and how to make turns. Avi and Ansh attend Thomas Jefferson Middle School in Fair Lawn, N.J.

ILLUSTRATION BY JOANNA WENDEL



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