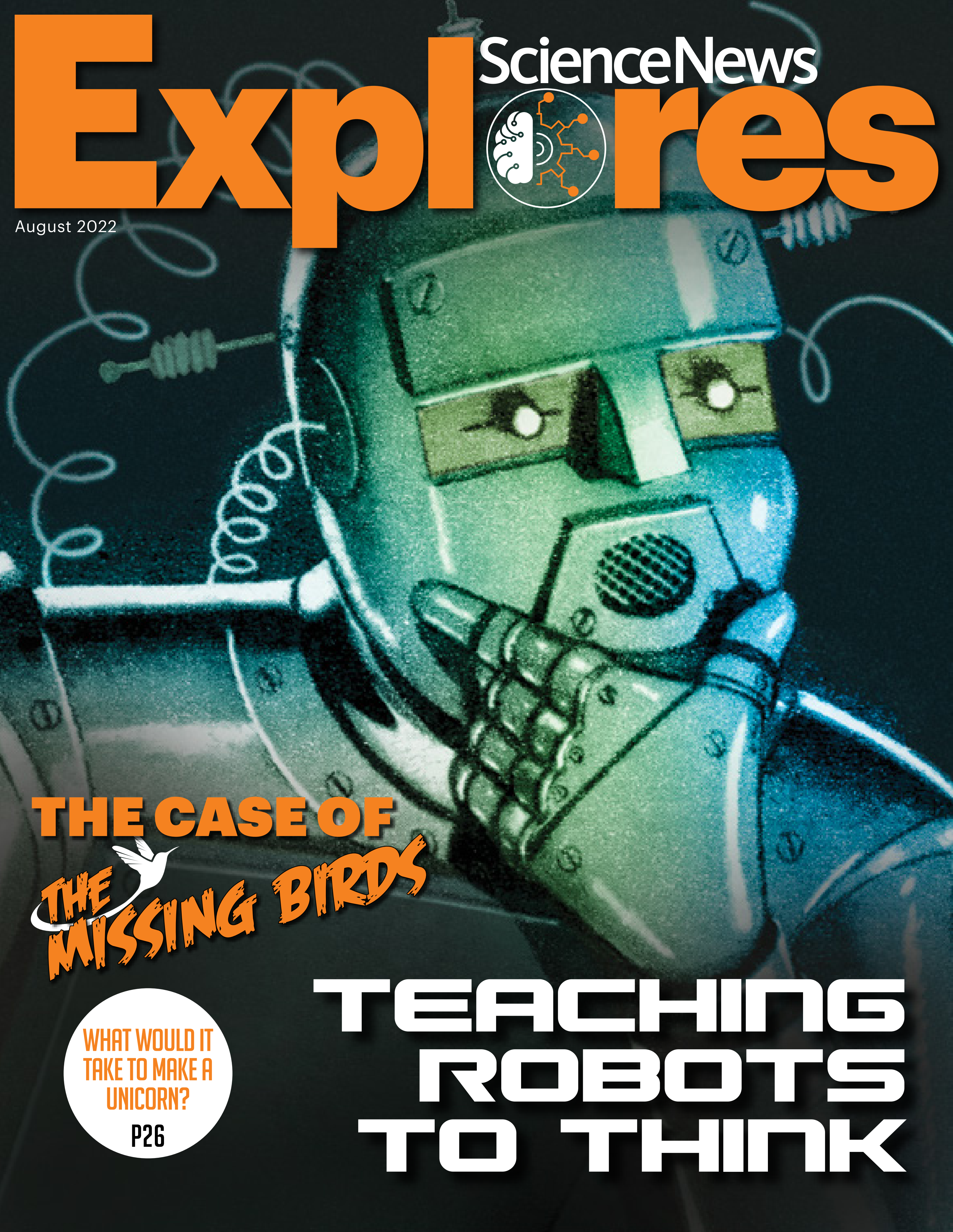
Science News Explores

August 2022



THE CASE OF THE MISSING BIRDS

TEACHING ROBOTS TO THINK

WHAT WOULD IT TAKE TO MAKE A UNICORN?

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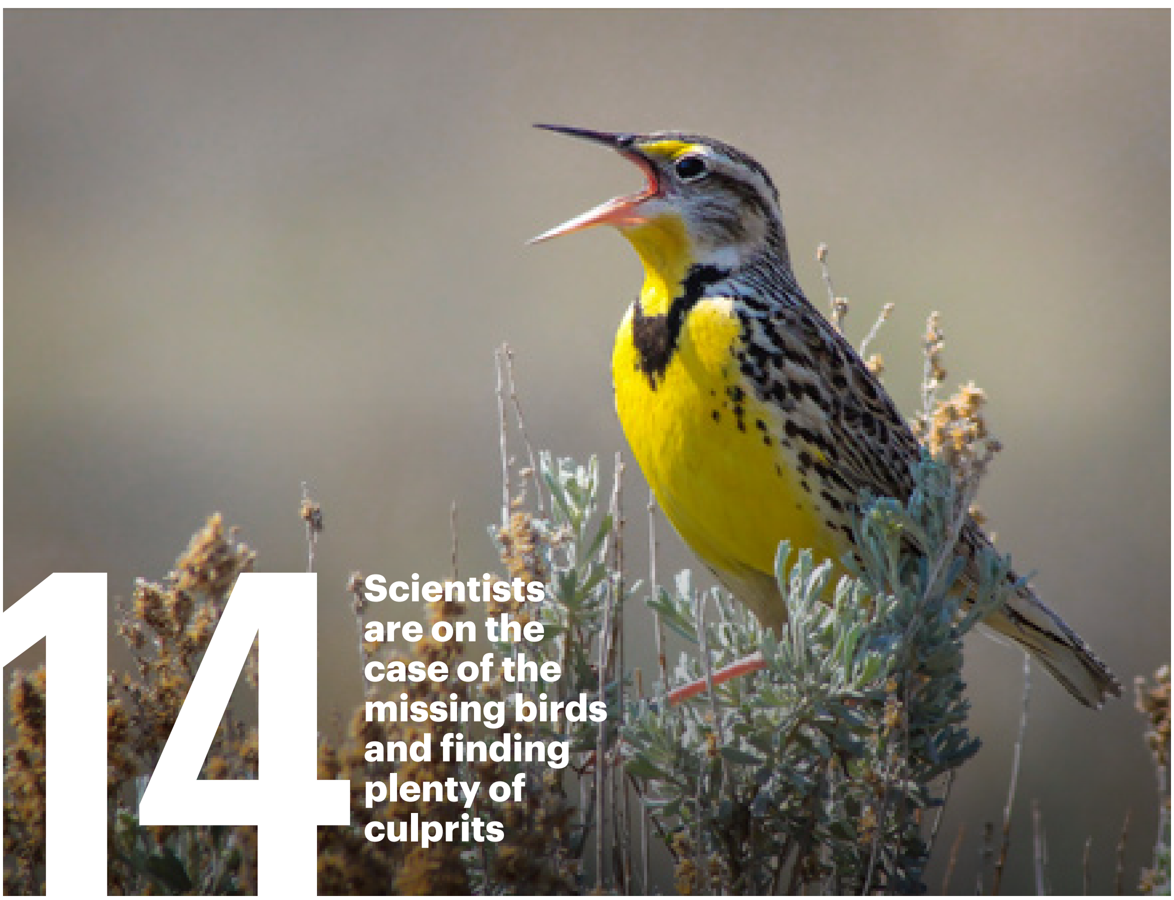

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Science News Explores
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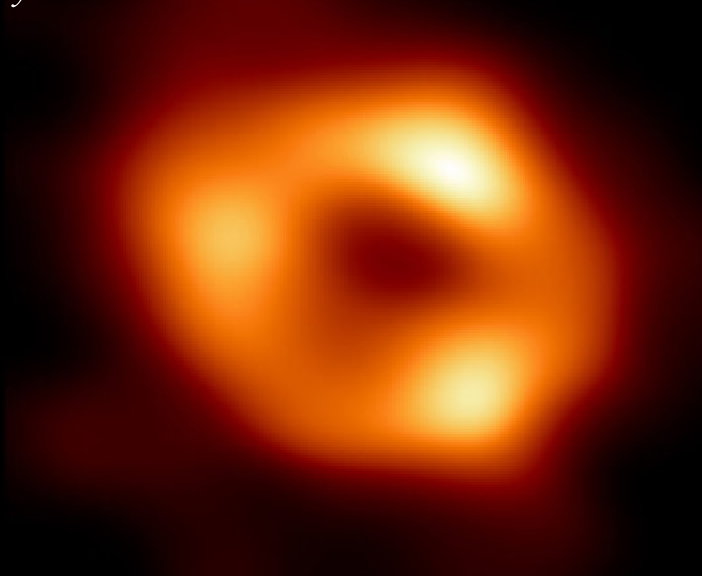
Q What happens when something gets inside a black hole?

— Jeremy F.



This is the supermassive black hole at the center of our home galaxy, the Milky Way. Its name is Sagittarius A*. Scientists believe every large galaxy has a supermassive black hole at its center.

A No one knows for sure what goes on inside a black hole. That's because a black hole's gravity is so strong that not even light can escape. As a result, it's impossible to peer into one. But scientists think they have a pretty good idea what happens to objects that fall in. A black hole's super-strong gravity crushes all infalling matter into a single point at its center, called a singularity. That singularity is infinitely small and infinitely dense. As the black hole gobbles up more matter, the singularity becomes more massive. So, a black hole literally is what it eats.

Q Why do we have to knead bread?

— Regina D.

A bread that contains yeast needs a protein known as gluten to give it structure and strength. Gluten will help trap the air bubbles created by the yeast to make your bread light and fluffy. Two proteins in wheat flour — gliadin and glutenin — can combine to form long strands of gluten in your dough, but they won't do it quickly. Or at least not without help. Gluten will form naturally as a dough ferments over about eight to 12 hours. But you can speed up the process with kneading, either by hand or with a machine. Kneading will help gliadin and glutenin link up and also stretch out those gluten strands. The result, if you've done it right, is a light and airy bread with a chewy texture.

Q Why do some animals glow in the dark?

— Faith Y.

There are many animals that glow in the dark, and this glow can serve different purposes. Some animals, such as fireflies, glow to attract mates. Others, such as the glass squid, emit light from under their eyes that makes them invisible to hungry predators below. Undersea tube worms produce mucus that glows on its own. That slime can mark predators with a sticky blue glow for days and serve as a "burglar alarm" if the predator comes near again. And bacteria in the ocean might light up just to hitch a ride. They can get swallowed by a larger animal for a free trip across the sea.

FIND OUT MORE USING THE QR CODES.

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

Sarah Zielinski
Editor, *Science News Explores*

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PHYSICS

Diamonds hold up under pressure

Experiments could illuminate the carbon-rich cores of distant planets

Diamond is surprisingly good under pressure. Its crystal structure holds up even when compressed to more than five times the pressure in Earth's core. Scientists reported this gem of a result in *Nature*.

Pure carbon can take on many forms. Diamond is one. Others include graphite (found in pencil lead) and tiny, cylinder shapes called carbon nanotubes. Carbon atoms are arranged in different ways for each form. Those patterns can be more or less stable under different conditions. Usually, carbon atoms take on the most stable state possible. At normal pressures on Earth's surface, carbon's most stable state is graphite. But given a forceful squeeze, diamond wins out. That's why diamonds form after carbon takes a plunge inside Earth.

But at even higher pressures, scientists had predicted that new crystal structures would be more stable than diamond. Amy Lazicki is a physicist. She works at the Lawrence Livermore National Laboratory in California. She and her colleagues pummeled diamond with powerful lasers to increase the pressure. Then they used X-rays to measure the material's structure. The predicted new crystals never showed up. Diamond persisted even after this laser beating.

The result suggests that, at high pressure, diamond is what scientists call metastable. That is, it can stay in a less stable structure rather than shift to a more stable one. This may interest astronomers who study distant planets around other stars. Some of these exoplanets may have carbon-rich cores. Studying diamond's quirks at extreme pressures could help reveal these exoplanets' inner workings.
— *Emily Conover*

Diamonds form deep within our planet. The ones we find now were brought to the surface through rare volcanic explosions of kimberlite magma, which cools into the black rock seen here.

BJOERN WYLEZICH/SHUTTERSTOCK

BRAIN

Nodding off could turn your creativity on

Insights may come just as you shift from between being awake to being asleep

The twilight time between wakefulness and sleep may be packed with creative potential. In an experiment, people who drifted into a light sleep were better problem solvers later.

Scientists shared those findings in *Science Advances*. The results help demystify the fleeting early moments of sleep. They may even point out ways to boost creativity.

Thomas Edison inspired the new study. Rumor has it that the famous inventor used to fall asleep in a chair holding two steel balls. As he drifted off, the balls fell into metal pans. The resulting clatter woke him. Then, he would write down his inventive ideas before he fell into a deep sleep and forgot them.

Researchers tested Edison's method of cultivating creativity with 103 healthy people. Volunteers came to the lab to solve a number problem. What the volunteers weren't told was that there was an easy trick to do this task. Once discovered, the trick dramatically cut the solving time.

After doing this task 60 times, the volunteers earned a 20-minute break. This downtime was spent in a quiet, dark room. Volunteers reclined in chairs and held a version of Edison's steel balls — a light drinking bottle in one dangling hand. The researchers told participants to close their eyes and rest or sleep if they desired. All the while, electrodes monitored their brain waves.

About half of the participants stayed awake. Twenty-four fell asleep and stayed in the shallow, fleeting stage of sleep called N1. Fourteen others progressed to the deeper N2 stage.

After their rest, participants returned to their number problem. The researchers saw a stark difference between the groups. People who had fallen into a shallow, early sleep were 2.7 times as likely to spot the hidden trick as people who stayed awake. Shallow sleepers were 5.8 times as likely to spot the trick as people who reached the deeper N2 stage.

Such drastic differences in such experiments are rare, says Delphine Oudiette. She's a cognitive neuroscientist at the Paris Brain Institute in France. "We were quite astonished by the extent of the results," she says.

The study doesn't prove that the time spent in N1 actually triggered later creativity, says John Kounios. He's a cognitive neuroscientist but wasn't involved in the study. He works at Drexel University in Philadelphia, Pa. Stewing over the problem may have caused these volunteers to both nod off and to have their later insight, he says. In that case, N1 sleep would be a "by-product of the processes that caused insight rather than the cause."

More work is needed to untangle the link between N1 and creativity, Oudiette says. But the results raise an interesting possibility. People may be able to learn to reach that twilight stage of sleep — or to produce the cocktail of brain waves associated with creativity — on demand.

It seems Edison was onto something about the creative powers of nodding off. But don't put too much stock in his habits. He also is said to have considered sleep "a criminal waste of time."

— *Laura Sanders*

AFRICA STUDIO/SHUTTERSTOCK

ANIMALS

These rabbits can't hop

A gene defect makes them do handstands

A breed of domesticated rabbit called sauteur d'Alfort has a funny way of walking. To move quickly, these bunnies send their back legs sky high and walk on their front paws. That odd gait may be due to a mutation in a gene called *RORB* that helps limbs move. Researchers reported this finding in *PLOS Genetics*.

Figuring out why the rabbits move in such a strange way could help scientists learn more about how the spinal cord works. The new study is "contributing to our basic knowledge about a very important function in humans and all animals — how we are able to move," says Leif Andersson. He's a molecular geneticist at Uppsala University in Sweden.

For their study, Andersson and his colleagues bred a hop-less sauteur d'Alfort male rabbit with a New Zealand white female rabbit that could hop. The team then scanned the genetic blueprints of the offspring. They looked in the young bunnies that couldn't hop for gene differences from ones that could.

A mutation in the *RORB* gene popped up as a likely suspect for the rabbits' acrobatic handstands. That change creates faulty versions of the genetic instructions that cells use to make proteins. As a result, there appears to be less of the RORB protein in nerve cells that have the mutation compared to cells without it. That includes special nerve cells called interneurons. Interneurons help coordinate the left and right side of the body by passing along nerve signals.

Uncovering how that genetic defect affects the body more broadly could be important for understanding the way animals move. Even people can't run without coordinated movements between their limbs. "If you look at the 100-meter sprint — [by] Usain Bolt or someone like that — there's super coordination between limbs," Andersson says. "If you lack the coordination between arms and legs … you could never compete for a gold medal."

— *Erin Garcia de Jesús*

SAMUEL BOUCHER

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

WHAT'S EASY FOR YOU MAY BE TOUGH FOR A ROBOT

Beating a robot at chess would be easier than you think

You're sitting across from a robot, staring at a chess board. Finally, you see a move that looks pretty good. You reach out and push your queen forward. Now it's the robot's turn. Its computer brain calculates a winning move in a fraction of a second. But when it tries to grab a knight, it knocks down a row of pawns. Game over.

"Robots are klutzes," says Ken Goldberg. He's an engineer and artificial intelligence (AI) expert at the University of California, Berkeley. A computer can easily defeat a human grandmaster at the game of chess by coming up with better moves. Yet a robot has trouble picking up an actual chess piece.

This is an example of Moravec's paradox. Hans Moravec directed the Robotics Institute at Carnegie Mellon University in Pittsburgh, Pa., for more than two decades. He also writes about AI and the future. Back in 1988, he wrote a book that noted how reasoning tasks that seem hard to people are fairly easy to program into computers. Meanwhile, many tasks that come easily to us — like moving around, seeing or grasping things — are quite hard to program. Even babies and kids can beat machines at these types of tasks.

It turns out that the tasks we find easy aren't really "easy" at all. As you walk around your house or pick up and move a chess piece, your brain is performing incredible feats of calculation and coordination. You just don't notice it because you do it without thinking.

Let's take a look at several tasks that are easy for kids but not for robots. For each one, we'll find out why the task is actually so hard. We'll also learn about the brilliant work engineers and computer scientists are doing to design new AI that should help robots up their game.

>>

By **Kathryn Hulick**

ILEXX/ENVATO MARKET

TASK 1: Pick stuff up

People and animals have evolved effective ways to grasp all kinds of things. Ken Goldberg's dog, Rosie, is great at grabbing onto toys with her mouth.

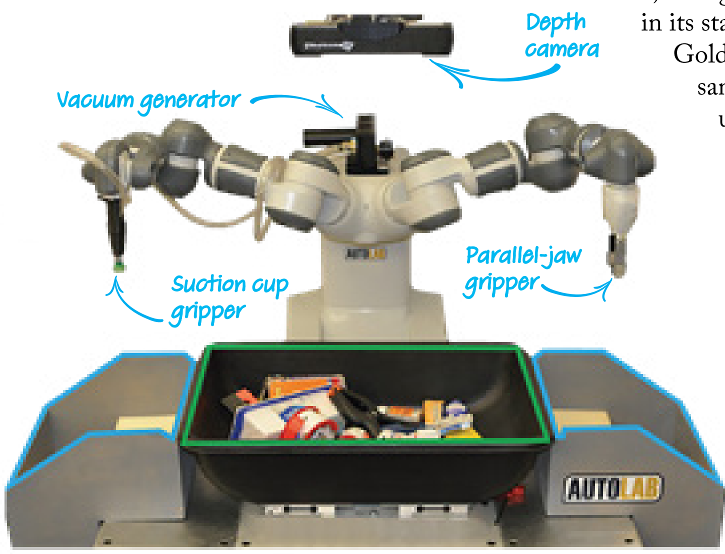
Goldberg has something in common with robots. He, too, is a klutz. "I was the worst kid at sports. If you threw me a ball, I was sure to drop it," he says. Perhaps, he ponders, that's why he wound up studying robotic grasping. Maybe he'd figure out the secret to holding onto things.

He's discovered that robots (and clumsy humans) face three challenges in grabbing an object. Number one is perception. That's the ability to see an object and figure out where it is in space. Cameras and sensors that measure distance have gotten much better at this in recent years. But robots still get confused by anything shiny or transparent, he notes.

The second challenge is control. This is your ability to move your hand accurately. People are good at this but not perfect. To test yourself, Goldberg says, "Reach out, then touch your nose. Try to do it fast!" Then try a few more times. You likely won't be able to touch the exact same spot on your nose every single time. Likewise, a robot's cameras and sensors won't always be in perfect sync with its moving "hand." If the robot can't tell exactly where its hand is, it could miss something or drop it.

Physics poses the final challenge. To grasp something, you must understand how that object could shift when you touch it. Physics predicts that motion. But on small scales, this can be unpredictable. To see why, put a pencil on the floor, then give it a big push. Put it back in its starting place and try again. Goldberg says, "If you push it the same way three times, the pencil usually ends up in a different place." Very tiny bumps on the floor or the pencil may change the motion.

Despite these challenges, people and other animals grasp things all the time — with hands, tentacles, tails and mouths. "My dog Rosie is pretty good at grasping anything in our house," says Goldberg.



A person can pick up 400 to 600 items every hour. A robot trained on Dex-Net (right) can grab up to 500 things per hour, but some items are much trickier to grasp than others (below). A suction cup can't pick up grapes. And a claw can't grasp flat things, like a playing card. Neither can grab a shower puff.

FROM TOP: K. GOLDBERG; J. MAHLER *ET AL*/*SCIENCE ROBOTICS* 2019; UC BERKELEY; CALIMEDIA, KEITH HOMAN, SHEILA FITZGERALD, AND DARRYL BROOKS/SHUTTERSTOCK

Millions of years of evolution provided brains and bodies with ways to adapt to all three challenges. We tend to use what Goldberg calls “robust grips.” These are secure grips that work even if we run into problems with perception, control or physics. For example, if a toddler wants to pick up a block to stack it, she won’t try to grab a corner, which might slip out of her grasp. Instead, she’s learned to put her fingers on the flat sides.

To help robots learn robust grips, Goldberg’s team set up a virtual world. Called Dex-Net, it’s like a training arena for a robot’s AI. The AI model can practice in the virtual world to learn what types of grasps are most robust for what types of objects. The Dex-Net world contains more than 1,600 different virtual 3-D objects and 5 million different ways to grab them. Some grasps use a claw-like gripper. Others use a suction cup. Both are common robot “hand” types.

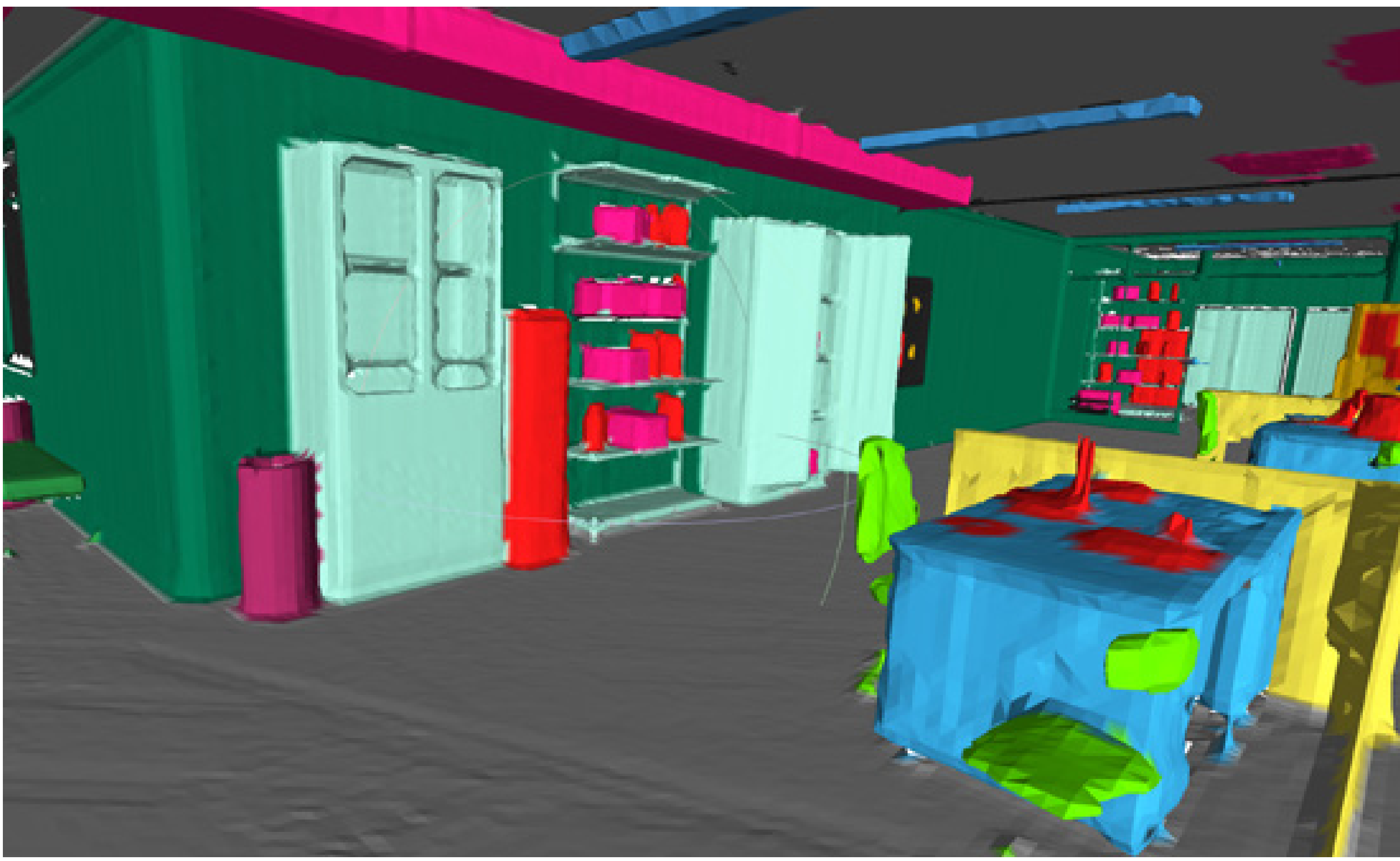
After a robot has completed this training, it can figure out its own robust grasp for a real-world object it has never seen before. Thanks to research like this, robots are getting much less clumsy. Maybe someday a grasping robot will be able to clean up your room.

TASK 2: Get around the world

If someone plops you down in the middle of a building you’ve never been in before, you might feel a bit lost. But you could look around, find a door and get out of the room quickly without bumping into anything or getting stuck. Most robots could not do that. Researcher Antoni Rosinol first got interested in this problem while working with drones. Usually, someone pilots a drone via remote control. That’s because most drones can’t fly very well by themselves. “They can barely go forward without colliding against a tree,” notes Rosinol. He is a PhD student studying computer vision at the Massachusetts Institute of Technology (MIT) in Cambridge.

Perception is a big problem for many navigating robots, just as it is for robots that grasp things. The robot needs to map the entire space around itself. It needs to understand the shape, size and distance of objects. It also has to identify the best paths to get where it needs to go.

Computer vision has gotten very good at detecting and even identifying the objects around a robot. Some robots, advanced drones and self-driving cars do a very good job at getting around obstacles.



ANTONI ROSINOL

Kimera maps and identifies the different objects in a room as well as structural parts and open spaces to help a robot know how to navigate the area.

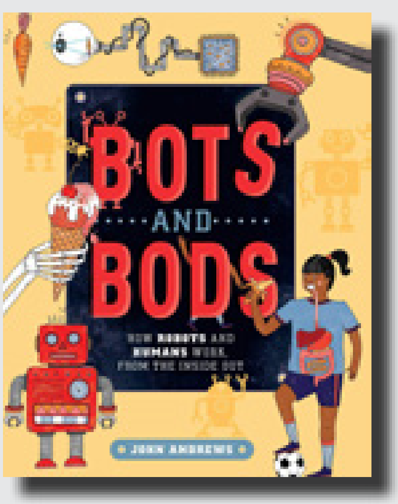
But too often, they still make mistakes. One of the trickiest things for a navigating robot to handle is a large, blank space such as a ceiling, wall or expanse of sky. "A machine has a lot of trouble understanding what's going on there," Rosinol explains.

Another issue is that robots don't understand anything about human living spaces. A robot trying to get out of an unfamiliar room might circle around, looking for openings everywhere — including on the floor. If it finds a bathroom, it may go in, not realizing that this room won't lead anywhere else.

The MIT team has developed a system that can help solve this problem. They call it Kimera. "It's a group of maps for robots," says Rosinol. Those maps are nested into layers. The bottom layer is what most robots already create. It's a map of the shape of the three-dimensional space around them. This shape has no meaning to a robot, however. All it sees at this level is a bumpy mass, as if the world around it were all the same color. It can't pick out walls, doorways, walking people, potted plants or other things.

Kimera's other layers add meaning. One layer divides up the bumpy mass into objects that don't move and agents that do. Another layer identifies places that the robot can move through and structures that it can't penetrate. The final two map-layers identify rooms and the entire building that those rooms belong to. A robot equipped with Kimera can build all these maps at once as it moves through a space. This should help it more easily find a direct path.

Read More



Bots and Bods: How robots and humans work, from the inside out

Did you know the word "robot" was first used in a play from 1920? Learn more fun facts about technology and the human body in this illustrated guide on all things robots.

The author, John Andrews, is a bod, not a bot.

TASK 3: Understand people

No matter what a robot tries to do, one big thing holds it back. Robots lack common sense. This is the knowledge that people don't have to think or talk about because it's so obvious to us. Thanks to common sense, you know that you should grab a lollipop by the stick and not by the candy. You know that doors are almost never located on the floor or ceiling. And so on.

> It's still a grand challenge in AI to get a machine that has the common sense of an 18-month-old baby.
> —Melanie Mitchell

Computer scientists have tried teaching robots common-sense rules. But even huge databases of these rules don't seem to help much. There are just too many rules and too many exceptions. And no computer or robot understands the world well enough to figure out these rules on its own.

This lack of understanding makes grasping and navigating tougher. It's also the main reason that virtual assistants sometimes say ridiculous things. Without common sense, an AI model can't understand people's words or actions, or guess what they'll do next. "We want to build AI that can live with humans," says Tianmin Shu, a computer scientist at MIT. This type of AI must gain common sense.

But how? While we learn a lot of common sense from our experiences in the world, some common sense is with us and many other animals from birth, or soon after. Before they are 18 months old, human babies understand the difference between agents and objects. They also understand what it means to have a goal and how obstacles can get in the way of a goal. We know this because psychologists have run experiments to test babies' common sense.

Based on these experiments, Shu decided to make a virtual world called AGENT. Like Dex-Net, AGENT is a training arena for AI models.

The models practice by watching sets of videos that demonstrate a basic common-sense concept. One of those concepts is that an agent will take the most direct route toward a goal. Shu trained a model on three types of common-sense scenarios. He then tested it on a fourth type. The first three scenarios contained all the concepts needed to understand the fourth. But still his model didn't get it. "It's still a grand challenge in AI to get a machine that has the common sense of an 18-month-old baby," says Melanie Mitchell. She's an AI expert at the Santa Fe Institute in New Mexico.

TASK 4: Think of new ideas

In spite of these challenges, AI has come a very long way — especially in recent years. In 2019, AI models that had learned to recognize both dragons and elephants still couldn't combine those into a new concept, an elephant dragon. Of course, a child can imagine and draw one quite easily. As of 2021, so can a computer.

DALL-E is a new AI model made by the company OpenAI. It turns a text description into a set of new, creative images. (The name "DALL-E" is a combination of the last name of Spanish artist Salvador Dali and the robot WALL-E, the star of a 2008 Disney movie.)

DALL-E doesn't have common sense. So its imaginings aren't always on target. When you ask it to make carrot-kangaroos, most of them look more like awkward orange blobs. And if you tell it to draw a penguin wearing a green hat and a yellow shirt, all the pictures show penguins, although some sport yellow or red hats.

Sometimes though, DALL-E's non-human way of seeing things is delightful and creative. For example, if you ask a person to imagine a shark playing chess, they'll probably draw the shark using its fins as hands. In one of DALL-E's images, a shark uses its tail instead. Someday, DALL-E or a similar model could help human artists and designers come up with a wider range of ideas.

It's very likely that in the coming years someone will design a graceful robot or even an AI model with common sense. For now, though, if you want to beat a robot at chess, make it play on a real, physical chess board.

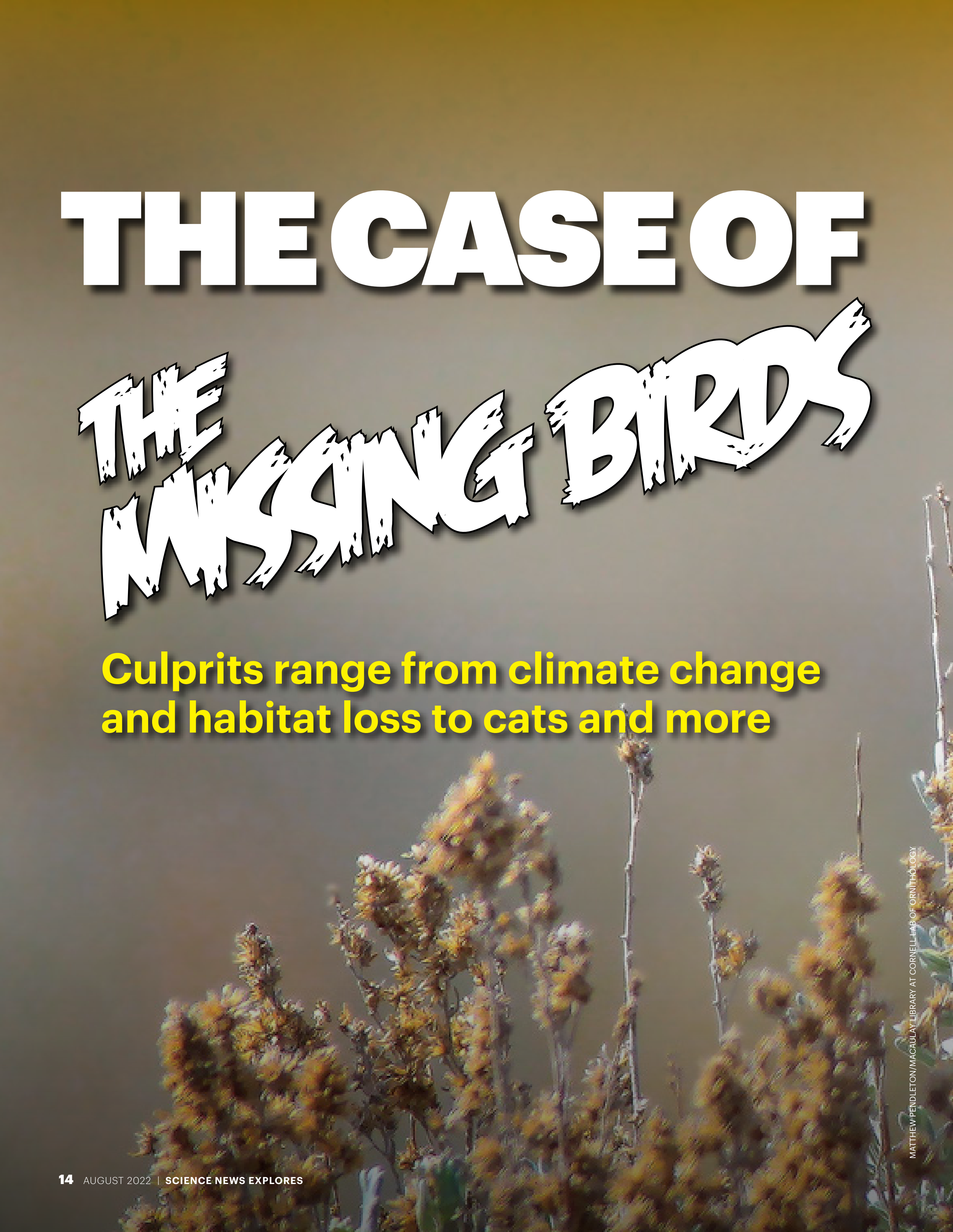
What would you create if you were asked to make out of plasticine a bowl of soup that looked like a monster? Would it look anything like DALL-E's inventions?

Some of DALL-E's kangaroos made of carrots (right, top rows) look a bit awkward. But for what it's worth, most people probably wouldn't make the best carrot art, either. A robot may not do a great job at picking up chess pieces. But at least DALL-E can draw some interesting pictures (right, bottom rows) of sharks playing chess!

OPENAI

THE CASE OF THE MISSING BIRDS

Culprits range from climate change and habitat loss to cats and more



MATTHEW PENDLETON/MACAULAY LIBRARY AT CORNELL LAB OF ORNITHOLOGY

By **Alison Pearce Stevens**

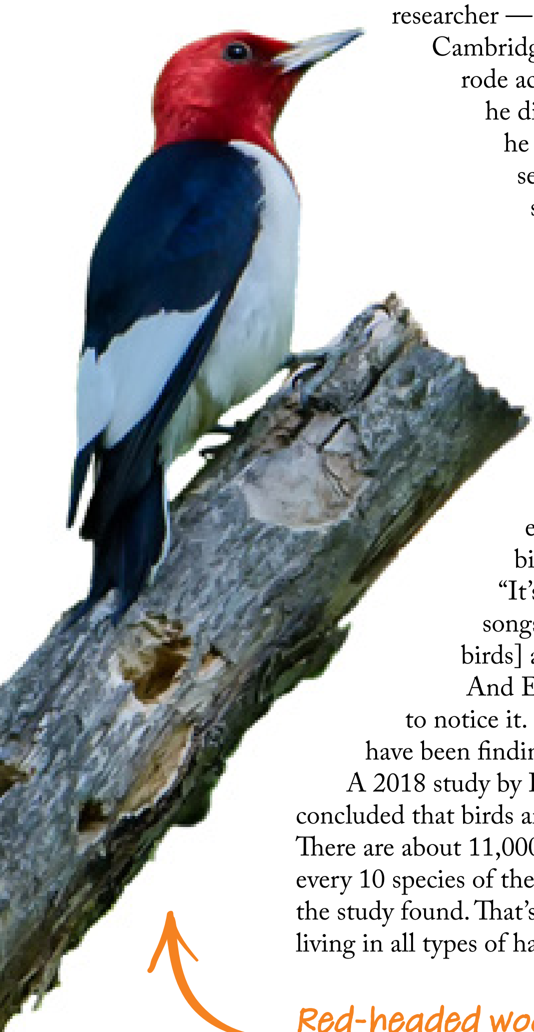
Scott Edwards paused his cross-country bike trip when he spotted a flash of black, white and red. It was a red-headed woodpecker. "I got my first good look today," he said. He was phoning from his tent in Illinois later that night. He had seen their distinctive black and white wings while riding. "But I hadn't seen the red head until today, so I was very excited."

Edwards is an ornithologist — a bird researcher — at Harvard University in Cambridge, Mass. Over one summer, he rode across the United States. In part, he did it to see the country. But he also used the trip to do some serious bird-watching. That's something he's been doing for more than 40 years.

When he was growing up in the Riverdale neighborhood of the Bronx, in New York City, there were lots of trees, he recalls. When he was 9 or 10, a neighbor took him bird-watching. Edwards has been doing it ever since. But finding those birds is getting more difficult. "It's quieter," he says of their songs and calls. "The numbers [of birds] are way down."

And Edwards is hardly the only one to notice it. Scientists around the world have been finding the same thing.

A 2018 study by BirdLife International concluded that birds around the world are in trouble. There are about 11,000 species of birds. Four in every 10 species of them are decreasing in number, the study found. That's true for many kinds of birds living in all types of habitats. And it's still true today.



Red-headed woodpecker

Habitat loss, food shortages and competition for nesting sites with European starlings are the main culprits behind a decline in red-headed woodpeckers.

Some birds, such as the California condor, are critically endangered. Only a few members of this species remain in the wild. Other species are frequently spotted at backyard feeders: sparrows, finches, warblers and more. But even common birds are less common than they were just 50 years ago. And that's now true almost everywhere.

Billions of birds gone missing

North America is losing lots of birds, says Ken Rosenberg. He is an ornithologist at the Cornell Lab of Ornithology. That's at Cornell University in Ithaca, N.Y. He was just one biologist who noticed changing bird populations in the mid-2000s. "We knew many bird species were declining," he says. But "some, like ducks, had been increasing." What the researchers didn't know was whether the increasing species made up for the losses.

In 2017, Rosenberg teamed up with scientists from across the United States and Canada to find out. The group turned to long-term bird surveys for their study. These surveys go back to 1970. Created by scientists and government agencies, they help researchers understand bird numbers, migration patterns and more. Researchers use them to create bird-identification guides and conservation plans. These surveys estimated population sizes for 529 bird species across North America.

The team found that species living in wetlands are doing well. Ducks and geese have increased in number over the past 50 years. "Waterfowl hunting contributes millions of dollars for wetland protection and management in order to have healthy populations for hunting," Rosenberg says. Those efforts are helping waterfowl populations overall.

Hill blue flycatcher

Male hill blue flycatchers are bright blue and orange. They are often captured and sold illegally as pets in Southeast Asia.

FOTOREQUEST AND INDEPENDENT BIRDS/SHUTTERSTOCK

SUMMER MIGRATION
WHERE DO THEY GO?

Migration isn't as simple as "birds go north in spring and south in the fall." And in the summer in North America, birds are going every which way. Knowing where and when birds migrate can help guide efforts to protect these animals on their perilous journeys.

1. King eiders
These Arctic birds travel to their nesting grounds in June and July. But climate change is reducing their range.

2. Surf scoters
Large numbers of surf scoters gather on the coast in summer, where they molt before heading farther south.

3. Rufous hummingbirds
The 6,400-kilometer (4,000-mile) migration path for this tiny bird stretches from Alaska to Mexico, where the birds overwinter.

4. Least sandpipers
Declines in these birds, which head south as early as July, can be traced in part to the loss of wetlands along their migration.

5. Little blue herons
Some adults and young birds will fly north in late summer after nesting season, before heading back south for the winter.

6. Red-tailed hawks and Bald eagles
After they leave their parents' nest, some young raptors, such as hawks and eagles, will head north during the summer.

7. Heermann's gulls
These birds time their summer journey north with that of the brown pelican, so the gulls can steal food from their neighbors.

8. Western songbirds
By August, species such as the lazuli bunting are already heading toward their winter territory in Mexico.

ITIM2101/SHUTTERSTOCK; ILLUSTRATION BY STEVE MCCRACKEN

But birds in other habitats are struggling. From coasts and forests to tundra, populations of birds have been declining, the analysis found. The biggest changes are in grassland species, especially sparrows, blackbirds and larks. That's because 90 percent of their habitat has been converted to agriculture, Rosenberg says. Their populations are less than half what they were in 1970.

Species that live in other habitats are suffering, too: warblers, finches, flycatchers, swallows, sandpipers and more. Overall, North America has lost some three billion birds, Rosenberg's team estimated in a *Science* study.

The trouble with migration

Birds can be divided into two groups: those that live in one place all their lives, and others that migrate from one home to another. And Rosenberg's team found evidence that migrators may face the greatest risk in North America.

But such trends aren't limited to that continent. Birds are declining in Europe, too, notes Franz Bairlein. He is an ornithologist at the Institute of Avian Research in Welhelmshaven, Germany. Migratory birds are in the most trouble there, also. Long-distance migrants travel from their breeding grounds in Europe. They end up in Africa, where they overwinter. Bairlein's research has found three main reasons for the decline in these birds.

Tens of millions of birds are killed illegally every year when they stop to refuel at spots along their journey. This hunting of the birds could be for food, trade, tradition or just for sport, Bairlein says. It doesn't take long for those losses to affect a population. But illegal killing isn't the major problem facing these species, he says.

A much more widespread concern is the severe destruction and loss of their habitat, he says. That's true, he adds, "almost everywhere: at breeding grounds, stopover locations and winter locations." All along the migration routes, people are changing the landscape in ways that imperil birds. In some areas, natural landscapes have become farm fields that no longer provide the food or shelter that birds need. In other areas, buildings and roads have been replacing these landscapes.

Lastly, there's climate change. The spring thaw now arrives earlier and earlier. When temperatures get warm enough, caterpillars and other insects emerge from their winter hideaways. Many birds, such as the pied flycatcher, rely on fat insect larvae to feed their young. But for many years now, the migrating birds arrive too late to catch the caterpillars. When this happens, the birds' young go hungry and may die. This, too, can affect a population's size, Bairlein says.

Climate change also will lead to longer migrations. That's the finding of a study in *Proceedings of the Royal Society B*. Two of its authors, Christine Howard and Stephen Willis, are conservation ecologists at Durham University in England.

Climate isn't changing at the same pace and in the same way everywhere. Some regions are getting hotter faster than others. Some are becoming drier. Or wetter. The researchers found that summer breeding grounds will shift by about 415 kilometers (258 miles) by 2070. In the Northern Hemisphere, many of those shifts will be to the north. "We expect that as

Yellow-breasted bunting

Yellow-breasted buntings were once one of the most abundant songbirds found north of the Himalayas. Their summer range spanned from Finland to eastern Russia.

INDEPENDENT BIRDS AND ITIM2101/SHUTTERSTOCK temperatures increase, many species will have to travel towards the poles to find areas of suitable climate," Howard says. The birds' migrations will take several days longer than they do now. And that means birds will need extra stopovers to refuel along the way.

"Migration is a period of high mortality," Howard says. Birds use lots of energy on the long flights. So starvation is a risk, she says. Stopovers are critical if birds are to safely reach their destination. They let birds refresh and refuel along the way. But these rest stops require suitable habitat — areas that provide good shelter and the right types of food.

"Any increase in reliance on stopovers might render birds more vulnerable to habitat changes in these locations," Howard says. In some cases, there may "not be suitable habitats" when the migrants need them.

Bird populations aren't as well studied in China and Russia. But even the limited data from those countries reveal a similarly dire situation. One study of yellow-breasted buntings in Asia found that this once-abundant species is rapidly disappearing. These birds are a traditional food in China. As the bunting populations began to drop, the government outlawed hunting them. But the new law didn't stop people from continuing to capture and eat the birds. In just 33 years, the numbers of yellow-breasted buntings dropped by 84 percent. Another study by Chinese researchers found almost all songbirds that fly through eastern China to breed in Russia are declining in number.

Getting to the root of the problem

Knowing why birds are declining is necessary if scientists are to help bird numbers rebound. As studies have shown, climate change and habitat loss are two major problems. They're also connected. Changes in climate can lead to dying vegetation, erosion of important habitats or changes in food supplies. These issues span countries and continents, making them tough to tackle.

Around the world, scientists are working to protect important habitats. But "we still don't understand fully the stopover locations that individual species are using," Howard says. And that makes it tricky to know which areas are essential for migration. A changing climate makes identifying those areas even harder.

Which areas should you protect? Howard asks. "Areas that are important now [or] areas that are important in the future?" Or perhaps, she says, some mix of both.

"Extreme climate will have a major impact on birds," says David Lindenmayer. He is a landscape ecologist at Australian National University in Canberra. "It's already changing bird body size," he notes. Birds are getting smaller as temperatures climb. That can make it harder for them to store enough energy for long migrations. And extreme weather events such as drought and flooding can also destroy important habitat.

Climate, weather and habitat loss aren't the only problems that birds face. Studies have turned up a wide range of problems, including cats, collisions, lights and pesticides (see box). "Birds are telling us what's going on in the larger environment," Rosenberg says. "And that story is not good."

But we can make changes to help birds. Some are easy, and you can start at home. "Make your parents sensitive to the causes of bird declines," Bairlein says. Talk to them about making your backyard bird-friendly by planting shrubs that provide both food and shelter. Ask local decision-makers "to make public parks bird-friendly." Even reach out to farmers and foresters, he suggests. Ask them "to protect habitats and increase habitat structures." This might include planting hedgerows or bushes to create more varied landscapes.

Lastly, do your part to fight climate change. Think about how you can personally reduce your impact. And "write your concerns to politicians," says Lindenmayer. Tell them you want them to take steps to slow climate change.

"Bird populations can be very resilient, once we remove the threats," Rosenberg says. So get involved. Become a citizen scientist and collect data on birds. Be a voice for change. After all, a healthy planet isn't just for the birds.

ITIM2101/SHUTTERSTOCK

Nothing could keep Kevin Burgio from becoming a scientist

Now he's an expert on extinct species such as the Carolina parakeet

For Kevin Burgio, the journey to becoming a successful scientist wasn't easy. When he was young, life was hard. Burgio's father left before he was born. His mother had dropped out of high school, and she never had a lot of money. Burgio knew he was different from other kids, and deep down, he knew he was bisexual when he was only 11 or 12. He didn't tell anyone then but was still bullied during his school years. Even so, he managed to graduate and joined the Air Force. After several years in the military, Burgio left and went to college, eventually receiving his PhD in ecology and evolutionary biology from the University of Connecticut.

Now Burgio is an ecologist and conservation biologist who conducts research at the U.S. Geological Survey and the University of Connecticut in Storrs. He has become an expert on extinct species such as the Carolina parakeet. Burgio has pieced together where the bright green parrot once lived in the eastern half of the United States. He's now trying to figure out why it went extinct. He has also helped students overcome hardships, like he did, and learn how to become scientists. In his free time, he loves exploring nature with his daughter. In this interview, Burgio shares some of his experiences. (This interview has been edited for content and readability.) — *Bryn Nelson*

COURTESY OF K. BURGIO

Q What inspired you to pursue your career?

A I started college later in life, when I was 28, and had planned to go to dental school. When I started school, my hands kept shaking. I went to a neurologist and they told me I had "essential tremor." (The incurable nervous system disorder can cause a person's hands to shake.) I had no idea what I was going to do. One day, I saw this woodcock outside my apartment window, and I had never seen anything like it. They're weird. They look like a bowling ball with a beak on it. So I read about the bird online and found it really interesting.

The next semester, I took an ornithology class. (Ornithology is the study of birds.) The professor asked me if I was doing research. I had no idea that undergraduates could even do anything like that. That professor became my undergraduate advisor, and I started working in her lab.

> At the end of the day, if I haven't done anything to improve the lives of people who have gone through the same stuff that I have gone through, I don't think I could live with myself.
> — Kevin Burgio

This 19th-century painting by John James Audubon shows a flock of very colorful Carolina parakeets. The bird species, once common in the eastern half of the United States, went extinct about 80 years ago.

FROM TOP: COURTESY OF K. BURGIO; JOHN JAMES AUDUBON

Q How do you get your best ideas?

A Talking to friends, really, and you start riffing about ideas. I kind of liken it to a band sitting together, writing songs. "What about this riff? What about this drum line here?" You just kind of riff with your friends or people you do research with, based on, "I read this cool paper and check this out. It had this cool thing." And, "Oh, I wonder if we had this kind of data, could we do something similar?"

Q What's one of your biggest successes?

A Seeing my name in print for the first time was just an indescribable feeling. I think that made it real for me, like, wow, I'm actually a scientist.

BODY

Test the power of touch

Grab a blindfold and some calipers

By Bethany Brookshire

Your fingertips are sensitive to touch. They have to be, to help you type, get dressed and pet kittens. But are they more sensitive than your arm or back? How would you be able to tell? A test called *two-point discrimination* can help determine which parts of the body are more sensitive than others. Two-point discrimination refers to the ability to perceive two points touching you as two actual points instead of one. You can test this by poking yourself or your friends (with permission, of course).

HYPOTHESIS

Fingertips are more sensitive to two points of contact than the arms or upper back.

METHOD

1. Find a volunteer. Blindfold them, or ask them to close their eyes. Then tell them to hold out their dominant hand (the right hand, if someone is right-handed).

2. Carefully touch a pair of calipers to the tip of their index finger. Start with the calipers completely closed, forming a single point. Ask if they feel one or two points of contact.

3. Repeat this test, widening the calipers each time. Test 0, 0.5, 1, 2, 5 and 10 millimeters (between 0 and 0.39 inch). Always ask if they feel one or two points of contact.

4. Repeat the test again on the person's dominant lower arm and back.

5. Repeat again with more volunteers. Carefully write down your data.

DID YOUR DATA SUPPORT YOUR HYPOTHESIS?
Find out how to analyze your data, and more, at www.sciencenewsforstudents.org/touch

PROSTOCK-STUDIO AND SIMONEN/SHUTTERSTOCK

These words are hiding in this issue. Can you find them?

The words below came from the stories in this magazine. Find them all in the word search, then search for them throughout the pages. Some words will appear more than once. Can you find them all?

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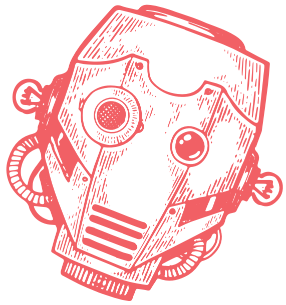

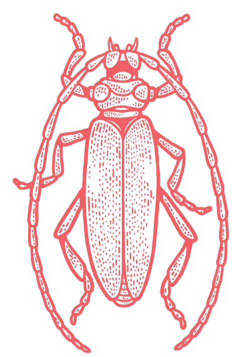

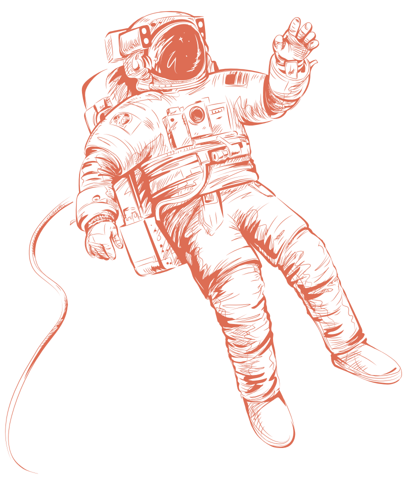

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PLASMA
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ROBOT
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SLEEP
STOPOVER
SURVEY
TACTOR
TOUCH

GRYVA AND ALEXANDER_P/SHUTTERSTOCK

TECHNOLOGY

An artificial skin could let you feel things that are far away

The tech could also help people with prosthetic limbs

Long-distance communication may benefit from a robot's touch. And that may come in the form of a gadget developed by engineers in Australia.

Haptic is a term for things that relate to one's sense of touch. The new haptic device slips over someone's finger like the tip of a glove. It interacts with the skin to simulate touching or feeling something. This new device makes it possible for people to feel something that isn't actually at their fingertips.

Its inventors see a variety of potential uses. "A surgeon can wear our gloves and touch a patient far away," says Thanh Nho Do. He's an engineer at the University of New South Wales in Australia who led design of the new skin stretch device, or SSD. "In the deep sea or in space, a robot can pick up things. This can let you feel [what the robot touches]. When a person has an artificial limb, they can wear this and feel [what it touches]."

Scientists have been working on haptic devices for years, but touch is a delicate sense, Do says. It's unlike vision, which can be communicated over distances with cameras and monitors. It's also unlike hearing, where sounds can be relayed to the ears with microphones and speakers.

In recent years, scientists have been finding new ways to build and improve haptic devices. Some have used vibration. (The button on a smart phone, for example, uses a small vibration to simulate the pressing of a button.) Others use motors to physically push on a user's skin. These, however, often require bulky and uncomfortable parts, notes Do. In fact, he observes, "Most of them have a big motor, and when it moves on the skin it's not comfortable."

His group took a new approach. They realized that the brain gets haptic information when something moves across the skin. With that idea in mind, they wanted to design something that could slide and stretch.

Their SSD is made from a piece of fabric into which tiny, fluid-filled tubes have been sewn. Those tubes connect to a small disk, called a tactor. The tactor can move up and down and side to side. As the tubes expand and contract, they slide the tactor across someone's skin. In this way, they act like artificial muscles. The researchers described their device in *IEEE Access*.

"It's quite interesting," says engineer Nadja Bressan. She notes that the new device relies on mechanical power rather than electrical. "As it stretches and contracts, it pulls and produces sensing. The stretch is where everything happens." Bressan did not work on the new invention.

A device made from a new kind of artificial skin, shown covering a finger, simulates the sense of touch.

UNSW SYDNEY

Doctors may use robots to perform surgeries that require more precision and control than a human can provide (left). But those robots can't tell the doctor what the patient feels like. Artificial skin could one day provide that information.

A person who lacks an arm and hand may use a prosthetic arm to help them with tasks (above). The addition of artificial skin to a prosthesis could restore the sense of touch and let the person feel something like the hand of a loved one.

ZAPP2PHOTO/SHUTTERSTOCK; KUZNETSOV DMITRIY/SHUTTERSTOCK

In her lab at the University of Prince Edward Island, in Charlottetown, Canada, she develops her own robotic technology for use in medicine.

Bressan says she admires the innovative concepts that underlie the new design. However, she cautions, with extended use the device may wear down. The designers will have to find a way to make their SSD both functional and durable, she says.

Do says he was inspired to work on the SSD after spending many years working on surgical robots. One day, a doctor asked him: When will I put on a glove and feel what the robot feels? Do kept that question in mind as he spent years learning about the sense of touch and haptic technology.

His team also is working on adding the ability to sense hot or cold to their device. "Then you can not only feel the force, but also the temperature," Do says. "If you wanted to touch ice in space, you could." — *Stephen Ornes*

GENETICS

What would it take to make a unicorn?

And would that be a good idea?

While everyone knows that unicorns — those beautiful white horses with heads that have sprouted a single spiraling horn — are just a flight of fancy, is there any chance they could ever exist? The short answer: It's highly unlikely. But scientists have ideas about how these animals could become real. A bigger question, though, is whether it would be a good idea to make one.

A unicorn doesn't look that much different from a white horse. And getting a white horse is pretty easy. One path to a white horse is a mutation on a single gene that turns an animal into an albino. These animals don't make the pigment melanin. Albino horses have white bodies and manes and pink or red eyes. But this mutation can also mess with other processes inside the body. In some animals, it can lead to poor vision or even blindness. So unicorns that evolved from albino horses might not be all that healthy.

A horn or rainbow coloring are more complex traits. They tend to involve more than one gene. "We can't say, 'we are going to change this gene and now we're going to have a horn,'" says Alisa Vershinina. She studied the DNA of ancient horses while at the University of California, Santa Cruz.

If any of these traits were to evolve, they would need to give a unicorn some advantage that helps it survive or reproduce. A horn, for instance, might help a unicorn defend itself against predators. Colorful features might help a male unicorn attract a mate. That's why many birds have bright and bold colors. "Maybe horses would be able develop these crazy colors … that would favor boys that are very beautiful pink and purple," Vershinina says.

But none of this would happen fast because horses (and the resulting unicorns) have relatively long lifespans and reproduce slowly. Evolution "doesn't work in a snap," Vershinina notes.

Insects generally have short generation times, so they might evolve body parts quickly. Some beetles have horns that they use for defense. A beetle might be able to evolve such a horn in 20 years, Vershinina says. But even if it were possible for a horse to evolve into a unicorn, that "would take more than a hundred years, probably, if not a thousand," she says.

Perhaps instead of waiting for evolution to make a unicorn, people could engineer them. Scientists might use the tools of bioengineering to cobble together the traits of a unicorn from other creatures.

Paul Knoepfler is a biologist and stem-cell researcher at the University of California, Davis. He and his daughter Julie wrote a book, *How to Build a Dragon or Die Trying*. In it, they ponder how modern techniques could be used to build mythical creatures, including unicorns. To transform a horse into a unicorn, you could try adding a horn from a related animal, Paul Knoepfler says.

One approach would be to use CRISPR. This gene-editing tool lets scientists tweak an organism's DNA. Researchers have found certain genes that are turned off or on when animals are growing their horns. So in a horse, "you might be able to … add a few different genes that would result in a horn sprouting on their head," he says.

It would take some work to figure out which genes are the best to edit, Knoepfler notes. And then there are challenges to making the horn grow properly. Also, CRISPR itself isn't perfect. If CRISPR creates the wrong mutation, this could give the horse an unwanted trait, such as a tail growing from its head instead of a horn.

Still, Knoepfler says, making a unicorn seems almost realistic compared with creating a dragon. And for any approach, you'd need a team of researchers, plus veterinarians and reproductive experts. Such a project would take years, he notes.

But if scientists succeed in giving a horse a horn, it might not be good for the animal. Vershinina questions whether a horse's body could support a long horn. A horn might make it harder for a horse to eat. Horses haven't evolved to deal with a horn's weight as some other animals have. "Rhinos have

MELKOR3D/SHUTTERSTOCK

this awesome horn on their head. But they also have a massive head, and they can eat with it," she notes. "This is because this horn evolved as a part of the body."

There are many other potential problems. Lab-grown unicorns would never have existed as part of an ecosystem. If they entered the wild, we have no clue what would happen and how they would interact with other species, Knoepfler says.

And what if unicorns aren't the sparkly, happy creatures of our fantasies? "What if we did all this work and we have these beautiful perfect unicorns with rainbow manes and these perfect horns, but they're very grumpy?" Knoepfler asks. They could be destructive, he says. They might even turn out to be pests.
— Carolyn Wilke

ANIMALS

A wondrous world of insects, arachnids and their arthropod kin

Beetle. Spider. Centipede. Lobster. Arthropods are everywhere

Arthropods come in almost every shape and color imaginable. And they can be found in diverse environments, from the ocean deep to dry desert to lush rainforest. But all living arthropods have two key characteristics in common: rigid exoskeletons and legs with joints. That last part should come as no surprise. *Arthropod* derives from ancient Greek words meaning "jointed foot."

Arthropod joints work similarly to ours, notes Greg Edgecombe. He works at the Natural History Museum in London, England. This paleobiologist studies arthropods. Many of them have "knee" joints very similar to ours, he says.

Our hard parts — bones — are on the inside, beneath our skin. Arthropods instead put their tough stuff on the outside where it acts as a suit of armor, Edgecombe says. This protects them and helps them live in rough environments, such as underwater and underground.

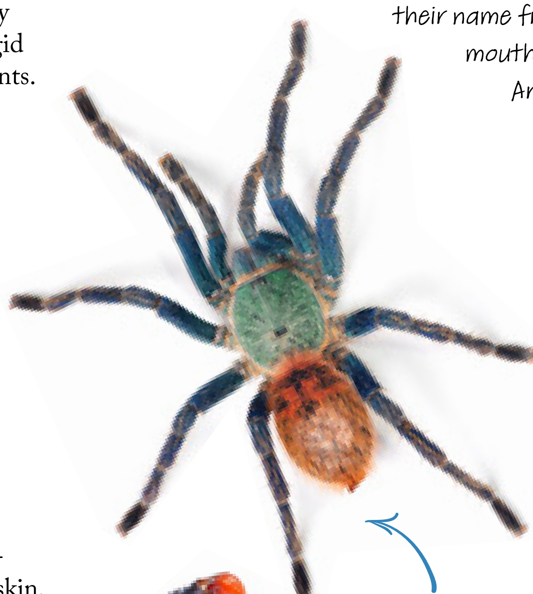
Different species of arthropods have many unique traits, but most fit into four main groups.

— *Curtis Segarra*

Chelicerates

ARACHNIDS, SEA SPIDERS AND HORSESHOE CRABS

Unique features help scientists put arthropods into subgroups. Most arthropods have jaws similar to ours, called mandibles. But unlike us, arthropods chew from side-to-side — unless they are chelicerates. Many of these critters have swapped out jaws for jointed fangs and scissor-like cutters. These animals take their name from those alternative mouthparts, called chelicera. Arachnids, such as spiders and scorpions, are one class with sharp chompers. Some have venom in their chelicera. But you don't have to get too close to those fangs to identify these critters because most arachnids have eight legs.



Greenbottle blue tarantula

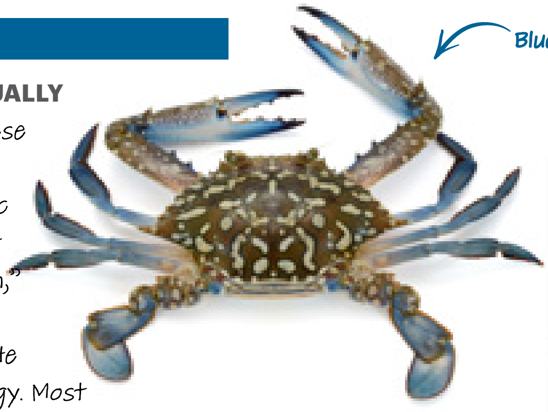
Emperor scorpion

FROM TOP: 2HAPPY AND ALEX STEMMERS/SHUTTERSTOCK

Crustaceans

CRABBY CREATURES OF THE SEA … USUALLY

Crustaceans range in size from the Japanese spider crab, which can grow to nearly four meters (around 12 feet), to tiny, microscopic copepods. "Those guys are really important because they're the basis of the food chain," says Brian Farrell. He's an entomologist at Harvard University in Cambridge, Mass. He works at its Museum of Comparative Zoology. Most crustaceans live in the water, Farrell points out. But woodlice, also called rollie pollies, dwell on land.



Myriapods

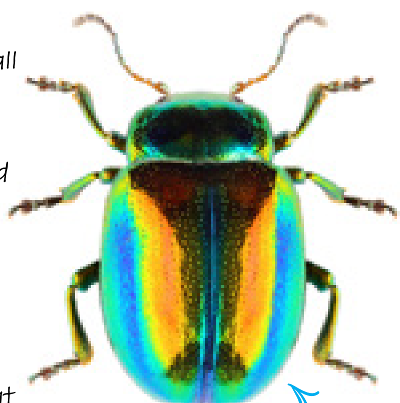
THE MANY-LEGGED ARTHROPODS

Myriapods live on land and most have lots of legs. And although centipedes and millipedes can look similar, there's a key difference. Centipedes are predators, says Farrell. "They have fangs." These fangs are not chelicera. Centipedes instead eat with mandibles, as crustaceans and insects do. But they also have a pair of venomous, fang-like legs. Millipedes, in contrast, are herbivores. Because they eat plants, they don't need to move quickly. So millipedes are much slower than centipedes.

Insects

THE LARGEST GROUP OF ARTHROPODS

There are more species of insects on land than all other arthropods combined, says Kip Will. He's an entomologist at the University of California, Berkeley. Bees fly, beetles crawl like tiny armored tanks and the Australian walking stick has camouflaged itself to look like a leaf mixed with a scorpion. Different as insects can be, pretty much all of them have six legs and the same three body parts — head, thorax and abdomen. "They've just modified each of those in ways that sometimes they look very, very different," Will explains.



FROM TOP: LOTUS IMAGES; MAXIMILLIAN CABINET; ANAT CHANT; LEAW7824; ANTON KOZYREV; AND NYNKE VAN HOLTEN/SHUTTERSTOCK

MATERIALS

Food waste could help builders on Mars

People will have to be resourceful to create Martian dwellings and tools

When people make it to Mars, they'll need somewhere to stay. There aren't many building materials available on the Red Planet. But a compound found in the shells of insects may help. That's the finding of a study in *PLOS One*.

Because Mars is so far away and bringing supplies from Earth so costly, astronauts will need to make a lot of what they'll need. "The problem is that you need to do it in a place that is the opposite of Earth," explains Javier Fernandez, who helped develop the new compound. A materials scientist, he works at the Singapore University of Technology and Design.

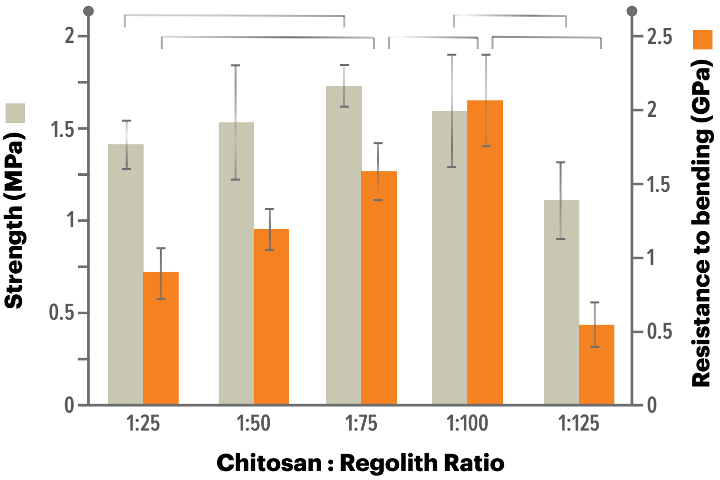
Earth has plenty of building materials. There's abundant stone, wood, metals and more. But on the Red Planet, Fernandez says, "the only thing that you have is the soil, the sand, that covers Mars." Astronauts also will have whatever wastes they create. The new material blends Martian soil and a compound found in fungi and the shells of crustaceans and insects. Called a composite, this material mix could offer one way to use up the discarded shells of insects that may be grown as food on Mars.

To make their composite, the researchers developed a simple process. First, it removes and modifies a compound, called chitin, from shrimp cells. The process also would work for the chitin in insect shells. Then, the scientists mixed that material with regolith. It's a rocky mixture that imitates Martian soil. The composite was similar to concrete and brick in strength and in density (or weight per volume). With a mold to shape their composite, the scientists made a working wrench. They also 3-D printed a small model of a Martian habitat.

The researchers tested different recipes for their building material. Those recipes differed in how much chitin and regolith were used. To determine how well these blends would work for building, the scientists tested the materials' strength and resistance to bending.

Materials that use waste and plentiful resources can help tackle big challenges, Fernandez says. And this composite could make it easier to settle on Mars.
— *Carolyn Wilke*

This Martian figurine and block have been molded from a material that could be used for building on the Red Planet. The material is made of a mock Martian soil with a bit of chitin. Chitin can be found in fungi and the shells of insects and crustaceans.



After a chemical treatment that makes it easier to use, chitin becomes "chitosan." Researchers mixed it with an imitation Martian soil, called "regolith," in varying ratios (plotted on the x-axis). They measured the properties of these mixtures, called composites. Gray bars (strength) show how much stress a composite can take before bending. Orange bars (bending resistance) quantify a composite's resistance to bending.

DATA DIVE

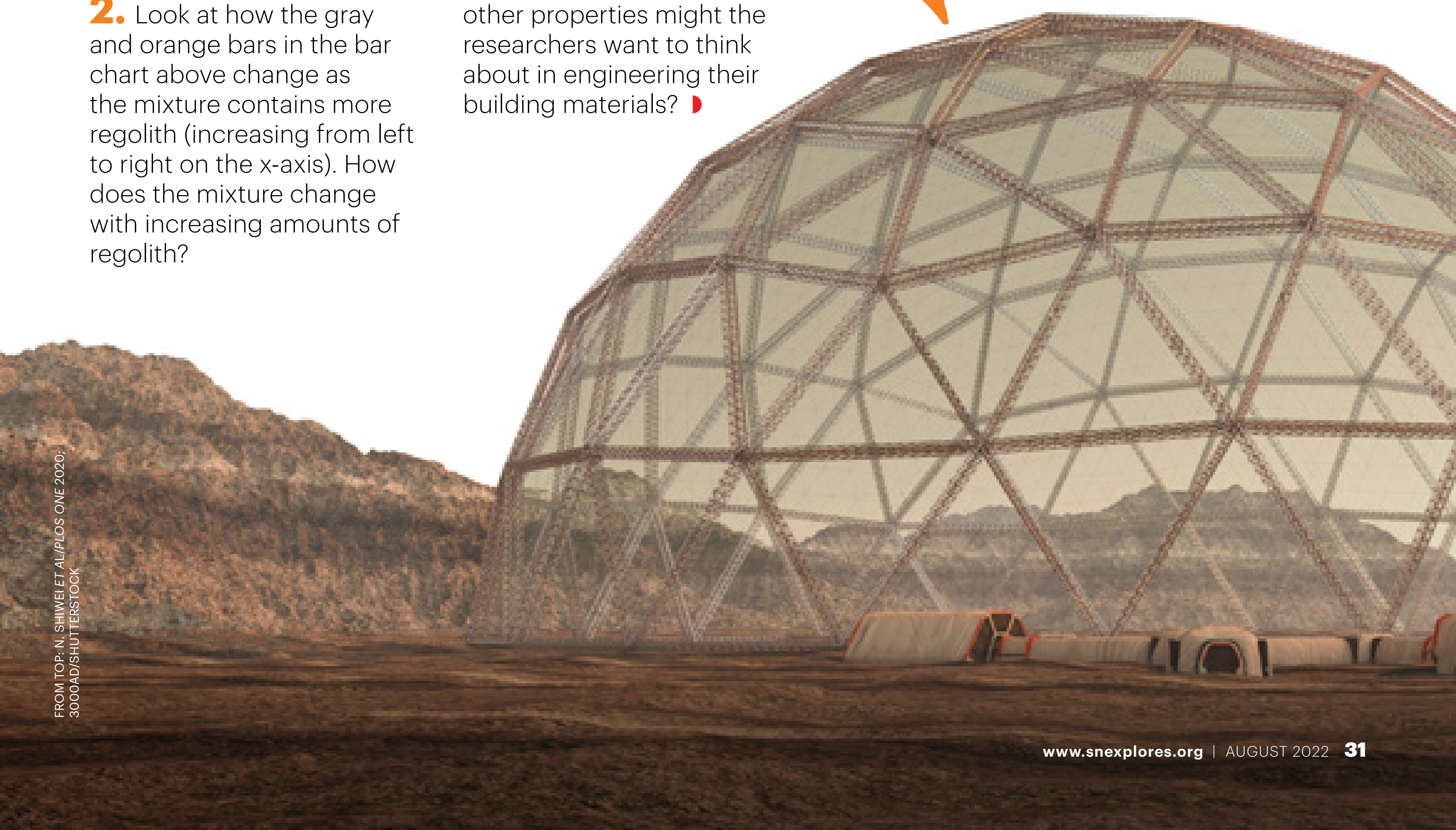
1. The researchers measured the stress a material can take before it bends and its resistance to bending. Why do you think they considered these two qualities when evaluating their composites?

2. Look at how the gray and orange bars in the bar chart above change as the mixture contains more regolith (increasing from left to right on the x-axis). How does the mixture change with increasing amounts of regolith?

3. Which ratios of chitosan to regolith are the best and worst for building? Why?

4. Think about some common materials used to build: stone, brick, concrete and metal. What other properties might the researchers want to think about in engineering their building materials?

Mars will be a tough place to live. It's very cold and windy, and there's not enough oxygen for us to breathe. Plus, traditional building materials are in short supply, so astronauts will have to get creative to build their settlements, such as in this illustration.



FROM TOP: N. SHIWEI *ET AL*/PLOS ONE 2020; 3000AD/SHUTTERSTOCK

ANSWER

Some of these coronal loops may be ghosts

Wrinkles in the sun's outer atmosphere might trick the eye into seeing glowing arches

Hot strands of plasma arch out from the sun's surface. These iconic features are known as coronal loops. But many of the loops we see might not actually be there, scientists report.

Some, they say, might be an illusion created by dense "wrinkles" in a curtain of plasma known as the coronal veil. The scientists base this idea on unexpected structures that emerged in computer programs that simulated the sun's atmosphere. That atmosphere includes the sun's outermost region, known as the corona. Researchers proposed these phantom loops in *The Astrophysical Journal*.

Scientists have begun to develop a better understanding of the sun's complex corona only in the past few years. Researchers have used the loops to measure many of the corona's traits, including its temperature and density. In fact, coronal loops may be key to figuring out why the sun's atmosphere is so much hotter than its surface. Astronomers have also puzzled over why the loops appear to be so orderly when they rise from the sun's turbulent surface.

Solar scientists will now need to figure out a way to tell which coronal loops are real and which are just ghosts. But that could lead to new insights about our starry neighbor.

— *Allison Gasparini*

SOLAR DYNAMICS OBSERVATORY/GSFC/NASA

These loops have formed on the outermost layer of the sun's atmosphere, called the corona. New research shows that not all loops that we see may actually be there.

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

Here's advice from a finalist 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, Gabriela Guerra Sanchez discusses her inspiration, what she enjoyed about her project and how to take the first step with your own science projects.

Q What inspired you to pursue this project?
A "I am really a fan of music," Gabriela says. "I listen to music every day. I don't leave home without my headphones." She started to notice that the type of music she was listening to influenced how she felt about visuals, like artwork or ads. Gabriela wondered, does background music affect how other people see things?

Q What resources helped you complete this project?
A Data collection was difficult for Gabriela because she was an at-home learner. And at home, her cousin was often the only other person around. So Gabriela got a teacher to help. The teacher showed Gabriela's painting to students in a classroom and collected survey data for Gabriela to analyze. "Sometimes, I would come after school once everybody left so it could be just me and the teacher," Gabriela says. Those meetings were helpful for completing her project.

Q What would you tell a kid who wanted to start a science project?
A "Have fun with it," Gabriela says. "Just have fun [with] what you're doing and find a way to help [yourself] during the process too." Gabriela says that her project, for instance, offered her a new way to talk about her emotions with her mother.

2021 Broadcom MASTERS Finalist

Gabriela Guerra Sanchez

Gabriela, 14, is a painter and music lover. So she investigated whether music affects how people see art. Student volunteers listened to happy or sad music while looking at a picture that Gabriela had painted. Then, the volunteers reported whether the song type changed how they viewed the painting. About 57 percent of the time, the answer was yes. Gabriela goes to Tennyson Middle School in Waco, Texas.

ILLUSTRATION BY JOANNA WENDEL