ScienceNews Explores
September 2023

# CAN A ROBOT BE YOUR FRIEND?

COULD STAR TREK REPLICATORS EXIST?
P26

## CARVINGS ON AUSTRALIA'S BOAB TREES REVEAL A PEOPLE'S LOST HISTORY

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CRYSTAL EYE STUDIO/SHUTTERSTOCK



D. LEWIS

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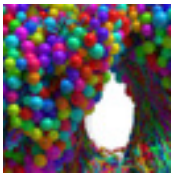













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## Q Why are icebergs so blue?

— *Eliot K.*

**A** Some icebergs look blue because their ice is so dense, according to the National Oceanic and Atmospheric Administration. When light passes through this dense ice, longer wavelengths — such as red and yellow light — get absorbed. Shorter wavelengths, such as blue, get reflected. Those reflected light waves are the ones that reach our eyes, so the iceberg appears bluish. Most icebergs, though, look white. That's because they're blanketed in ice crystals that are less densely packed. All the light waves that hit this looser jumble of ice crystals and air bubbles bounce off about equally. Since all wavelengths of visible light reach the viewer's eyes, the iceberg appears white.

## Q One little flame can turn a whole lot of wood into charcoal. How?

— *Charlie N.M.*

**A** Fires can create different kinds of debris depending on how well the wood burns and if it is in contact with oxygen, says John Bailey. This researcher studies wildfires and forest health at Oregon State University in Corvallis. Charcoal forms when wood is partially burned with a limited supply of oxygen. This oxygen-starved smolder releases water vapor and other gases from the wood, leaving behind a lump of carbon known as charcoal. Wood that is burned in open air, meanwhile, breaks down more completely. Any organic material is incinerated, leaving behind mostly smoke and minerals in the form of ash.

## Q Why can't kids drink coffee?

— *Jeremy F.*

**A** Coffee contains a chemical called caffeine. Caffeine belongs to a group of chemicals known as stimulants. Like other stimulants, caffeine can help keep people alert and focused. But too much caffeine can make it hard to fall asleep. "Sleep is incredibly important to overall health — especially for kids," says Gregory Marcus, a medical doctor at the University of California, San Francisco, who has studied the health effects of caffeine. Sleep-deprived kids and teens may become more irritable or have trouble focusing on schoolwork. Missing out on a full night's rest has also been linked to a higher risk of developing certain diseases, such as diabetes. Many adults drink coffee in the morning to help them wake up. But even consuming caffeine early in the day can affect sleep at night, says Marcus. "I would strongly recommend avoiding coffee until one reaches adulthood."

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**Sarah Zielinski**
Editor, *Science News Explores*

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ANIMALS

# Body of a bird, head like a *T. rex*

## This ancient mashup could show how dinosaurs took to the air

Modern birds evolved from meat-eating dinosaurs called theropods. A fossil of a dino-bird mashup could help explain how.

A 120-million-year-old bird fossil was dug up in northeastern China. The creature had a body like today's birds but rocked a dino-like head.

Paleontologist Zhiheng Li led a team that studied the ancient bird, named *Cratonavis zhui*. The scientists work at the Chinese Academy of Sciences in Beijing. They described their findings in *Nature Ecology & Evolution*.

The researchers used CT scans to build a digital 3-D model of the fossil. *Cratonavis* had a skull nearly identical to meat-eaters like *Tyrannosaurus rex*, they found. It lacked the movable upper jaw that helps most of today's birds preen their feathers and snatch food.

The CT scans revealed other curious features of *Cratonavis*, too. It didn't have a well-developed breastbone, for one. That's where modern birds' flight muscles attach. But the creature did have weirdly long shoulder blades, where flight muscles might have attached. That may have allowed *Cratonavis* to fly.

*Cratonavis* also had a strangely long, backward-facing toe. The creature might have used this impressive digit to hunt, like today's eagles and owls. But *Cratonavis* was only about as big as a dove, so it likely went for small prey like insects and the occasional lizard.

When *Cratonavis* was alive, ancient birds lived alongside nonbird dinosaurs. About 60 million years later, all nonbird dinosaurs were wiped out. The ancient birds left behind eventually gave rise to today's hummingbirds, chickens and other birds.

— *Aaron Tremper*

CT scans of this flattened fossil (right) guided a reconstruction (left) of what the 120-million-year-old Cratonavis might have looked like.

ILLUSTRATION: ZHAO CHUANG; FOSSIL: WANG MIN

HUMANS

# Cleaner buses could get more kids to school

## Less-polluting buses cut down on student absences

Riding the bus to school could be keeping some kids out of class.

Most school buses run on diesel fuel. Diesel buses spew pollution, including tiny particles and gases. Bus riders get exposed to high levels of this pollution. When inhaled, it can lead to breathing problems, such as asthma, and other health issues that may keep kids home from school. But replacing the worst-polluting buses should cut down on student absences, a new study shows.

The study focused on schools that asked to take part in a U.S. government program. The program offered schools cash back for money spent on cleaner school buses. The 2,816 school districts in the new study all asked for the money. But not all got it. They were put into a random lottery. Only 383 were picked to receive funding. Winning districts could buy new buses and scrap old ones. Or they could add new pollution controls to existing buses. Most bought new buses.

The program started in 2012. From 2012 to 2017, the winning districts very likely had less bus pollution. And a year after getting new buses, student attendance had improved in those districts.

For an average district of 10,000 students, about six more students attended school each day in the winning districts. Districts that replaced the oldest buses saw the biggest jump. They had an average of 45 more students in school each day.

Those numbers may sound small, but they can add up, says Meredith Pedde. She's an environmental epidemiologist — a disease detective — at the University of Michigan in Ann Arbor. Her team reported the results in *Nature Sustainability*.

Almost 3 million U.S. kids ride school buses more than 20 years old, her team figures. Replacing all of those older buses could mean 1.3 million fewer student absences each year, the data suggest. And school attendance matters for student achievement.

Jay Shimshack has also found links between buses and student health. He is an economist at the University of Virginia in Charlottesville. He studied a program that upgraded pollution controls in old diesel buses in Washington. Afterward, fewer kids were hospitalized for asthma and pneumonia in those districts than in schools without bus upgrades.

Now the U.S. Environmental Protection Agency (EPA) has a new rebate program for school buses. It's offering $5 billion through 2026 to replace old diesel buses with electric buses. Or districts can buy buses that run on cleaner fuels, such as propane or compressed natural gas.

Almost all U.S. school districts can apply for the new rebates. But schools in low-income areas, in tribal areas and in rural areas will get priority. Kids in these areas tend to face the most health risks from older buses, EPA notes.

And anything that cuts air pollution, Pedde says, should improve student health.

— *Kathiann Kowalski*

VIKTORIIA HNATIUK/SHUTTERSTOCK

SPACE

# Earth's moon and plate tectonics may share an origin story

## One catastrophic smashup may have given Earth two of its most iconic features

Our moon is thought to have formed when a Mars-sized planet called Theia slammed into early Earth. That smashup would have kicked debris into space that later clumped together to form the moon. Now, computer models suggest that bits of Theia left deep inside Earth kick-started plate tectonics. That's the continual shuffling of pieces of Earth's surface.

Qian Yuan shared this idea at the Lunar and Planetary Science Conference in The Woodlands, Texas. Yuan studies how Earth's layers move at Caltech in Pasadena, Calif.

His team thinks that two continent-sized blobs of material in Earth's lower mantle might be remnants of Theia. So, the team built computer models to see how Theia's sunken remains would affect the flow of rock inside Earth.

Once Theia's remains sank to the bottom of the mantle, these hot blobs could have caused large plumes of warm rock to rise up. As more material rose, these plumes would eventually push slabs of Earth's surface beneath them. When pieces of Earth's surface slip down into the mantle, it's called subduction. And subduction is a main feature of plate tectonics.

Large blobs in Earth's lower mantle could have helped start subduction, says Laurent Montési. But he's not convinced these masses came from Theia. At the University of Maryland in College Park, Montési studies how the layers of planets move.

If Theia did form both the moon and plate tectonics, that could help astronomers spot Earthlike worlds around other stars. "If you have a large moon, you likely have a large impactor," Yuan said at the conference. If you have a large impactor, that might mean you have plate tectonics. So keeping an eye out for planets with big moons, Yuan said, could help us uncover another world as tectonically active as our own.

*— Nikk Ogasa*

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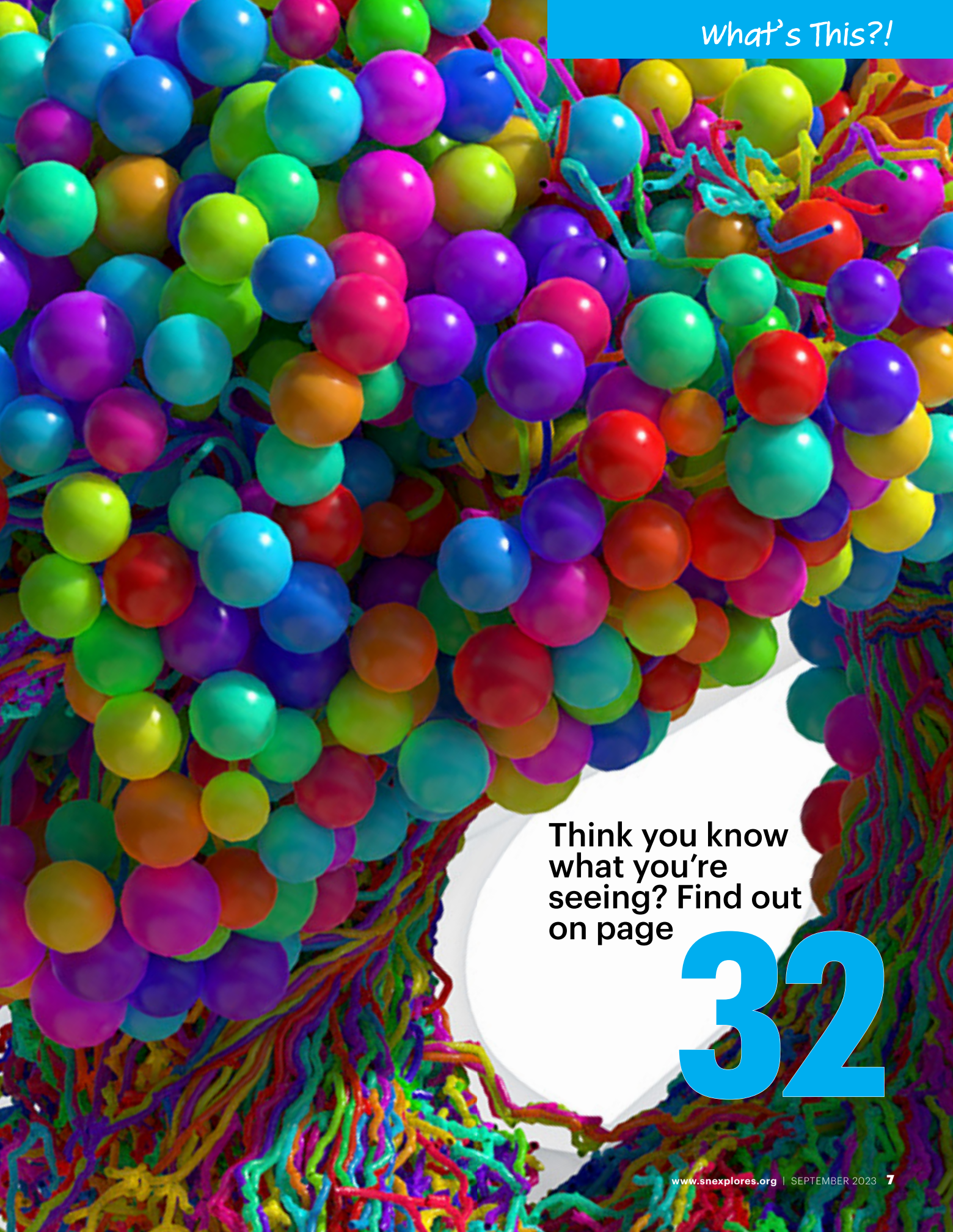


Think you know what you're seeing? Find out on page 32

# CAN A ROBOT BE YOUR FRIEND?

## Researchers are making machines that can hug, laugh and more

Would you hang out with R2-D2 if you got the chance? Seems like it could be pretty fun. In the *Star Wars* universe, droids appear to form meaningful friendships with people. In real life, however, robots can't actually care about anyone or anything. At least, not yet. Today's robots can't feel emotions. They also have no self-awareness. But that doesn't mean they can't act friendly in ways that help and support people. >>

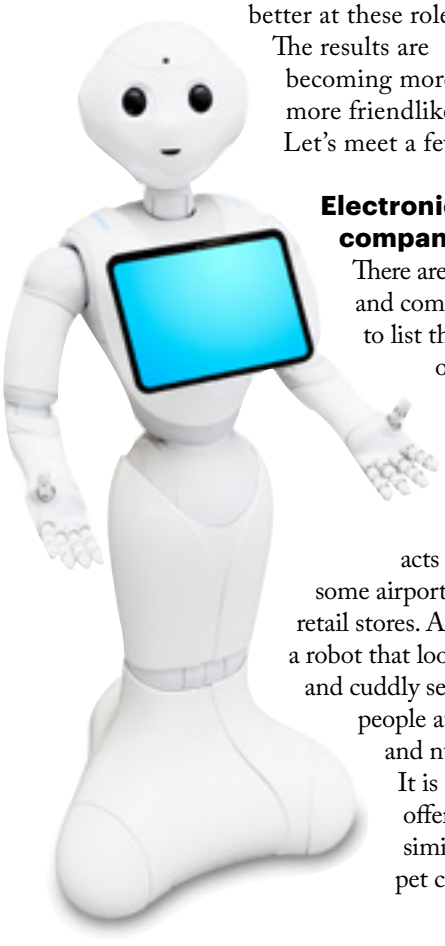
PHOTO 12/ALAMY

By **Kathryn Hulick**

An entire field of research called human-robot interaction — or HRI for short — studies how people use and respond to robots. Many HRI researchers are working to make friendlier, more trustworthy machines. Some hope true robot friendships may one day prove possible.

"I think we're on the right track," says roboticist Alexis E. Block. "But there's a lot more work to do." Block is affiliated with the University of California, Los Angeles and the Max Planck Institute in Stuttgart, Germany.

Other researchers are more skeptical about using the word "friend" for machines. And today's bots aren't yet true friends, like R2-D2 or C-3PO (right). But some are helpful assistants or engaging teaching tools. Others are attentive companions or delightful petlike toys. Researchers are working hard to make them ever better at these roles. The results are becoming more and more friendlike. Let's meet a few.



## Electronic companions

There are too many social and companion robots to list them all — new ones come out all the time. There's Pepper (left), the humanoid robot that acts as a guide in some airports, hospitals and retail stores. And Paro (right), a robot that looks like a soft and cuddly seal. It comforts people at some hospitals and nursing homes. It is supposed to offer companionship similar to a pet cat or dog.

A robot pet isn't nearly as lovable as a real one. Then again, not everyone can keep a cat or dog. "Petlike robots can be especially useful in environments where a real pet wouldn't be allowed," notes Julie Robillard. Also, she says, "There is no poop to pick up!" Robillard is a neuroscientist and expert in brain-health technology at the University of British Columbia in Vancouver, Canada. She has been studying whether robot friendships might be a good or bad thing for people.

MiRo-E (right) is another petlike robot. It has been designed to engage with people and respond to them. "It's able to see human faces. If it hears a noise, it can tell where the noise is coming from and can turn in the direction of the noise," explains Sebastian Conran. He co-founded Consequential Robotics in London, England. It makes this robot.

If someone strokes MiRo-E, the robot acts happy, he says. Talk to it in a loud, angry voice and "it will glow red and run away," he says. (Actually, it'll roll away; it travels on wheels). With the right code, Conran notes, the robot

The companion robot MiRo-E responds with animal-like sounds and motions — and colors to indicate its mood. "MiRo is fun because it seems to have a mind of its own," says Julie Robillard.

PEPPER: KASPARS GRINVALDS/SHUTTERSTOCK; C3PO: JANSON_G/PIXABAY/NEEDPIX; PARO: YAMAGUCHI HARUYOSHI/CONTRIBUTOR/GETTY

could recognize people or tell if they are smiling or frowning. It could even play fetch with a ball.

He doesn't go so far as to call MiRo-E a friend, though. He says a relationship with this type of robot is possible. But it would be most similar to the kind of relationship a child might have with a teddy bear or that an adult might have with a beloved car.

## A childhood dream

Moxie (right) is a different sort of social robot. "It's a teacher disguised as a friend," says Paolo Pirjanian. He founded Embodied, a company in Pasadena, Calif., that makes Moxie. Bringing a lovable character to life as a robot was his childhood dream. He wanted a robot that could be a friend and a helper, "maybe even help with homework," he jokes.

In fact, Moxie doesn't do your homework. Instead, it helps with social and emotional skills. Moxie has no legs or wheels. It can swivel its body, though, and move its arms in expressive ways. It has a screen on its head that displays an animated cartoon face. It plays music, reads books with kids, tells jokes and asks questions. It can even recognize emotions in a human's voice.

Moxie tells kids that it is trying to learn how to become a better friend to people. By helping the robot with this, kids learn new social skills themselves. "Children open up and start talking to it, as if with a good friend," says Pirjanian. "We have seen children confiding in Moxie, even crying to Moxie. Children also want to share exciting times of their life and experiences they've had."

The idea of kids spilling out their hearts to a robot makes some people uncomfortable. Pirjanian admits this is something that his team thinks about — a lot. "We definitely have to be careful," he says. The best artificial intelligence (AI) language models are starting to converse with people in a way that feels natural. Add this to the fact that Moxie mimics emotion so well, and kids may get tricked into believing it's alive.

To help prevent this, Moxie is always very clear with kids that it is a robot. Also, Moxie can't yet understand things like TV shows or recognize toys that kids show it. Pirjanian's team hopes to overcome these problems. But his goal is not for kids to become best friends with a robot. "We are successful," he says, "when a child no longer needs Moxie." That will be when they have strong enough social skills to make lots of human friends.

**Rocco (right) lives in Orlando, Fla. His Moxie doesn't take the place of human friends. If they've been interacting for 30 or 40 minutes, Moxie will say it is tired. It will prompt him to go play with family or friends.**

MIRO: © CONSEQUENTIAL ROBOTICS 2019; MOXIE: COURTESY OF EMBODIED

### 'I'm ready for a hug!'

HuggieBot (right) may seem simple in comparison to MiRo-E or Moxie. It can't chase a ball or chat with you. But it can do something very few other robots do: It can ask for hugs and give them out. Hugging, it turns out, is really difficult for a robot. "It's so much harder than I initially thought," says Block.

The robot has to adjust its embrace to people of all sizes. It uses computer vision to estimate someone's height so that it raises or lowers its arms to the right level. It must gauge how far away someone is so it can start closing its arms at just the right time. It has to figure out how tight to squeeze and when to let go. For safety, Block used robot arms that are not strong. Anyone can easily push the arms away. Hugs also need to be soft, warm and comforting — words not typically used with robots.

Block first started working on a hugging robot back in 2016. Today, she's still tinkering with it. In 2022, she brought the current version (HuggieBot 4.0) to the Euro Haptics conference, where it won an award. Her team set up a demonstration booth for attendees.

When someone walked by, the robot would say, "I'm ready for a hug!" If that person approached it, the robot would carefully wrap its padded, heated arms around them in an embrace. If its human partner patted, rubbed or squeezed while hugging, the robot would perform similar gestures in response. These comforting actions "make the robot feel so much more alive," says Block.

A. E. BLOCK

### Sharing laughs

Many social robots, including Pepper and Moxie, converse with people. These chats often feel mechanical and awkward. And no one yet knows how to teach a robot to understand the meaning behind a conversation.

It's possible, however, to make such chats feel more natural, even without the robot understanding anything. People make many subtle gestures and sounds when they talk. You may not even realize you're doing this. For example, you may nod, say "mhmm" or "yeah" or "oh" — even laugh. Roboticists are working to develop chatting software that can respond in similar ways. Each type of response is a separate challenge.

Divesh Lala is a roboticist at Kyoto University in Japan. He recalls watching people talk with a

STOCK-ASSO/SHUTTERSTOCK

realistic social robot called Erica. "A lot of times they'd laugh," he says. "But the robot wouldn't do anything. It would be uncomfortable." So Lala and a colleague, roboticist Koji Inoue, went to work on this issue.

The software they designed detects when someone laughs. Based on how that laugh sounds, it decides whether to laugh, too — and what type of laugh to use. The team had an actor record 150 different laughs.

If you just chuckle, Lala says, the robot is "less likely to want to laugh with you." That's because a very small laugh could mean you're just releasing tension. For example, "I forgot to brush my teeth this morning, haha. Oops." In this case, if the person you were chatting with also laughed, you might feel even more embarrassed.

But if you tell a funny story, you'll probably laugh louder and longer. "My cat tried to steal my toothbrush while I was brushing! HAHAHA!" If you use a big laugh, "the robot responds with a big laugh," says Lala. The vast majority of laughs, though, fall somewhere in between. These "social" laughs just indicate you're listening. And they make chatting with a robot feel a bit less awkward.

Lala did this work to make robots more realistic companions for people. He thinks that robots that appear to listen and show emotions can help lonely people feel less isolated.

## A new kind of friendship

Most people who interact with social robots understand that they are not alive. Yet that doesn't stop some people from talking to or caring for robots as if they were. People often give names to even lowly vacuum-cleaning machines, such as Roomba, and may treat them almost like family pets.

Before he started building Moxie, Pirjanian helped lead iRobot, the company that makes Roomba. iRobot would often get calls from customers whose robots needed repairs. The company would offer to send out a brand-new one. Yet most people said, "No, I want *my* Roomba," he recalls. They didn't want to replace the robot because they'd grown attached to it. In Japan, some people have even held funerals for AIBO robot dogs after they stopped working.

Clearly, some folks are already forming relationships with robots. This can be a problem if someone neglects their relationships with people to spend more time with a machine. Some people already spend excessive amounts of time playing video games or looking at social media. Social robots could add to the list of entertaining but potentially unhealthy technology.

But relating to robots can have its benefits. Other people won't always be available when someone needs to talk or get a hug. Although not ideal companions, social robots might be better than no one.

Plus, asking for a hug from someone, especially someone who's not a very close friend or family member, may feel scary or awkward. A robot, however, "is just there to help you for whatever you need," says Block. It can't care about you — but it also can't judge or reject you.

The same goes for chatting with robots. Some neurodivergent people — such as those with social anxiety or autism — may not feel comfortable talking to others. Technology, including simple robots, can help them open up.

Perhaps someday, someone will build a true R2-D2. Until then, social robots offer a new and intriguing type of relationship. "Robots could be like a friend," Robillard says, "but also like a toy — and like a tool."

Alexis E. Block enjoys an embrace from HuggieBot. "I think it feels very nice," she says.

FEIWEL & FRIENDS

**Having a robot at home will likely become more common in the future. If you had one, what would you want it to do with you or for you? What would you prefer to do with other people?**

## READ MORE


***Kid-ventors: 35 Real Kids and Their Amazing Inventions***

*—by Kailei Pew, illustrated by Shannon Wright*

**Only adults can invent new machines, right? Think again! In this book, meet one girl who taught herself the skills to make robots as well as other young inventors changing the world.**

# Magic, cooking and droids inspire this roboticist

## Dennis Hong builds robots that help solve problems — and entertain

One day, you may get to try food prepared by a robot — and it just might be one invented by Dennis Hong.

Hong is a roboticist and the founding director of the Robotics and Mechanisms Laboratory at the University of California, Los Angeles (RoMeLa). He and his graduate students at the UCLA Samueli School of Engineering study how robots move. They also design human-like robots, including a cooking robot called Project YORI. The team wants YORI to be able to cook an entire menu of food. "Just yesterday, [YORI] cooked steak frites, or steak and french fries," says Hong.

YORI is only the latest of Hong's robot inventions. There's DAVID, the world's first and only car that can be driven by the blind. And SAFFiR, a two-legged robot designed to extinguish fires on Navy ships, to name a couple. Robots, Hong notes, are intelligent machines that do the work humans are often unable or unwilling to do. And Hong is finding plenty of work for his robots. In this interview, Hong shares his experiences and advice with *Science News Explores*. (This interview has been edited for content and readability.) — *Aaron Tremper*

**Q What inspired you to pursue this career?**

**A** When I was 7 years old, I watched *Star Wars: Episode Four [A New Hope]* for the first time. In the movie, there are two robots they call droids. Everybody knows R2-D2 — the one that looks like a trash can — and the humanoid robot, C-3PO. I was so mesmerized by those two robots. On my way back home in the car, I told my parents that I was going to become a robot scientist.

**Q How did you get to where you are today?**

**A** When I was in elementary school, I hated math. My father — an aerospace engineer — told me that engineers solve problems in the world by using science as a tool and mathematics as a language. Even though I did not like math, he helped me realize that I had to study harder to follow my dream of becoming a roboticist.

**Q What is one of your biggest successes when it comes to your career?**

**A** If I had to choose a project, it would be the robot called DARwIn-OP. It's one of the most widely used humanoid robots for research and education. We made it completely open source, meaning the software and instructions on how to build it are free for anyone to use. Many new types of robots have been built based on its design.

**Q What do you like to do in your spare time?**

**A** I'm a pretty serious gourmet chef. I was on the cooking competition *Master Chef USA*.

I'm also a magician. I started as a kid with a basic magic kit my dad bought me. I read books about magic and created my own tricks.

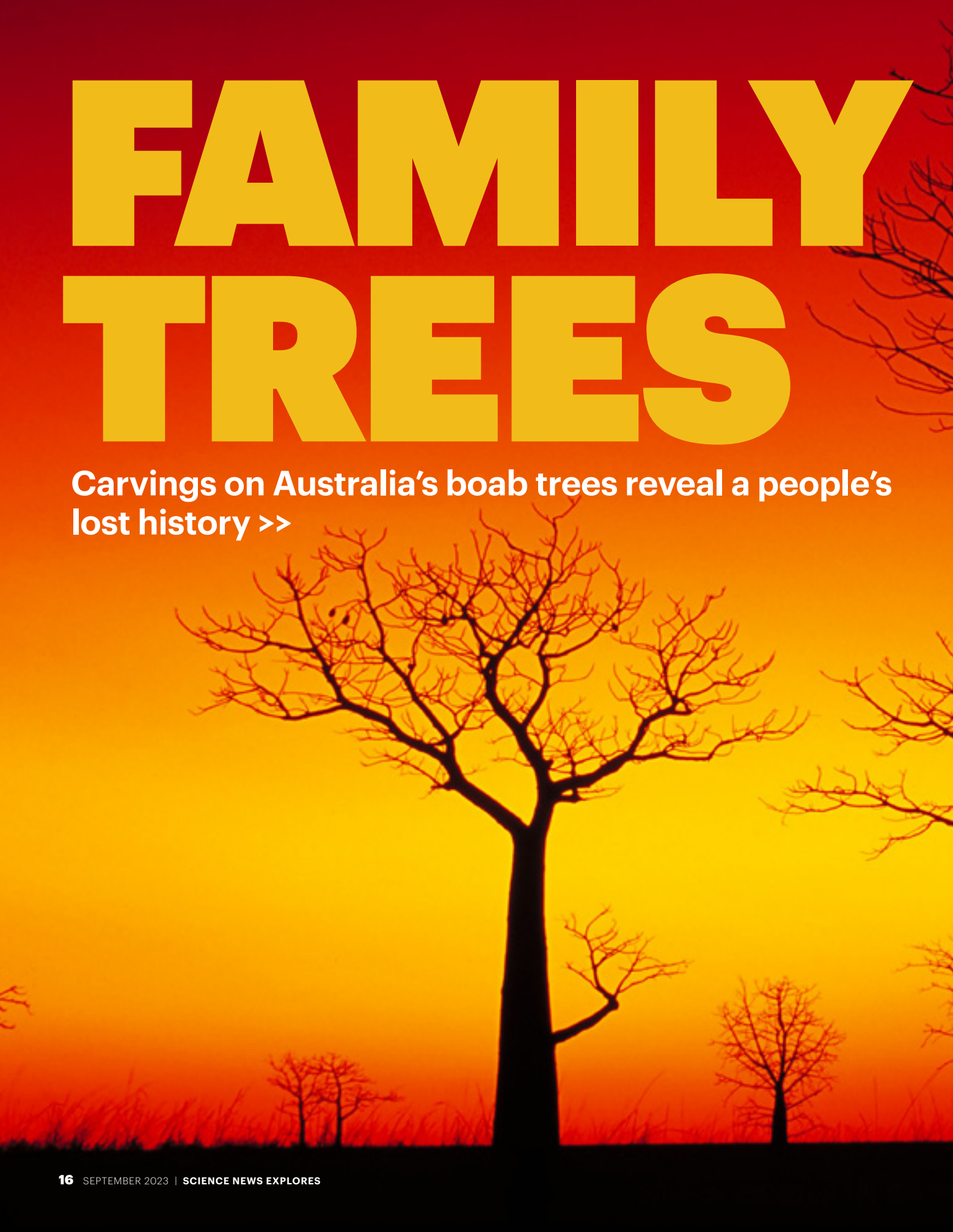
My job and hobbies share a common theme. They're all about giving people happiness. Robots can do things that people don't want to do. Cooking food lets you share your love with family and friends with yummy food. Magic tricks entertain people. I am most happy when I try when I make other people happy. I think that's my whole life's purpose.


**Failure is a necessary step, says roboticist Dennis Hong. "If you're too afraid of failure, then you only get to walk on the safer side [and] then there's no innovation." That attitude has helped him invent a host of robots (right), including the humanoid DARwIn-OP (inset).**

ROBOTICS & MECHANISMS LABORATORY/UCLA

# FAMILY TREES

**Carvings on Australia's boab trees reveal a people's lost history >>**



By **Freda Kreier**

BILL BACHMAN/SCIENCE SOURCE

Brenda Garstone is on the hunt for her heritage. Parts of her cultural inheritance are scattered across the Tanami Desert in northwestern Australia. There, dozens of ancient boab trees are engraved with Aboriginal designs. These tree carvings — called dendroglyphs — could be hundreds or even thousands of years old. But they've received almost no attention from Western researchers.

That is slowly starting to change. Garstone is Jaru. This Aboriginal group hails from the Kimberley region of northwestern Australia. In the winter of 2021, Garstone teamed up with archaeologists to find and document some boab carvings.

For Garstone, the project was a bid to piece together parts of her identity. Those pieces were scattered 70 years ago when Garstone's mother and three siblings were separated from their families. Between 1910 and 1970, an estimated one-tenth to one-third of Aboriginal children were taken from their homes by the Australian government. Like many others, the siblings were sent to live at a Christian mission thousands of kilometers (miles) from home.

As teens, the siblings returned to their mother's homeland and reconnected with their extended family. Garstone's aunt, Anne Rivers, had been just two months old when she was sent away. One family member now gave her a type of shallow dish. Called a coolamon, it was decorated with two bottle trees, or boabs. Her family told Rivers that those trees were part of her mother's Dreaming. That's a name for the cultural story that connected her and her family to the land.

Now, researchers have carefully described 12 boabs in the Tanami Desert with dendroglyphs that have links to Jaru culture. And just in time: The clock is ticking for these ancient engravings. The host trees are ailing. That's partly due to their age and partly to growing pressure from livestock. They may also be affected by climate change.

Garstone was part of the team that described these carvings in the journal *Antiquity*.

In the race against time, there's more at stake than just studying an ancient form of art. It's also the need to heal wounds inflicted by policies that aimed to erase the connection between Garstone's family and their homeland.

"To find evidence that ties us to the land has been amazing," she says. "The puzzle we've been trying to piece together is now complete."

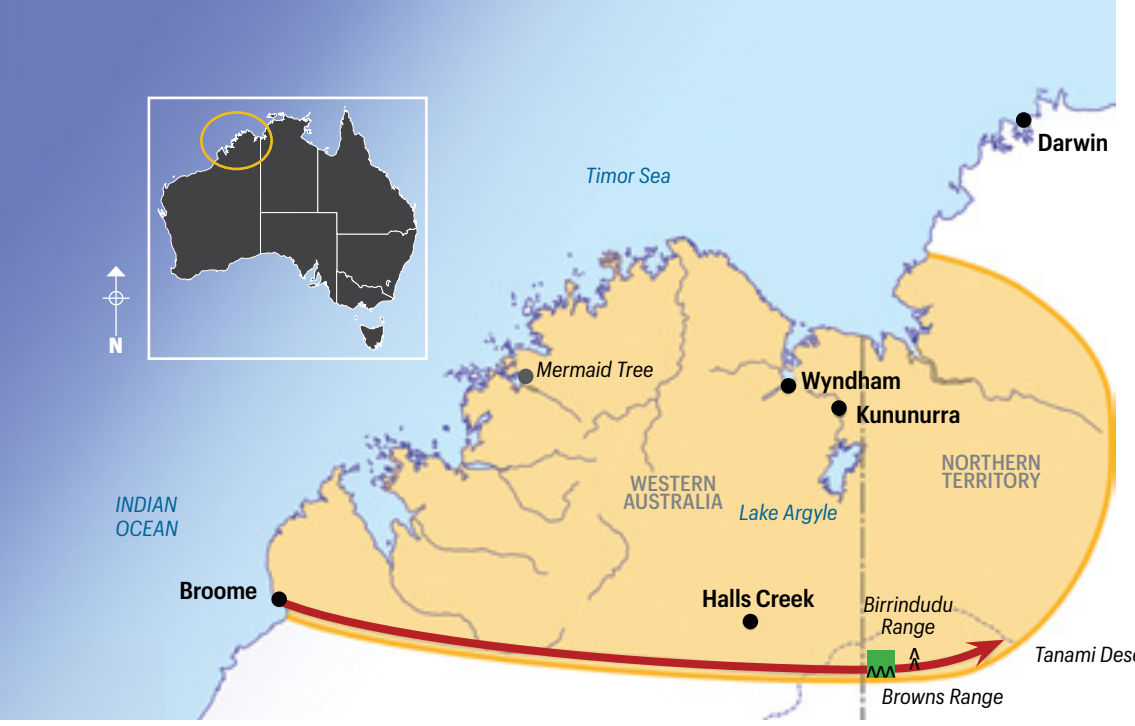
## An outback archive

Australian boabs proved pivotal to this project. These trees grow in the northwestern corner of Australia. The species (*Adansonia gregorii*) can be recognized easily by its massive trunk and iconic bottle shape.

Writings about trees carved with Aboriginal symbols in Australia date back to the early 1900s. These records indicate that people were continuously carving and recarving some trees until at least the 1960s. But the carvings aren't as well known as some other types of Aboriginal art, such as rock paintings.

**Brenda Garstone (above) joined a research team on an expedition to look for boab trees with Jaru carvings. This boab is 5.5 meters (18 feet) around. It was the smallest carved tree found during the expedition.**

S. O'CONNOR *ET AL*/*ANTIQUITY* 2022




**Boab trees grow in the northwestern corner of Australia. A survey (green rectangle) near the edge of the Tanami Desert revealed a patch of boab trees carved with dendroglyphs. The carvings tie the region to the path of the Lingka Dreaming (red arrow). This trail connects cultural sites across hundreds of kilometers.**

"There does not appear to be a wide general awareness of [boab carvings]," says Moya Smith. She works at the Western Australia Museum in Perth. A curator of anthropology and archaeology, she was not involved with the new study.

Darrell Lewis has come across his share of carved boabs. He's a historian and archaeologist in Australia. He works at the University of New England in Adelaide. Lewis has worked in the Northern Territory for half a century. In that time, he's spotted engravings made by all different groups of people. Cattle drovers. Aboriginal peoples. Even World War II soldiers. He calls this mixed bag of engravings "the outback archive." He says it's a physical testament to the people who have made this rugged part of Australia their home.

In 2008, Lewis was searching the Tanami Desert for what he hoped would be his biggest find. He'd heard rumors about a cattle drover working in the area a century earlier. The man, so the story went, had found a firearm stashed in a boab marked with the letter "L." A roughly cast brass plate on the gun was stamped with a name: Ludwig Leichhardt. This famed German naturalist had disappeared in 1848 while traveling across western Australia.

*Dendroglyphs like this one are tied to the survival of the host trees. Unlike other trees, boabs quickly disintegrate after death, leaving behind little evidence of their presence.*

**This boab is engraved with the image of a snake. It's one of 12 carved trees rediscovered during a 2021 expedition into Australia's Tanami Desert.**

FROM TOP: MAP: ADAPTED FROM S. O'CONNOR *ET AL/ANTIQUITY* 2022; AUSTRALIAN NATIONAL UNIVERSITY (CC BY-SA 4.0); AUSTRALIA: NOOK HOK/SHUTTERSTOCK; TRUNK: S. O'CONNOR; BAOB TREE: D. LEWIS, S. O'CONNOR *ET AL/ANTIQUITY* 2022

The museum that now owned the gun hired Lewis to look for the rumored "L" tree. The Tanami was thought to be outside the boab's natural range. But in 2007, Lewis rented a helicopter. He crisscrossed the desert in search of the Tanami's secret stash of boabs. His flyovers paid off. He spotted roughly 280 centuries-old boabs and hundreds of younger trees scattered across the desert.

"Nobody, not even locals, really knew there were any boabs out there," he recalls.

He embarked on a ground expedition in 2008. He never did spot the elusive "L" boab. But the search did uncover dozens of boabs marked with dendroglyphs. Lewis recorded the location of these trees in a report for the museum.

That information sat untouched for years. Then one day, it fell into the hands of Sue O'Connor.

## Crumble into dust

O'Connor is an archaeologist at Australian National University in Canberra. In 2018, she and other archaeologists were growing more and more concerned about the survival of boabs. That year, scientists studying a close relative of boabs in Africa — baobabs — noticed a worrying trend. Older trees were dying at a surprisingly high rate. The scientists thought climate change might be playing some role.

The news alarmed O'Connor. Dendroglyphs are often engraved on the largest and oldest boabs. Nobody knows exactly how old these trees can get. But researchers suspect that their lifetimes could be comparable to their African cousins. And baobabs can live more than 2,000 years.

When these long-lived trees do die, they pull a disappearing act. Other trees' wood can be preserved for hundreds of years after death. Boabs are different. They have a moist and fibrous interior that can quickly disintegrate. Lewis has witnessed boabs crumble into dust a couple of years after dying.

Afterward, he says, "You would never know there'd been a tree there."

Whether Australian boabs are threatened by climate change is unclear. But the trees are coming under attack from livestock. The animals peel back boabs' bark to get to the wet interior. Considering all of this, O'Connor "thought we better try and locate some of the carvings." After all, she says, "they probably won't be there in a few years."

Lewis's report provided a good jumping-off point for this work. So O'Connor reached out to the historian and suggested they work together.

Around that same time, Garstone was four years into her own research on her family's heritage. The long and meandering search led her to a small museum. It happened to be run by a friend of Lewis's. When Garstone mentioned she was from Halls Creek — a town near where Lewis did his fieldwork in 2008 — the curator told her about the carved boabs.

"'What?' she recalls: 'That's a part of our Dreaming!'"

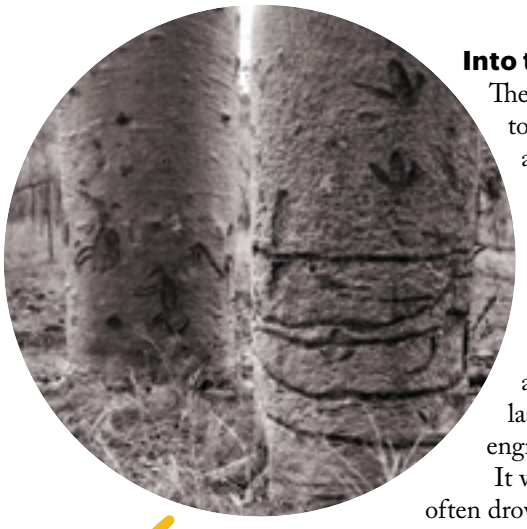
Dreamings are a Western term used for the vast and diverse stories that — among other things — recount how spiritual beings formed the landscape. Dreaming stories also pass down knowledge and inform rules of behavior and social interactions.

Garstone knew her grandmother had ties to the Bottle Tree Dreaming. The trees featured in an oral history passed down through her family. And they were painted on her aunt's coolamon. The Bottle Tree Dreaming is one of the eastern-most signs of the Lingka Dreaming track. (Lingka is the Jaru word for the King Brown Snake.) This path spans hundreds of kilometers (miles). It runs from the western coast of Australia into the neighboring Northern Territory. It marks Lingka's journey across the landscape. It also forms a byway for people to travel across the country.

Garstone was eager to confirm that the boabs were a part of this Dreaming. She, her mother, her aunt and a few other family members joined the archaeologists on their mission to rediscover the boabs.

**Brenda Garstone's aunt, Anne Rivers, holds a shallow dish called a coolamon, passed down from her extended family. The boabs painted on the dish (inset) were an early hint of the connection between dendroglyphs in the Tanami and her cultural heritage.**

JANE BALME, S. O'CONNOR *ET AL/ANTIQUITY* 2022



## Into the Tanami

The group set out from the town of Halls Creek on a winter day in 2021. They set up camp on a remote station mainly populated by cattle and feral camels. Each day, the team climbed into all-wheel-drive vehicles and headed out to the last known location of the engraved boabs.

It was hard work. The crew often drove hours to the supposed position of a boab, only to find nothing.

They had to stand on top of the vehicles and scan for trees in the distance. What's more, wooden stakes sticking out of the ground constantly shredded the vehicles' tires. "We were out there for eight or 10 days," says O'Connor. "It felt *longer*."

The expedition was cut short when they ran out of tires — but not before finding 12 trees with dendroglyphs. The archaeologists painstakingly documented these. They took thousands of overlapping pictures to make sure these images covered every part of each tree.

The team also spotted grinding stones and other tools scattered around the base of these trees. In a desert with little cover, large boabs provide shade. These tools suggest that people probably used the trees as resting spots while crossing the desert. The trees likely also served as navigational markers, the researchers say.

Some of the carvings showed emu and kangaroo tracks. But by far the largest number depicted snakes. Some undulated across the bark. Others coiled onto themselves. The knowledge provided by Garstone and her family, along with historical records from the area, points toward the carvings being linked to the King Brown Snake Dreaming.

"It was surreal," Garstone says. Seeing the dendroglyphs confirmed the stories passed down in her family. It's "pure evidence" of their ancestral connection to the country, she says. This rediscovery has been healing, especially for her mother and aunt, both in their 70s. "All of this was nearly lost because they didn't grow up in their homeland with their families," she says.

## Maintaining the connection

The work to find and document carved boabs in the Tanami has just begun. There may be engraved trees in other parts of the country, too. But this trip shows the "vital importance" of scientists working together with First Nations knowledge-holders, says Smith.

O'Connor is organizing another expedition. She hopes to find more of the engravings Lewis had spotted. (She plans to take better wheels. Or better yet, a helicopter.) Garstone is planning on coming along with more of her extended family in tow.

For now, O'Connor says this work appears to have stimulated others' interest. Researchers and other Aboriginal groups want to rediscover the overlooked boab carvings and preserve them for future generations.

"Our connection to country is so important to maintain because it makes us who we are as First Nations people," says Garstone. "To know that we have a rich cultural heritage and to have our own museum in the bush is something we will treasure forever."

Some carvings on boab trees (above) found by Darrell Lewis in 2008 contained the tracks of animals such as large flightless birds called emus (far left) and kangaroos (left).

CARVING: D. LEWIS, S. O'CONNOR *ET AL/ANTIQUITY* 2022; EMU: MARIAT/SHUTTERSTOCK; EMU TRACK: DANA VICKERS/SHUTTERSTOCK; KANGAROO: BENNY MARTY/SHUTTERSTOCK; KANGAROO TRACK: TIPODEES/SHUTTERSTOCK

PHYSICS

# The puzzle of parallax

## Discover how parallax reveals the distances of stars

By Science Buddies

Parallax is the way an object seems to move when viewed from two different spots. For instance, nearby stars seem to move relative to background stars when viewed from two different points in Earth's orbit. Astronomers use that phenomenon to find stars' distances. To see how, this experiment measures the parallaxes of household objects.

**OBJECTIVE**

*To discover the relationship between the distance of an object and the viewing perspective*

**EXPERIMENTAL PROCEDURE**

**1.** Place two hula hoops side-by-side on the ground several meters from a tree.

**2.** Place a small table about 2 meters (6.6 feet) from the hoops, between them and the tree.

**3.** Rubber band the middle of a meterstick to a rock and put it on the table. The meterstick should be horizontal with its markings facing the hoops.

**4.** Sit in the left hoop and see what meterstick marking the tree seems to line up with. Write that number in a lab notebook. Repeat this process in the right hoop.

**5.** Move the table 2 meters closer to the tree.

**6.** Repeat steps 4 and 5 several times.

**7.** On the x-axis of a graph, plot the distance between the hoops and the table. On the y-axis, plot how much the tree appears to move along the meterstick when you view it from one hoop versus the other.

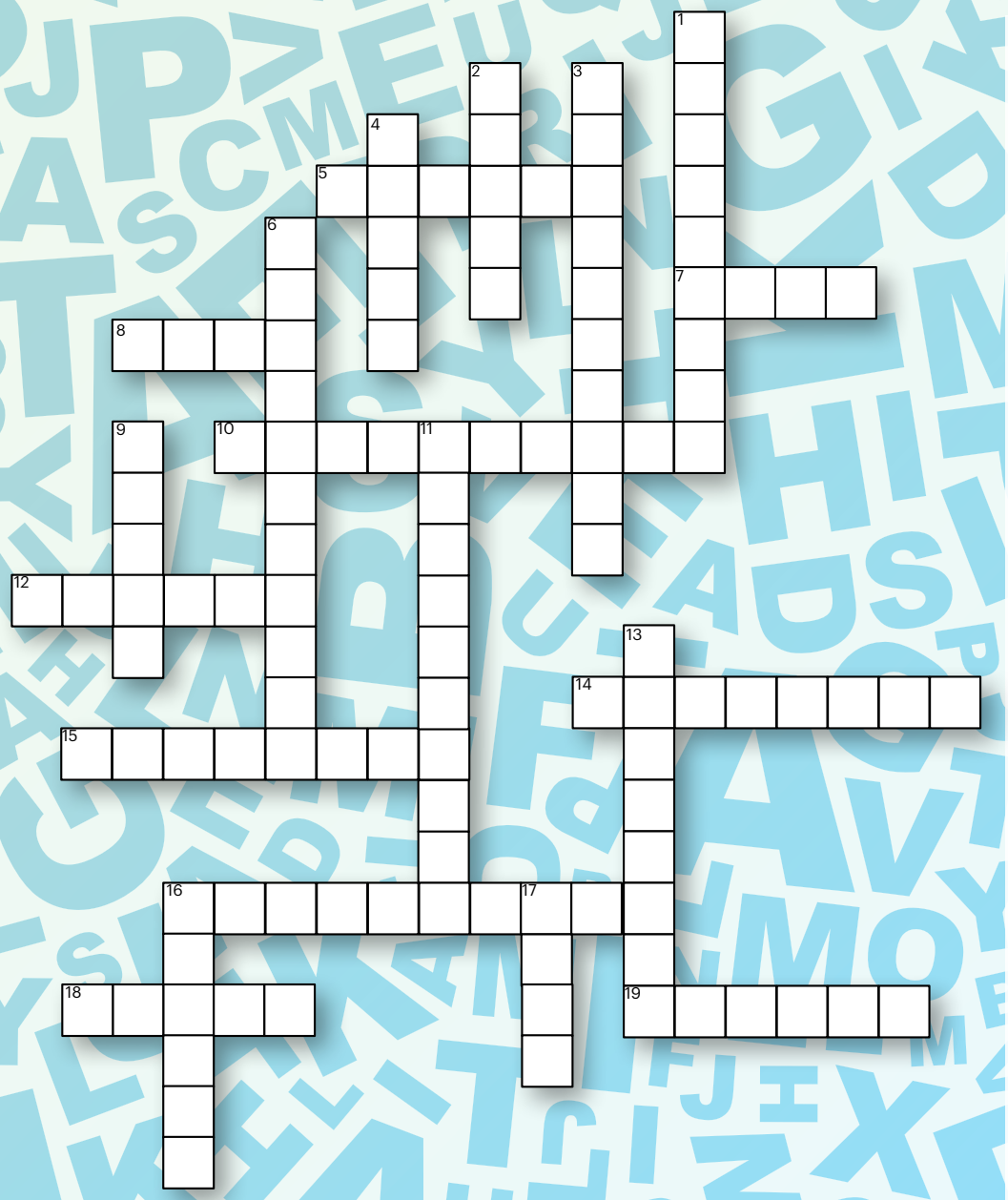
**8.** When the table is closer to the hoops, does it appear to move more or less relative to the tree?

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

IBOM/SHUTTERSTOCK

# 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**

**5** An African tree that can live more than 2,000 years

**7** Scientists recently created this food with a 3-D printer

**8** A collision between Earth and Theia probably created this object

**10** This is the "A" in AI

**12** Most school buses run on this type of fuel

**14** A chemical in coffee that is a type of stimulant

**15** You can use this toy in an experiment to learn about parallax

**16** A *Star Trek* technology that makes food in an instant

**18** A type of robot found in the *Star Wars* universe

**19** Exposure to this element determines how wood burns in a fire

**DOWN**

**1** A two-word term that is another name for a neuron

**2** A machine that may walk or wheel itself around

**3** This movement is one of the main features of plate tectonics

**4** A beam of light you might use to play with a cat

**6** A carving found on some boab trees

**9** A fluffy animal that has undergone domestication

**11** A type of glass cable known as a "light pipe"

**13** A large Australian animal that hops

**16** A popular home robot that cleans floors

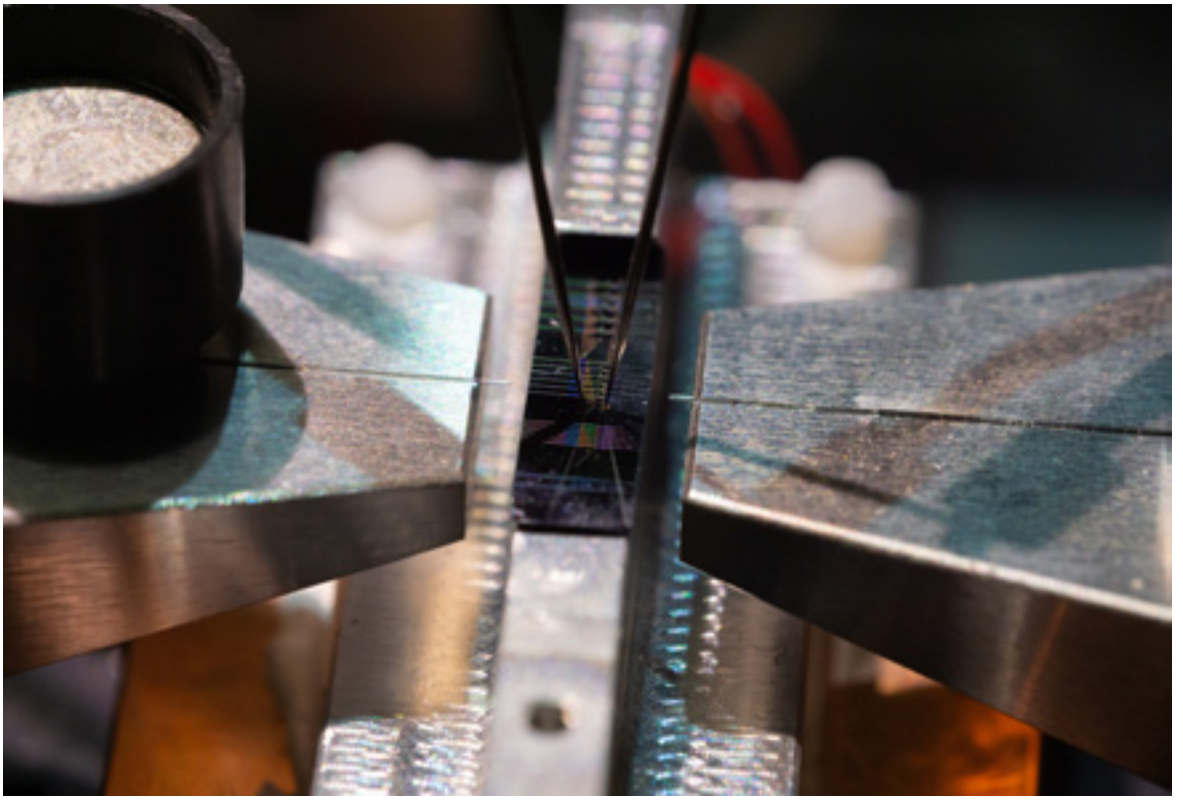
**17** A famous terrifying dinosaur with tiny arms

BEKUL NIS/SHUTTERSTOCK

COMPUTING

# Tiny chip breaks data-sending record

## The chip transferred more than a world's worth of information per second



This tiny chip used thousands of beams of light to carry more data per second than the entire world's internet.

JULIAN CURRY ROBINSON-TAIT

One small computer chip has set a new record for data-sending speed. Researchers used it to move 1.84 petabits of data per second. That equals 122 million Netflix movies streaming at the same time.

That's truly impressive, says Bill Corcoran. Until now, such a feat would have taken many chips and consumed far more energy. Corcoran is a physicist at Monash University in Melbourne, Australia. He was not involved in this research. But he knows a lot about this field. Since 2020, his group had held the record for the highest data-transmission rate using a single chip.

"It's great to see records being broken at this pace," Corcoran says.

Physicist Asbjørn Arvad Jørgensen and his colleagues reported the new record in *Nature Photonics* last October. Jørgensen did the work at the Technical University of Denmark and the University of Copenhagen.

The Danish team's record-breaking chip pushed data through many fiber optic cables at once. These glass cables, or "light pipes," move data as pulses of light. This is how internet signals travel to and from devices in many cities and towns.

Sending data through a fiber optic cable involves shining a laser through a device called a modulator. The modulator converts packets of data from their digital form into patterns of light. It manipulates the laser's light to create these patterns. One pattern might involve turning on and off rapidly. The patterns then zip along the fiber optic cable to their destination.

Most fiber optic cables have just one core — a single pipe through which light can travel. To send a lot of data at once, you have to fit multiple beams of light into that one pipe. And to travel together without messing up each other's data, the light beams must have unique wavelengths. In other words, they must be different colors.

Usually, you need separate lasers to generate each color. Systems using this technique today may operate 80 different lasers at once.

Jørgensen's team used a special phenomenon of light called a microcomb to replace all those different lasers. Shining a single laser beam of light into a special type of chip split it into many different wavelengths. This happened because the light traveled around a tiny ring made of a special material. The properties of this material only let light escape at certain, evenly spaced wavelengths of light. Out popped a carefully crafted rainbow, or microcomb. "My 6-year-old son calls these rainbow lasers," says Corcoran.

The chip that Jørgensen's group used created a whopping 223 different wavelengths — or a rainbow of 223 colors! You can't see them, sadly, as each color is in the infrared range.

But the Danish group didn't stop there. They also used a new type of fiber optic cable that contains 37 cores. That means a single cable has 37 separate pipes inside. Each can carry the same wavelengths as the others without interference. So the team started with 223 different colors, then split each color 37 ways. The grand total was 8,251 different beams of light. These beams got sent through modulators that manipulated the light to carry data.

The 8,251 beams of light carried more than an entire world's worth of data. For this test, the data traveled 7.9 kilometers (4.9 miles) along the fiber optic cable.

Of course, all of the data of the entire world's internet never needs to travel along a single cable. In fact, no single supercomputer today can even generate 1.84 petabits per second. For their test, the researchers copied the same data over and over again to total 1.84 petabits.

Even though no one needs to move data so quickly right now, researchers are planning ahead. "We take the long view," says Corcoran. Ten years from now, he says, some links between cities or countries may require petabit-scale rates of data transmission.

The new technology could also save electricity. Since it uses fewer lasers than current methods, it's more energy efficient. And that could help lessen the internet's climate impact.

— *Kathryn Hulick*

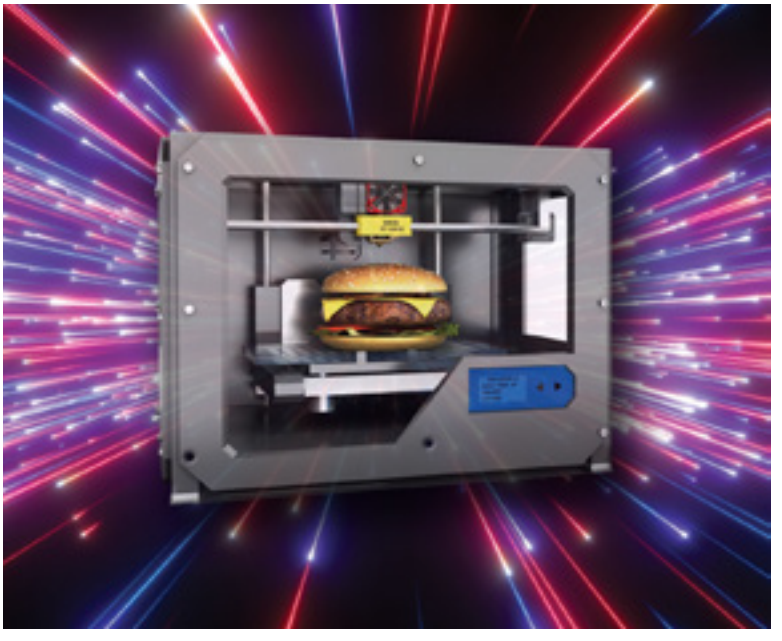
LEIF KATSUO OXENLØWE

**This research team, based in Denmark, broke a data-transmission speed record that had stood since 2020.**

TECHNOLOGY

# Could *Star Trek* replicators exist?

## Yes, but there may be better ways of feeding space explorers



It's not quite a replicator, but maybe future space travelers will be able to 3-D print dinner on demand.

Let's say you're hungry. Wouldn't it be great to walk up to an appliance, tell it what food you want and have that food appear magically in front of your eyes? In the TV franchise *Star Trek* this is possible with a piece of technology known as a "replicator." Getting to a future where this tech exists, though, might take a bit of imagination and invention.

The *Star Trek* replicator is used to make all kinds of objects, from a hot cup of Earl Grey tea to spare parts for spaceships. Biowaste and other recycled material is broken down into basic parts: water, carbon and other molecules, explains Erin Macdonald. She's an astrophysicist and science advisor for the *Star Trek* franchise. Those molecules are then fed into the replicator. When a person asks for an item, lasers reassemble the bits according to a recipe in the computer until it looks like that cup of tea, a dish of mint chocolate chip ice cream or a piece of a warp coil.

What, exactly, is the biowaste that goes into the machine? It will probably include poop. "We don't want to think about that too much," Macdonald says.

The replicator's superfast lasers convert incoming matter into energy. Then, they change it back into matter. "On a fundamental level, there is nothing that prevents you from building a replicator-like machine," says Gianluca Sarri. He's a quantum physicist who works with lasers at Queen's University Belfast in the United Kingdom.

But a replicator is just not a top priority at the moment, he says. All that matter to energy to matter conversion would require a lot of energy. Plus, there's no way to currently make an object appear within seconds. And food can be generated in a much simpler way — by cooking.

### LET'S PRINT A MEAL

For now, astronauts eat food sent up from Earth. Future space tourists and crews might rely on hydroponics — growing plants without soil — to make sure they get the food they need. Cooking that food in space like you do at home might be an option. But it might not always be practical inside the tight fit of a spaceship. So spacefarers might instead print their meal with a 3-D printer.

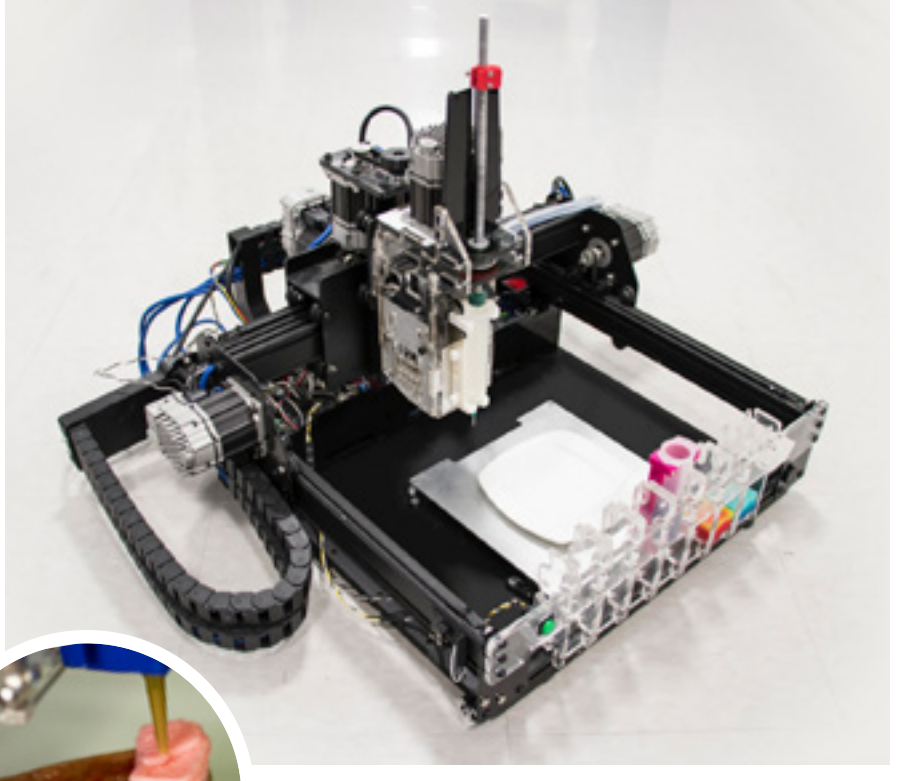
Today's 3-D printers are similar to regular printers, says Jonathan Blutinger. Just as normal printers must be fed cartridges of ink, 3-D printers must be fed cartridges of printing material. Blutinger is a mechanical engineer. While at the Creative Machines Lab at Columbia University in New York City, he helped create a 3-D printer that acts as a digital chef. "The printer will not allow you to make something from nothing," he says. "You need to start with the right base ingredients."

Blutinger's group recently started with ingredients for a "cake." They put graham cracker paste, strawberry jam, peanut butter, Nutella, cherry drizzle, banana puree and frosting into the food printer. The printer assembled and cooked the ingredients with lasers to make a slice of cake.

The cake tasted great, Blutinger says, but it was definitely a unique experience because the flavors came in "waves." The group's paper about the cake appeared in *npj Science of Food*.

REPLICATOR: WACOMKA/SHUTTERSTOCK; BACKGROUND: NOSOROGUA/SHUTTERSTOCK

Each ingredient — graham cracker paste, peanut butter, strawberry jam, Nutella, banana puree, frosting and cherry drizzle — is readied for a food printer (below).



Piece of cake! Layers of each ingredient get printed and cooked with lasers to make a tasty dessert.

JONATHAN BLUTINGER/COLUMBIA ENGINEERING

**APPETIZING OR OFF-PUTTING?**

The 3-D printing robot chef can only assemble the ingredients it's given and then add heat to cook the food. It cannot create foods from pure energy made from biowaste, like a *Star Trek* replicator can. But people may not yet be comfortable eating even this relatively simple version of machine-made meals, Blutinger says.

Most people are comfortable with items like flour and peanut butter because we know where they come from. As science moves food away from the source, though, people could get grossed out. That 3-D printed cake might be easier for some to eat than 3-D printed meat, for instance. And people who did not grow up with 3-D printers in the kitchen might prefer food from the grocery store, Blutinger says.

"But pretty soon … kids will be growing up with these kinds of food robots in their kitchen," Blutinger predicts. "Then that's all they're going to know."

Macdonald agrees. "It's just one of those things that people will have to come to terms with."

Food printers might be on our kitchen counters within the next 5 to 10 years, Blutinger says. These printers could be like "having a personal chef and nutritionist all in one." The machine could someday recommend and create healthier food that's customized to your diet needs.

A *Star Trek* replicator could come maybe 100 years down the line, says Sarri. And those replicators of the future could be useful in areas besides outer space. They could provide food in places where putting a chef might be dangerous, like a warzone.

"There's a feedback loop," Macdonald says, "of scientists being inspired by *Star Trek* and then making that science. And then that continues to feed into the science fiction of, 'Well this is what we can do now, so what's next?'"

The next tech to materialize might just be a replicator.

— *Deborah Balthazar*

ANIMALS

# What is animal domestication?

## Domestication brings animals and people closer together

Put a miniature poodle next to a wolf. The poodle is domesticated. The wolf? Definitely not. But the two creatures aren't so far apart biologically. They can even mate and produce puppies. The biggest difference is in which one has a close relationship with people.

Domestication is a process, says Sarah Crowley. She studies the relationship between humans and animals at the University of Exeter in England. That process takes place over many animal and human generations. The animal may end up with changes in its genes, appearance and behavior.

The humans, though, will change their own actions as they live more and more closely with the animal. Domestication is never one way, Crowley notes. It's "a relationship and process that affects us, too."

Domestication is "a long-term population shift," explains Greger Larson. He's an evolutionary biologist at Oxford University in England. Consider two populations of sheep: One lives wild, while another hangs around people. Over time, the sheep living with people start to relax. They rely on people for food. The people also change their behavior with the sheep. They might pen the animals, shear them or breed them instead of letting the sheep romance each other. Hundreds or thousands of years later, the wild sheep and domesticated sheep might appear completely different.

The process is also not intentional — for the animal or the people, Larson explains. No one made the decision to grab a wolf and keep it for thousands of years until it was a dog. Instead, animal domestication is a growing relationship. Different animals will be at different relationship stages with people. Humans and another animal get closer and closer together. Eventually, they couldn't imagine a life apart.

— *Bethany Brookshire*

A poodle and a wolf share most of the same genes and many behaviors. The big difference is in how they relate to people.

JAGODKA, PHOTOMASTER/SHUTTERSTOCK

ILLUSTRATION BY STEVE MCCRACKEN

## DOMESTICATED DOG, 'SEMI-DOMESTIC' CAT?

Dogs and cats are some of the closest animals in our lives. But why do scientists consider dogs "domestic" and cats "semi-domesticated"?

**ACCEPTANCE:** Both dogs and cats probably came to hang with people on their own. Braver animals could make a good living off humans' trash and the mice that went with it, explains Sarah Crowley. She studies the relationship between humans and animals at the University of Exeter in England. But humans then began to hunt with dogs. That brought the two species closer together. Cats, on the other hand, "are more likely to have been 'tolerated' in agricultural settlements because they control pesky rodents," Crowley says.

**APPEARANCE:** Many dogs have physical traits associated with domestication, such as wide faces, curly tails, white patches of fur and floppy ears. Cats can have white patches of fur, but the faces of most cats are still very similar to those of their wild ancestors.

**BEHAVIOR:** Dogs are social, like their wolf ancestors. They are glad to hang out in packs. They now just add humans to the group. Cats, Crowley notes, are territorial, less social and, unlike dogs, can't digest anything but meat. Both dogs and cats can be trained, but dogs are motivated by wanting to please people while cats are not. "Cats don't do anything if there isn't something in it for them," she says.

**BREEDING:** Over the past few hundred years, many modern dogs "have been rigorously selected to look very specific ways according to their breed standards," explains Christina Hansen Wheat. She is a behavioral ecologist at Stockholm University in Sweden. Think of the pug's squished face or a corgi's stubby legs. Humans only started to breed cats in the past 150 years or so, Crowley says. "Humans were not directly manipulating their genes to a great extent."

**INDEPENDENCE:** While some dogs can end up lost in the woods and be okay, many are dependent on people for food, medical care and companionship. Cats, on the other hand, merely know people are useful. "Cats have kept a lot of 'wild' traits and a lot of independence," Crowley says. "If humans all suddenly disappeared, many of them would be absolutely fine without us."

**TIME:** Dogs have been hanging around people for far longer than cats. Dogs began associating with humans anywhere between 40,000 and 15,000 years ago. Cats slunk on to the scene less than 10,000 years ago.

ANIMALS

# Puppy see, puppy do. Kitty, not so much

## Young dogs are much more prone to mimic humans than kittens or wolf pups

Puppies are often trained with treats — but maybe they don't have to be. Pups may be able to learn by mimicking people's actions.

Some past studies have hinted at dogs' ability to learn by observing humans, says Claudia Fugazza. She studies animal behavior at Eötvös Loránd University in Budapest, Hungary. But past experiments used food to reward dogs when they mimicked people. So, they didn't reveal whether dogs were natural copycats. And there's even less known about puppies.

Fugazza and her team tested whether puppies and other young animals might imitate people. They rounded up 42 puppies, 39 kittens and 8 young wolves. All of these animals lived with human families. In each test, the researchers showed an animal an object. Once they got the animal's attention, a researcher modeled an action — touching an object with either their nose or hand. Then, the scientists watched whether the animal copied the human.

It often took a while to get the attention of kittens and young wolves, Fugazza says. But "the dog puppies were basically immediately looking at the human even before we started to call their attention." After showing the actions, cats rarely replicated what humans did. Wolves sometimes copied, but the dogs were much more reliable. The team shared its findings in *Scientific Reports*.

Dogs and cats have both been bred to live with humans — a process known as domestication (see p. 28). "They should have the same tendency to match human actions," Fugazza says. But cats don't. That suggests the importance of another aspect of the animals' history: how they behave in groups.

Cats evolved from solitary hunters. Once they cozied up to humans, cats helped people get rid of mice, but they didn't work with humans. Dogs evolved from wolves. Wolves work together, hunting in packs. And once dogs started hanging around humans, they worked with people. Those relationships might have provided the motivation for dogs to imitate humans.

— *Carolyn Wilke*

OLEKSANDR LYTVYNENKO/SHUTTERSTOCK

## MINI MIMICS

Researchers placed a box or wobbly toy in front of a dog puppy, wolf puppy or kitten. For 25 seconds, the team observed if the animal touched the object and how. Then, a scientist would try to get the animal's attention and show a different way to touch the object. For instance, if the animal nudged it with its nose, the human would touch it with a hand. Then the researchers watched whether the creature copied them. They calculated the probability that an animal mimicked a human. That was based on whether the animal did the same thing as the human and how long it took (Figure A). They also calculated the probability that an animal would use its paw when a human modeled using a hand or a nose (Figure B).

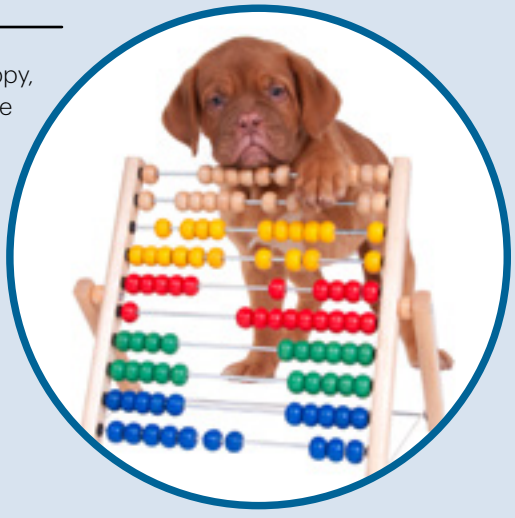


**FIGURE A**

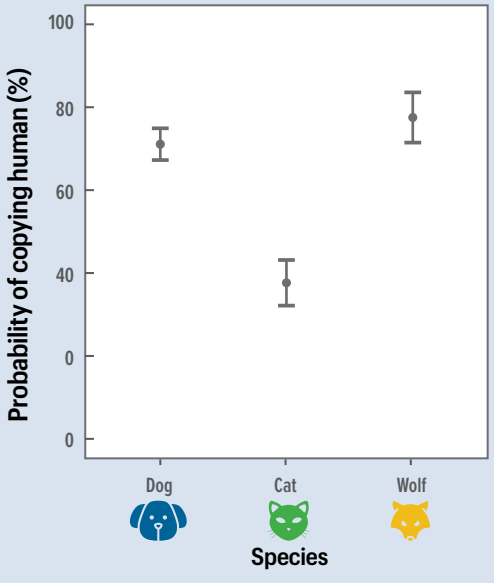
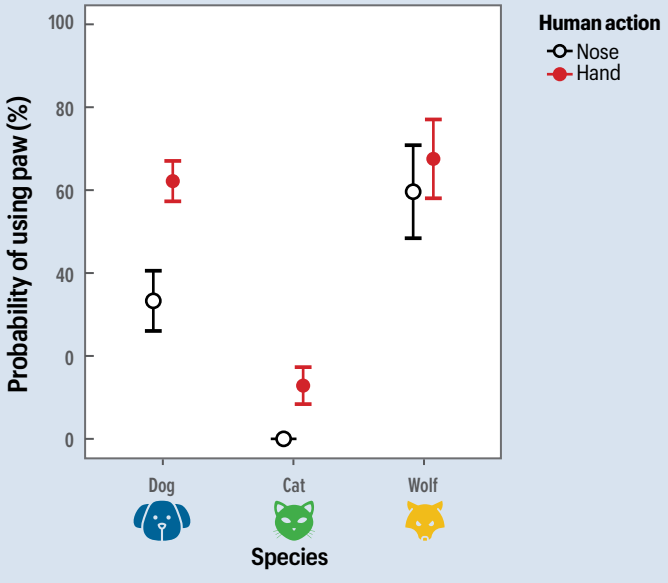



**FIGURE B**




## DATA DIVE

**1.** Look at Figure A. Which animals were most likely to match the action of the human? Which animal was least likely?

**2.** Look at Figure B. How likely was a kitten to use a paw when a human used a nose? How much more likely was a kitten to use a paw when the human used a hand?

**3.** How likely was a dog to use a paw when a human used a nose? How much more likely was a dog to use a paw when the human used a hand?

**4.** How did wolves behave differently from dogs?

**5.** What is another way these data could be displayed?

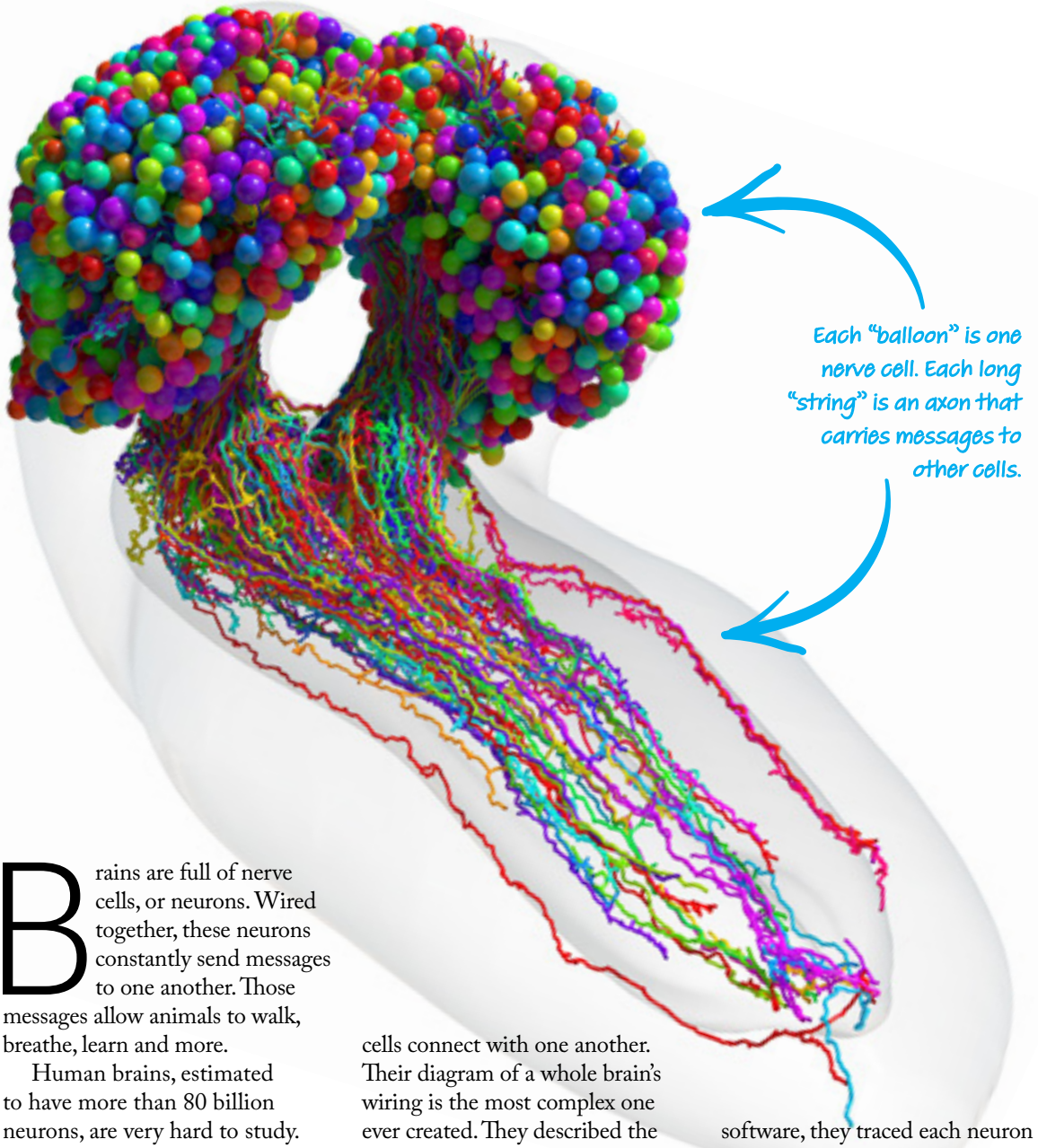
**6.** In this study, the animals saw the researchers touch an object. What are some other actions the researchers could have tried?

VITALY TITOV/SHUTTERSTOCK; FUGAZZA ET AL/SCIENTIFIC REPORTS 2023

ANSWER

# It's a brain, not balloons

## Mapping every nerve cell in this fly brain took years




Brains are full of nerve cells, or neurons. Wired together, these neurons constantly send messages to one another. Those messages allow animals to walk, breathe, learn and more.

Human brains, estimated to have more than 80 billion neurons, are very hard to study. But many animals — such as fruit flies — have smaller brains with fewer neurons. That makes them useful for learning how brains work.

A team of scientists mapped all the neurons in a baby fruit fly brain. They also tracked how the cells connect with one another. Their diagram of a whole brain's wiring is the most complex one ever created. They described the work in *Science*.

First, the researchers took pictures of each part of the fly brain. They used a powerful tool for zooming in on tiny things called an electron microscope. They stitched all those images together with a computer. Using special software, they traced each neuron by hand through all the images. Putting them all together made a 3-D virtual model of all the cells.

The work started 12 years ago. In all, the 3-D model revealed more than 3,000 neurons and almost 550,000 connections.

— *McKenzie Prillaman*

MICHAEL WINDING

# INSIDE THE MIND OF A YOUNG SCIENTIST

## Regeneron International Science and Engineering Fair competitors answer four questions about their science

**Science competitions can be fun and rewarding.** But what goes on in the mind of these young scientists? Raquel Rowland and Brandon Martinez, who competed together at the 2023 Regeneron International Science and Engineering Fair (ISEF), share some of their science inspiration and advice.

**Q What inspired your project?**
**A Raquel:** I was born without an eyelid muscle, and I actually have six prosthetic bands in my eyelid. So I've always been interested in prosthetics. I went to Brandon because we've always been friends, and I knew that he was good at engineering things.

**Q How did you come up with your project idea?**
**A Brandon:** Conventional prosthetics for dogs are straight legs. We call them peg legs. These peg legs do not allow the dog to sit properly. We thought that we could use electromagnets and infrared emitters and receivers to create a more dynamic prosthetic.
**Raquel:** It's supposed to allow for a dog to have a more dynamic life, like they normally would if they had four legs.

**Q What was a memorable moment from your science fair experience?**
**A Raquel:** At regionals, we were handling the prosthetic and showing it to a judge. And it just snapped because we were working with cheaper plastic. But that helped us advance because we changed that plastic.

**Q What advice would you give to other students?**
**A Raquel:** In my school, since the science fair is required, a lot of kids take it as a joke. But honestly, science fair can bring you to such a high level, and you can meet so many people and do so many different things. Take it seriously. Don't look at it like it's just another school activity.



### Biomedical Engineering

## Raquel Rowland and Brandon Martinez

**Raquel, 18, and Brandon, 18, developed prosthetics to help three-legged dogs more easily sit and lie down in a natural position. One shoulder prosthetic, which has a spring design, can be 3-D printed in a single piece. The second prototype employs sensors and electromagnets to reduce whiplash movement in the shoulder. Raquel and Brandon, who recently graduated from Wildwood Middle High School in Florida, hope that their designs will help other engineers develop better animal prosthetics.**

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**Why are giraffe tongues blue?**
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