ScienceNews Explores
March 2023

THE JUNKYARD IN SPACE

AMERICAN DEMOCRACY — OLDER THAN THE U.S.A.

INVESTIGATE THE LAYERS OF OUR ATMOSHPERE
P28

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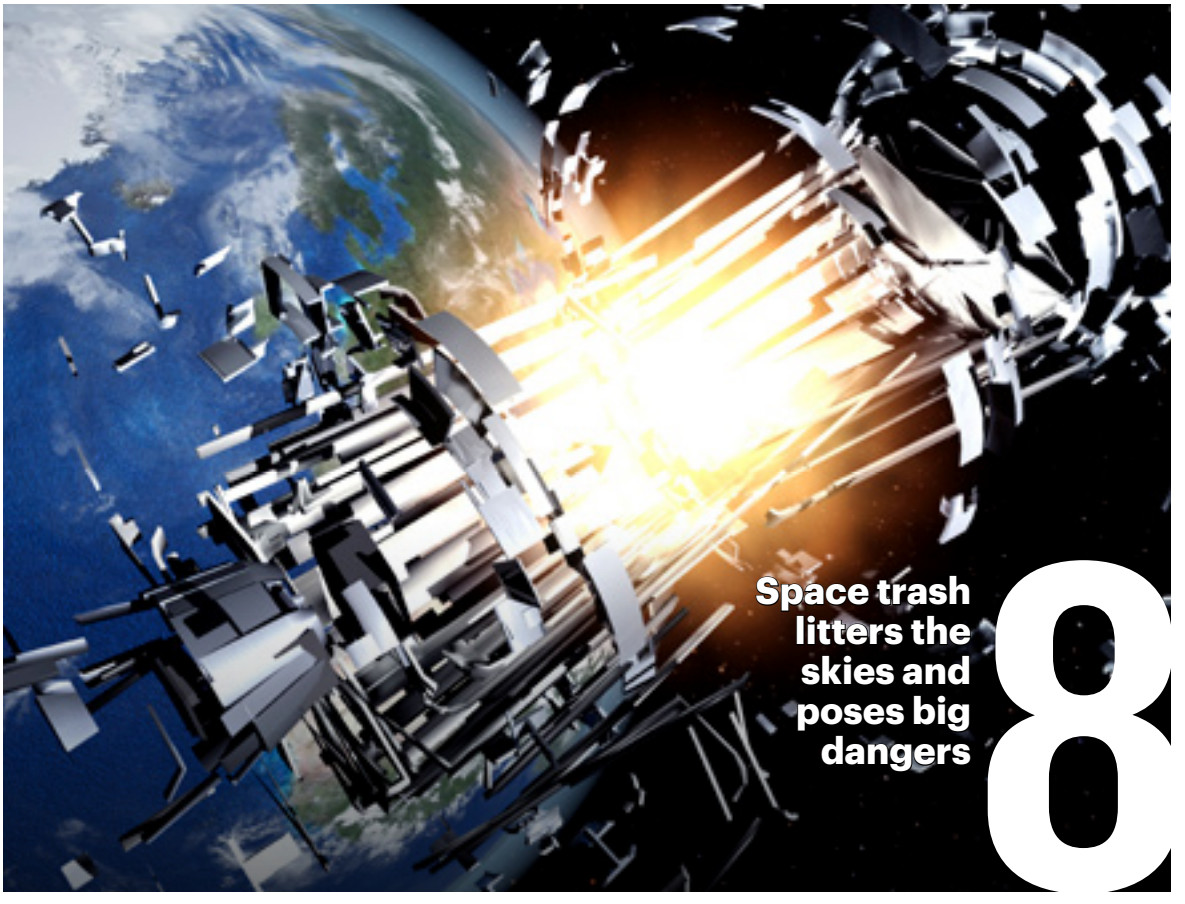

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Q How does salt preserve meat?

— *Corin C.*

A Salt prevents meat from spoiling by drying it out. This makes it hard for harmful microbes to grow. Pathogens such as bacteria and mold need water to help give them shape and carry out important life functions. But salt-curing, or preserving meat or fish with salt, doesn't just make meat too dry for germs to live on. It can suck the water straight out of microbes through a process called osmosis. Without this water, the microbes die or are left unable to reproduce. Salt-curing has been done for thousands of years. It is still used today to preserve hams, hot dogs, bacon and corned beef.

Q How long will it be for all the oxygen on Earth to run out?

— *Bright W.*

A About 1 billion years from now, Earth's atmosphere will contain almost no oxygen, researchers estimated in *Nature Geoscience* in 2021. As the sun ages, it will become hotter and give off more energy. That blistering radiation will break down the carbon dioxide in Earth's atmosphere. Plants and other life forms that need carbon dioxide to survive will die off. And without those organisms pumping oxygen into the air through photosynthesis, oxygen levels in Earth's atmosphere will quickly plummet.

Q Why don't you build immunity against bacterial infections like you do for viral infections?

— *Amber W.*

A The body can build immunity, or learn to fight off, both bacteria and viruses. Building immunity to such infectious disease involves the adaptive immune system. The adaptive immune system uses special cells to learn about and destroy new germs, or pathogens. These germs include not only viruses and bacteria but parasites and fungi as well. Vaccines help teach our immune systems to recognize potentially dangerous infections. "We do have a lot of vaccines that target bacteria, just like we have vaccines that target viruses," says Erin Garcia de Jesús. She's a microbiologist who has studied how viruses evolve with our immune systems and is now a staff writer at *Science News*. Garcia de Jesús says that while our immune systems use different ways to detect viruses and bacteria, they all lead to the same result: helping the body remember a certain germ it's fought off before.

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*

ARTHUR VILLATOR/SHUTTERSTOCK

ANIMALS

The top of an elephant's trunk stretches more than the bottom

This may help the animals get a grip

On a sunny Georgia day at Zoo Atlanta in 2020, Kelly the African bush elephant reached for a snack. Her action revealed something strange. The skin on the top of her trunk stretched more than the skin underneath. High-speed cameras caught this on video.

"But that didn't make any sense," says Andrew Schulz. He's a mechanical engineer now at the Max Planck Institute for Intelligent Systems in Stuttgart, Germany. Scientists had assumed that the skin on elephant trunks largely stretches the same way all over. Schulz sent data on Kelly and a male elephant, Msholo, to colleagues for a second opinion. "Oh yeah, your data is wrong," he remembers them saying.

But follow-up experiments would show otherwise. Those studies involved stretching pieces of elephant skin in the lab. And they showed the same strange phenomenon. The skin on the top and bottom of the trunk were totally different. "Talk about a great day as a scientist!" Schulz says. "That's when we really started to believe that what we were saying was true."

The tough upper skin on an elephant's trunk crumples into creases like the folded skin of a shar-pei puppy. The skin on the underside, however, is only lightly wrinkled. Schulz and his colleagues showed that the bunched upper skin is about 15 percent stretchier than the lower skin.

The team shared its findings in the *Proceedings of the National Academy of Sciences*.

That extra stretch up top probably helps elephants reach down and wrap their trunks around a log or a tree branch, Schulz says. Meanwhile, the less stretchy skin underneath gives the animals a good grip.

— *Meghan Rosen*

HUMANS

Eight billion people now live on Earth — a new record*

Experts predict the global population will peak in the 2080s, reaching some 10.4 billion individuals.

*As of November 15, 2022

ELEPHANT: TRISTAN TAN/SHUTTERSTOCK; GLOBE ILLUSTRATION: AWSOME DESIGN STUDIO/SHUTTERSTOCK

TECH

This leaping robot can out-jump anything

Clever engineering lets it reach lofty heights

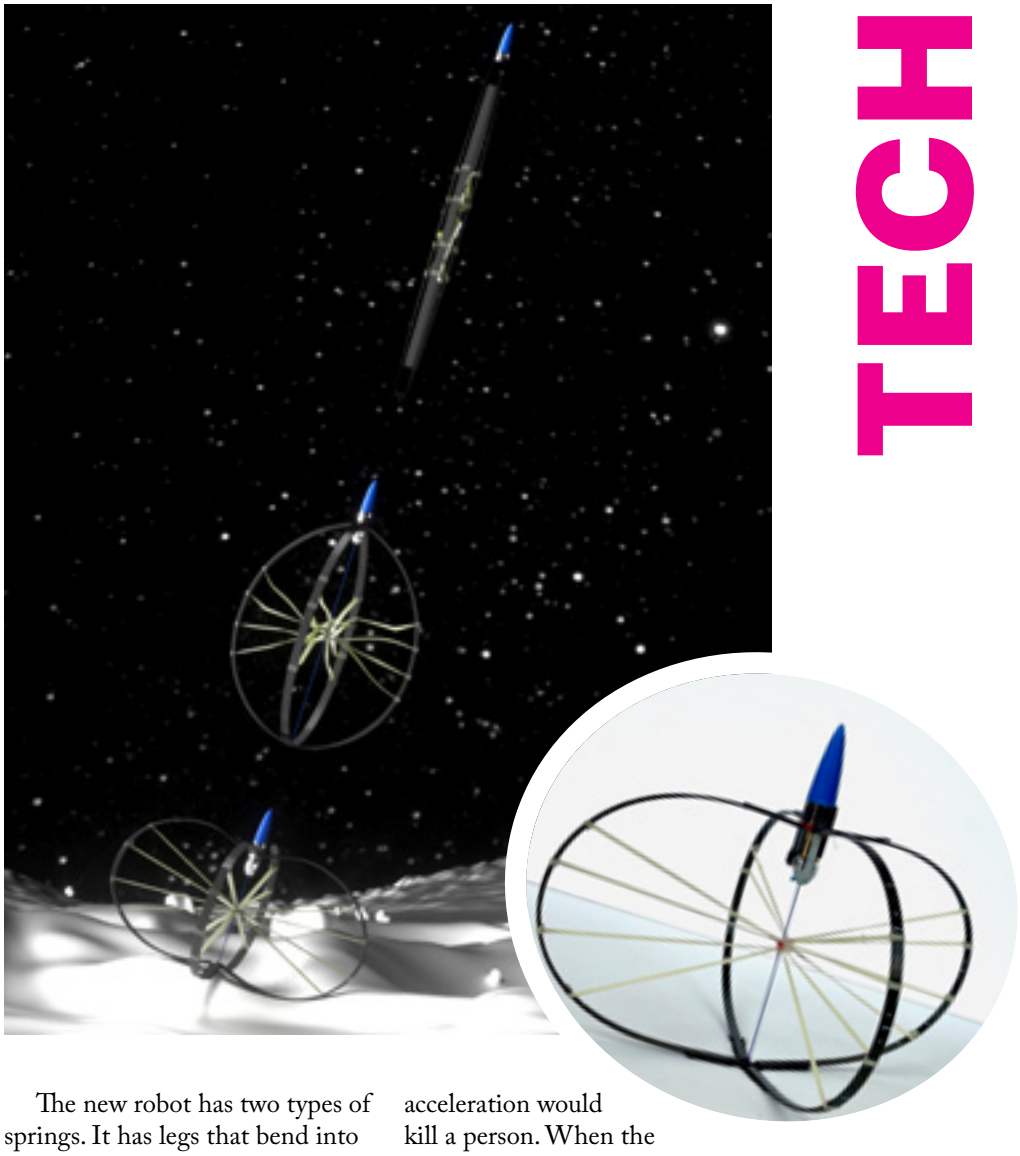
What's the size of a soccer ball but can jump a distance spanning from the Statue of Liberty's feet to her eye level? A new record-setting robot. It soars three times higher than any other jumping robot that its builders know of. It also out-jumps any living creature.

"It is truly amazing to stand near it and see it launch itself skyward faster than you can even see," says Elliot Hawkes.

A mechanical engineer at the University of California, Santa Barbara, Hawkes has been working on this robot for seven years. It started out as a "stick with weights and rubber bands," he recalls. No one would have called it a robot at that point because it had no motors or electronic parts. But, he notes, it got him and his colleagues thinking, "just how high could we go?"

After years of work, the robot has reached heights of 30 meters (100 feet), Hawkes and colleagues reported in *Nature*.

The researchers studied how animals jump. They looked into leaping frogs, spiders, kangaroo rats, squirrels, lizards, dogs and more. But Hawkes' group didn't want to copy any of these animals. Instead, the team learned what features set the limits for animal jumpers. Then, the group found ways around those limits.



The new robot has two types of springs. It has legs that bend into a hoop shape. As these legs bend, rubber bands connected to them also stretch. By the time the robot is ready to jump, it has a squat, round shape. When the latch releases, the legs and rubber bands all snap back into a narrow shape similar to a model rocket. That's not an accident: This shape will easily cut through the air.

As the springs snap, the robot shoots skyward. In just 9 thousandths of a second, it can go from sitting still to shooting upwards at nearly 100 kilometers (60 miles) per hour, says Hawkes. That amount of sudden acceleration would kill a person. When the robot lands, it can now position itself for the next jump.

Hawkes' team is working to add steering to its robot. These researchers hope to send their robot to the moon, so they also want to find a way for it to collect samples. A jumper can go places a robot with wheels can't. "[This type of robot] could leap into the bottom of a crater, take samples and return to a wheeled rover," points out Hawkes. His team is already working with NASA. They hope to turn their robot into a space explorer.

— *Kathryn Hulick*

Powered by rubber bands stretched between its hoop-like legs (inset), this robot is poised to snap into a streamlined shape and fly nearly as high as the Statue of Liberty's head.

BRIAN LONG, AMY HAO, CHRIS KEELEY AND ELLIOT HAWKES

GENETICS

Some kids' rock-star hair comes naturally

Uncombable hair syndrome could be genetic

In 2016, Regina Betz's inbox was flooded with frizzy-hair emails.

Betz is a human geneticist in Germany at University Hospital Bonn. Her team had just linked three genes to a striking hair disorder. People born with the altered genes have a headful of fluffy hair that won't lie flat. This "uncombable hair syndrome" causes dry, shiny hair that looks a bit like dandelion fluff. As of early 2016, only about 100 cases had ever been reported.

But after Betz's study came out, people from around the world started emailing the researchers, saying they or their children had hair like this. The group knew they had to investigate. So, Betz told the emailers to send in samples of blood and other substances for DNA extraction.

The team analyzed DNA from 107 people with uncombable hair syndrome. Variations in just one gene accounted for 71 percent of the cases. The other two genes Betz's group had studied before accounted another 4 percent. But the other 25 percent of cases remain unexplained. These findings appeared in *JAMA Dermatology*.

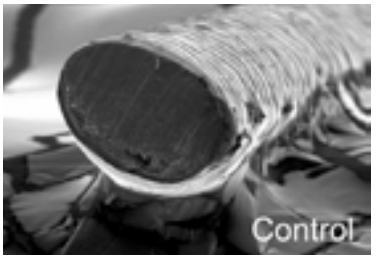
The gene responsible for most cases of the disorder is *PADI3*. It directs certain cells to make an enzyme involved in forming hair shafts. Mutations in the gene can disrupt that process, causing changes in the hair's structure. Hair shafts in people with the syndrome can have grooves that extend along each strand.

The hair looks somewhat like a crinkled-up straw, says Gillian Westgate. She's a biologist who studies hair at the University of Bradford in England but was not involved in the study.

The new findings could help doctors better diagnose uncombable hair syndrome. It isn't typically tied to health problems. And hair manageability often improves with age. But a genetic cause might calm parents who worry that their child's unusual hair is a sign of some bigger problem, Westgate says.

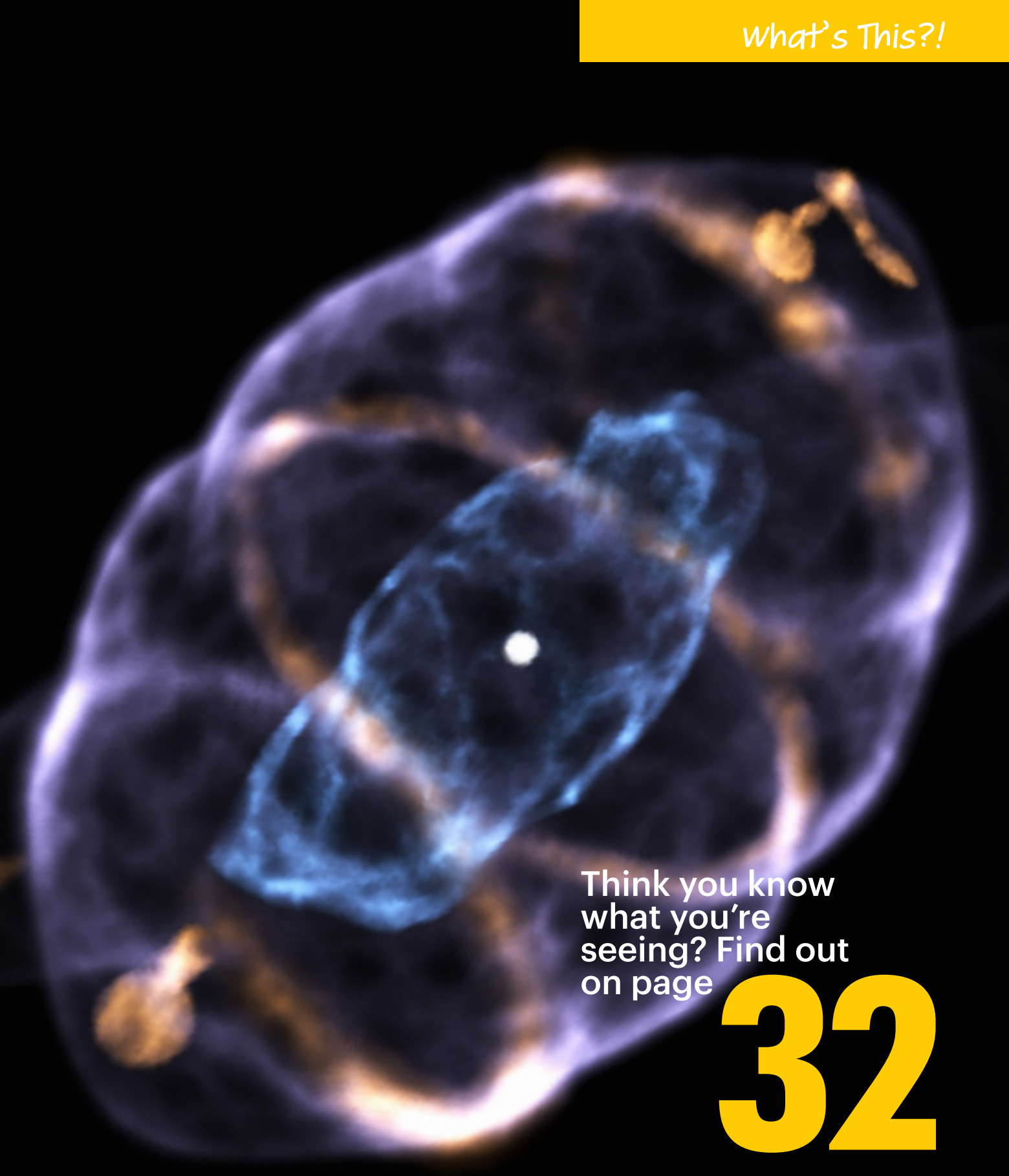
— *Meghan Rosen*

These kids' "uncombable" hair is caused by a genetic change that affects the shape of the hair shaft.



Seen in cross-section, this hair shaft from a girl with uncombable hair syndrome, or UHS, shows a groove along one side (top). Typically, a hair shaft is not grooved (bottom).

F.B. BASMANAV *ET AL./AMERICAN JOURNAL OF HUMAN GENETICS* 2016



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

THE JUNKYARD IN SPACE

Space trash could kill satellites, space stations — and astronauts >>

Seven astronauts aboard the International Space Station (ISS) woke to unwelcome news on the morning of November 15, 2021. NASA, the U.S. space agency, was worried. The station was zooming directly into a suddenly dangerous area littered with trash. A collision could damage the spacecraft. And that could threaten the safety of everyone inside. NASA warned the astronauts to take cover.

By **Stephen Ornes**

JOHAN63/ISTOCK/GETTY

The astronauts closed hatches between sections of the ISS and climbed into escape ships. Then they waited. Fortunately, they transited the area without a mishap. All clear.

Soon, the source of all that debris would be revealed. Earlier that day, the Russian government had launched a rocket to blow up a big satellite. The satellite hadn't worked since the 1980s. This launch was testing a new missile technology.

While the missile did its job, the explosion created a "debris field." The shattered satellite showered space with some 1,500 pieces of trash big enough to see and track by telescope. It also produced hundreds of thousands of smaller pieces. Even a small piece could have ripped a hole through the exterior of the ISS. And the threat from this one satellite may persist for years, if not decades.

Space junk races around the planet at up to 8 kilometers (5 miles) per second. The speed of an impact can reach 15 kilometers per second, or 10 times as fast as a bullet. NASA scientists estimate that a marble-sized piece could smash into another object with as much force as a bowling ball traveling nearly 500 kilometers (300 miles) per hour.

The ISS passes through the same spot about every 93 minutes as it circles the planet. On that mid-November day, the scientists watching the debris feared an impact. But this wasn't the first, or last, time space junk had threatened a mission.

Space junk is a growing menace. Indeed, this trash "is now the number one concern of people who study space-traffic management," says Pat Seitzer. He's an astronomer at the University of Michigan in Ann Arbor. He uses telescopes and computers to study orbital debris.

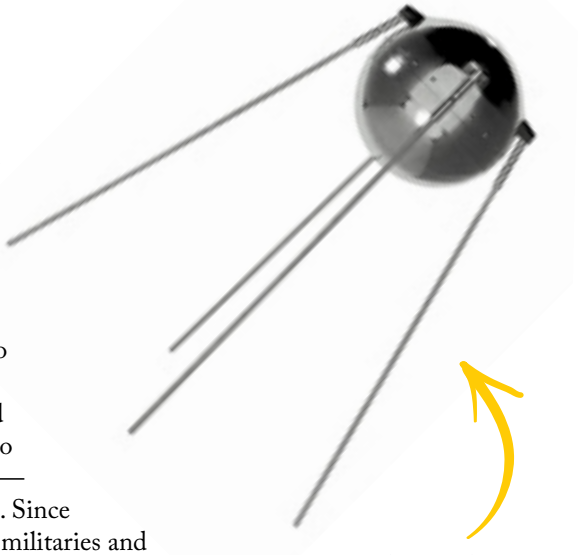
"We created this risk ourselves," says Don Pollacco. Fortunately, he adds, "there's stuff we can do to stop it from being a risk." An astronomer at the University of Warwick in England, Pollacco runs the new Center for Space Domain Awareness. Scientists there focus on the environment in outer space that's closest to Earth. The debris problem, he warns, threatens the future of space traffic.

"If you don't deal with it, sooner or later it will catch up," he says. "You can't ignore it forever."

Tracking the trash

The European Space Agency, or ESA, estimates that about 36,500 pieces of debris larger than 10 centimeters (4 inches) now orbit Earth. There are about a million pieces between 1 and 10 centimeters in diameter. More than 300 million tinier pieces can be found in orbit, as well. Scientists use radar to track the biggest pieces. The smallest? They're too small to measure precisely.

Soviets launched the first satellite into space — Sputnik I — on October 4, 1957. Since then, governments, militaries and companies around the world have sent up tens of thousands more. In 2020 alone, more than 1,200 new satellites entered space — more than any previous year. Of more than 15,000 satellites sent into space, the ESA estimates that about 9,800 are still in orbit. Some 7,200 still work.



The beach ball-sized Sputnik I, launched on October 4, 1957, was the world's first artificial satellite.

Space debris has been growing for decades. Most of it resides in what scientists call a low-Earth orbit, or LEO. That means it orbits about 1,000 kilometers (620 miles) above Earth's surface. The ISS is also in low-Earth orbit.

Space debris includes big objects, such as pieces of rockets used to lift satellites into space. It also includes things such as nose cones and payload covers from those rockets. Then there are satellites that don't work anymore — or failed from the start.

One is Envisat, a satellite ESA launched in 2002. It died 10 years into its mission of monitoring Earth's climate. Its carcass will likely remain a threat for the next 150 years.

"It's a big car crash in the sky just waiting to happen," worries Pollacco.

A few big smashups have produced much of the known space debris. In 2007, China launched a missile to blow up one of its old weather satellites. The blast produced more than 3,500 pieces of large debris, as well as giant clouds of small pieces. In 2009, a defunct Russian satellite collided with a communications satellite owned by a U.S. company. This smashup also produced large clouds of debris.

The U.S. Department of Defense runs a Space Surveillance Network. It uses radar and other telescopes to track larger pieces of debris. This network now tracks more than 25,000 big chunks, according to NASA. When the chance that one of those chunks will collide with the ISS is greater than 1 in 10,000, the space station will move out of the way. Private companies have also started tracking debris in recent years.

SPUTNIK: WOVERWOLF/SHUTTERSTOCK; ILLUSTRATION OF GLOVE: JOSEPPERIANES/SHUTTERSTOCK; SPACE JUNK: NASA ODPO

BUSY SKIES

People have been sending rockets, satellites and more into space for more than 65 years, making the skies more and more crowded.

NUMBER OF SATELLITES

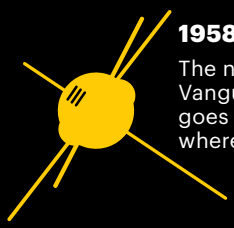
15,000+
Satellites sent to space

~9,800
Satellites still in orbit

~7,200
Satellites that still work

These dots represent pieces of orbital debris — all the manmade bits in Earth's orbit that aren't functional satellites.

INTERESTING SPACE JUNK OVER THE YEARS



1958
The now-defunct Vanguard 1 satellite goes into space, where it still remains

1960s
NASA missions start dumping urine directly into space — a practice that ends in the late 2000s

1965
Astronaut Ed White makes the first spacewalk and loses a glove

1997
Star Trek creator Gene Roddenberry's ashes spend time on a rocket in space

2008
Astronaut Heidemarie Stefanyshyn-Piper mislays a bag full of tools

2012
The Envisat satellite dies 10 years into its mission and becomes trash

2021
Russia blows up a defunct satellite, creating a field of debris in orbit

Space trash can be quite diverse

In 1965, astronaut Ed White lost a glove during a spacewalk. Other astronauts have lost screwdrivers and other tools. Pieces of exploded batteries or fuel tanks — some with fuel still in them — are whizzing in orbit. So are flecks of peeled paint, nuts and bolts. At the speed they're moving, all are dangerous.

Scientists can't see pieces of debris as small as bolts, nuts and paint flecks. Instead, they study the scratches and dents these leave behind on existing satellites. During an inspection in May 2021, astronauts found that a robotic arm of the ISS had been damaged by space debris. The arm still works, but it has a hole about 0.5 centimeter (0.2 inch) across.

The Hubble Space Telescope has provided a wealth of data from similar encounters with debris. Astronauts have visited and repaired the telescope multiple times in the last three decades. Each time they have found hundreds of tiny craters in the solar panels. These were left by collisions with small pieces of debris. Scientists have been logging the pattern and incidence of these impacts. Those data will help the scientists build computer models that predict not only how many tiny pieces remain in orbit, but also where they are.

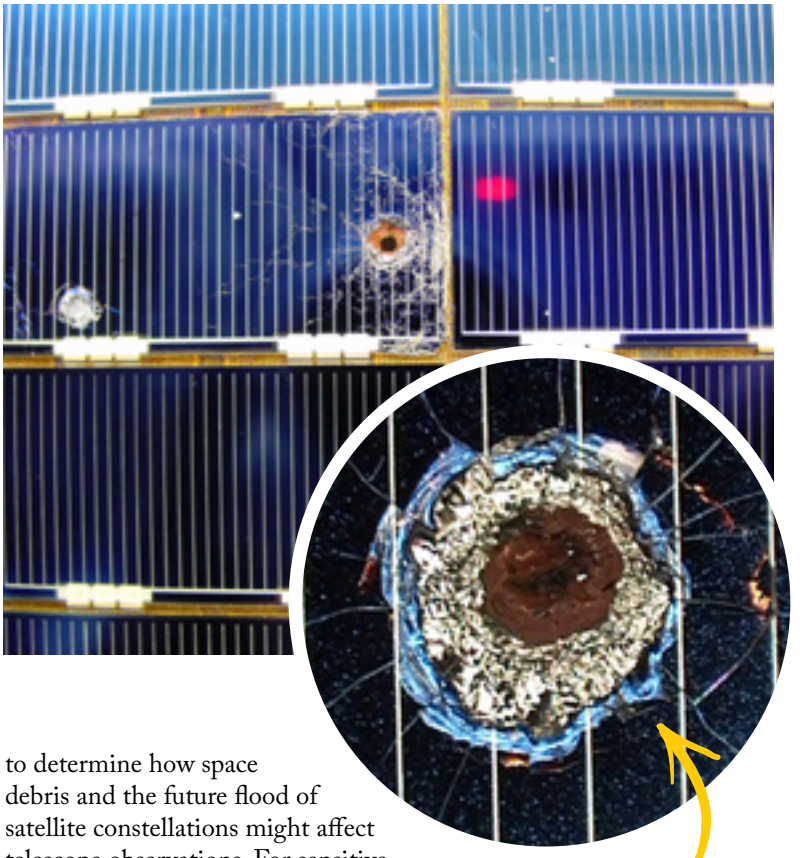
Studies of space debris confirm the threat is growing, says Seitzer, in Michigan. "It's a real problem." But he worries that people aren't learning the right lessons. So the problem continues to grow. And space is only getting more crowded. A communications company called OneWeb, for instance, has announced plans to launch a constellation of tens of thousands of satellites.

When a company learns that its satellite is going to fly close to a piece of space junk, it can redirect its satellite a bit. But as the number of satellites in the sky mushrooms, so will the threat from collisions with debris, says Pollacco. "It's a cumulative thing," he says. "The less we do about it, the worse it gets."

Beware the cascades

Astronomers worry that as space litter grows, these fragments also will interfere with telescope observations. "If you get enough of these collisions, you could brighten the night sky," says Connie Walker. She's an astronomer at the National Science Foundation's NOIR Lab, in Tucson, Ariz.

She is concerned that space debris and satellites could limit the scientific study of space. That junk could reflect so much light that it hides the light of distant stars. Right now, scientists are trying to determine how space debris and the future flood of satellite constellations might affect telescope observations. For sensitive observatories, Walker says, "we need a sky that's pretty clear and not highly light-polluted."



A marble-sized piece of debris could hit another object with as much force as a bowling ball traveling at about 500 kilometers (300 miles) per hour.

Another less obvious risk is one that experts call the "Kessler Syndrome." In 1978, NASA astronomer Donald Kessler looked at data on space debris and made an ominous prediction. Eventually, he said, LEO would accumulate so much space junk that it could trigger a cascade. The fragments from one collision would cause other collisions, he projected. Debris from those collisions would then cause more. And more, and more. This became known as the Kessler Syndrome.

"We're not there yet," says Seitzer. But unless private companies, military operations and spacefaring governments take the problem seriously, he says, such a cascade could happen. "Even if we add nothing else, more collisions of existing things in orbit will create more debris."

To the graveyard orbit!

Some experts worry that people won't take the problem seriously until tragedy strikes.

"Most people haven't had an issue with a satellite problem," observes science historian Lisa Ruth Rand. She works at the California Institute of Technology in Pasadena. "If we were to lose a satellite that the defense uses, or if something falls from space, that's when people get terrified. That's when space junk is a problem."

Solar panels on the Hubble Space Telescope (above) had to be replaced after almost a decade in space left them pockmarked with small impact craters caused by collisions with bits of space junk. ESA

DAVID DUCROS/SCIENCE PHOTO LIBRARY

Some scientists worry that one space collision (above) could create more fragments of junk that set off a series of collisions with other satellites. This is known as Kessler Syndrome.

Yet make no mistake, she says, space debris is already an environmental hazard. And she's not the first to point this out. Scientists have warned about the dangers of polluting near-Earth space since the 1960s.

There are also companies and scientists working on ideas for cleaning up the mess. But they will need different strategies depending on which part of space they're cleaning, says Walker, the NSF astronomer in Tucson.

"The higher you go, the longer it takes" for a satellite to de-orbit, she explains. Big pieces in LEO could be redirected back toward the planet, to burn up in the atmosphere.

The Japanese company Astroscale has designed spacecraft that will magnetically "grab" space junk and drag it to a lower orbit, from where it would then fall and burn up in the atmosphere. The company launched a pair of the satellites into space to test the technology in March 2021.

"When it comes to orbital debris, there are a variety of approaches on how to handle these things," says Tom McCarthy. He's a robotics expert at Motiv Space Systems in Pasadena, Calif. McCarthy has been developing spacecraft that can fix and recycle old satellites. Such technology could help extend the working life of those satellites, he says.

Space junk farther out may require a different strategy. Big pieces in a geostationary orbit — about 36,000 kilometers (22,000 miles) up — could be sent to a "graveyard orbit." They would be propelled an additional 300 kilometers (190 miles) away from Earth, where they would remain, far from where they could do any major damage.

"A satellite could dock or connect with a geostationary satellite and then take it to the disposal orbit and release it," says McCarthy.

Other experts say that plans for removing satellites from orbit need to be built into a craft's design. An international committee with members from space agencies around the world recommends that all new satellites have the ability to de-orbit themselves within five years after their missions. Some satellites are close enough to do that naturally. Others aren't.

Pollacco says satellite designers need to address the space debris issue well before liftoff. But right now, he says, the operators of the satellites don't see the problem. "It's in everybody's interest for this stuff to be cleaned up," he says. "If it isn't, it will become all of our problem."

Read More

50 Things to Know About the International Space Station
—by John A. Read

Think you can handle a ride on the "vomit comet," the airplane once used to train astronauts for weightlessness? See what it takes to be an astronaut in this fun, photo-packed book about the ISS.

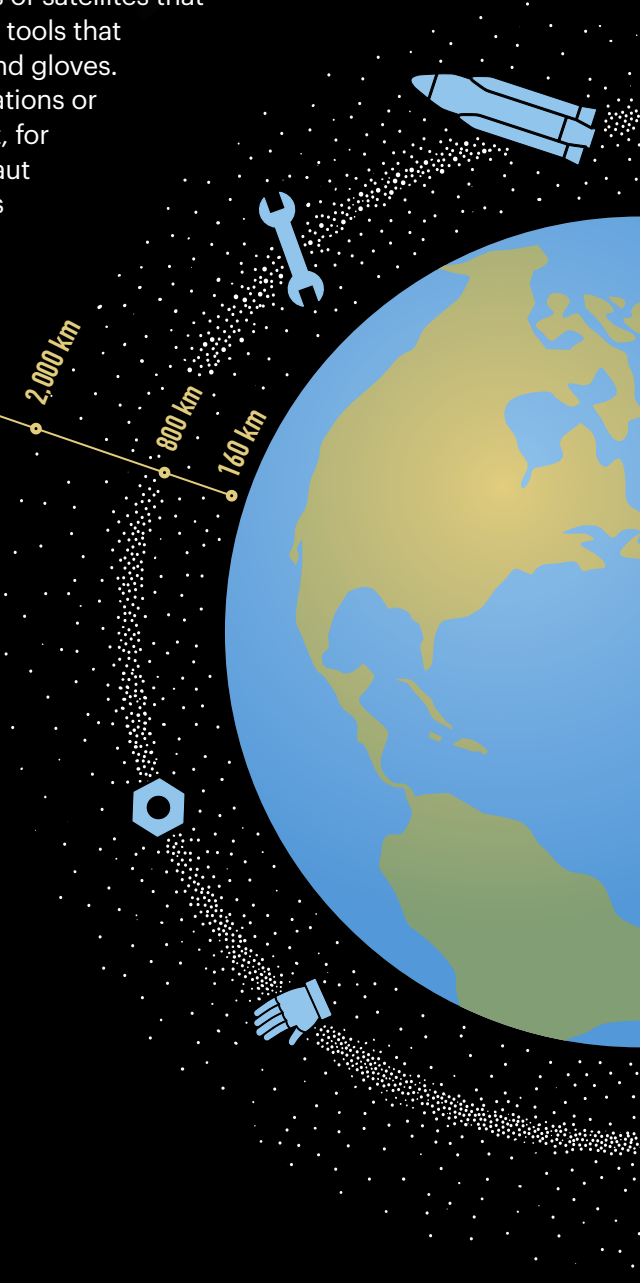
SPACE JUNK

The big mess around our planet

Call it space trash, litter or debris, human-made junk drifting out in space is a growing problem. For more than 65 years, people have sent satellites into orbit around Earth. More than half of those satellites are still there, but many no longer work. They just contribute to a massive space traffic jam in low-Earth orbit. That traffic jam also contains pieces of rockets that were used to lift the satellites into space, as well as remains of satellites that smashed into each other or broke apart. There are even flyaway tools that astronauts have lost during spacewalks, such as screwdrivers and gloves. When small bits of this debris strike working satellites, space stations or spacefarers, it can prove catastrophic. A tiny hole in a spacesuit, for instance, can cause the suit to depressurize, putting the astronaut at risk of injury. Larger collisions can create thousands of pieces of new debris, making the space junk problem bigger and bigger with every satellite smashup.

Where is it found?

Most active satellites are orbiting in LEO (low-Earth orbit), 160-2,000 kilometer altitude, with the greatest concentration of debris between 800 and 850 km.



How big is it? How much is there?

There are currently more than 20,000 large trackable space debris orbiting Earth, along with an estimated hundreds of millions of objects too small to track.

36,500+ OBJECTS — **10** centimeter / size of a softball

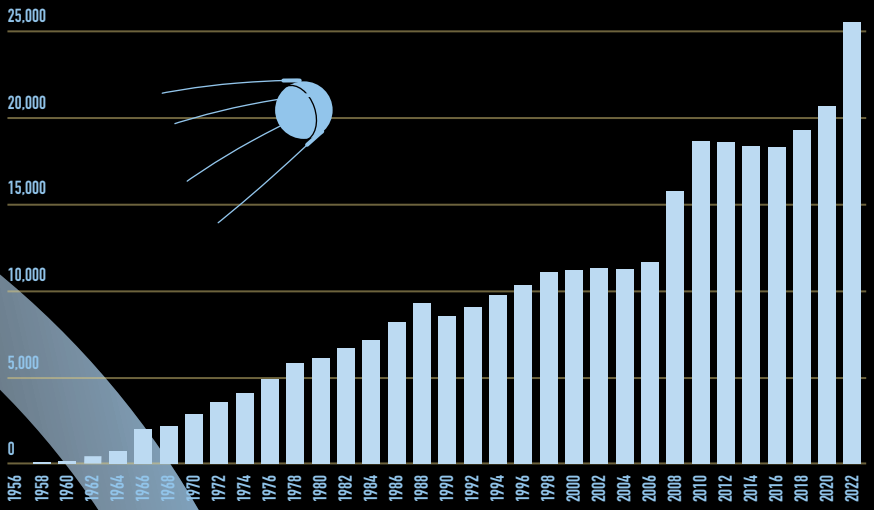
1,000,000+ OBJECTS — **1** cm / size of a pea

130,000,000 OBJECTS — **1** mm to **1** cm

Sources: ESA, FCC, GAO, NASA

How long has this been happening?

The total number of trackable objects in orbit by year



How fast does the trash move?

8 kilometers (5 miles) per second

Impacts can reach 15 km/s (9.3 mi/s), which is more than 10 times as fast as a bullet.

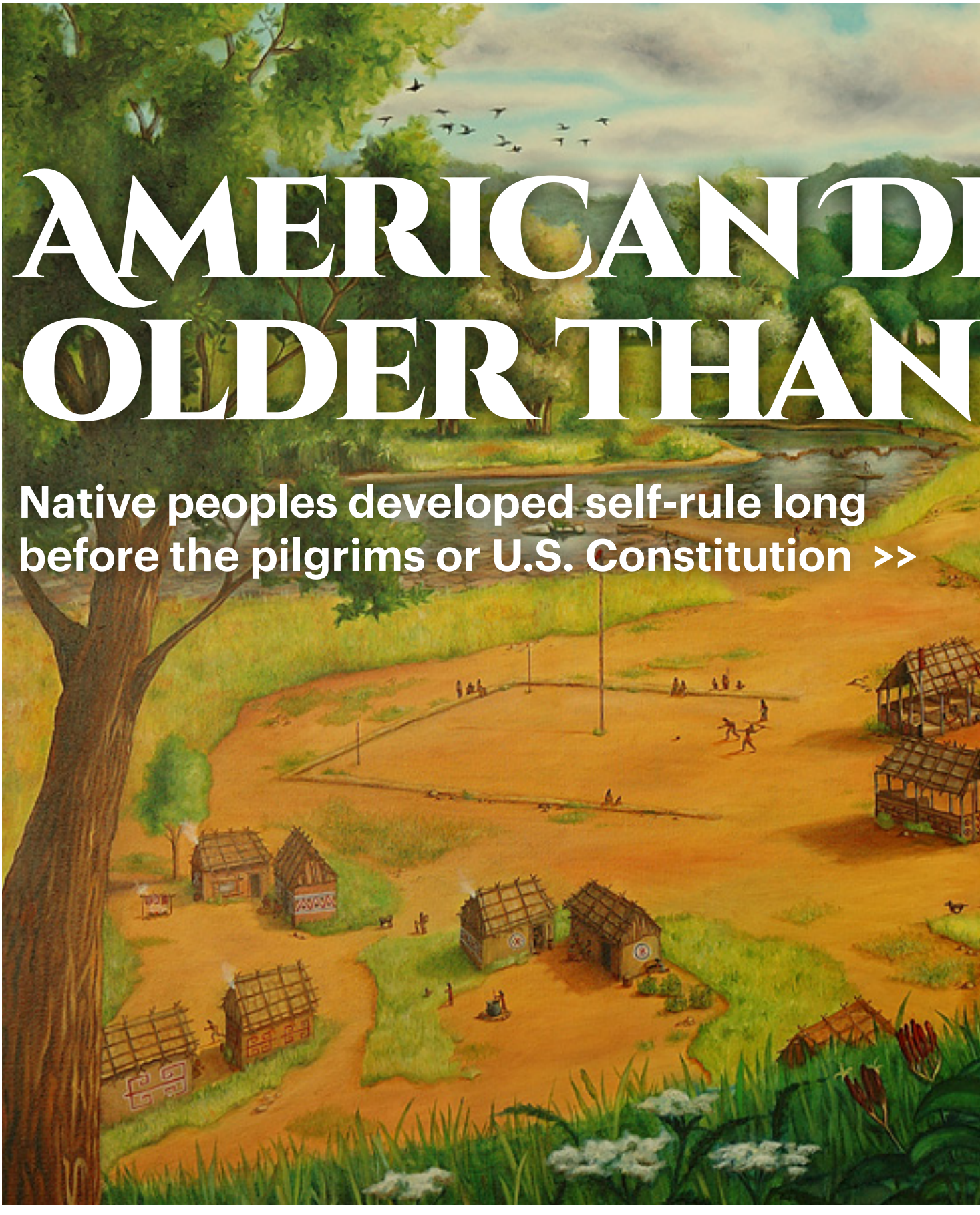
What's at risk?

- Satellites
- International Space Station
- Astronauts

How can we get rid of this junk?

- Fix and recycle old satellites
- Grab space trash in low-Earth orbit and push it into a lower orbit around Earth, where it will burn up in the atmosphere
- Push space debris in higher orbit farther away from Earth, into a "graveyard orbit" where it poses less danger
- Require that satellites have de-orbiting plans that bring spacecraft back to Earth (or burn them up) at the end of their lives

ILLUSTRATION BY STEVE MCCRACKEN

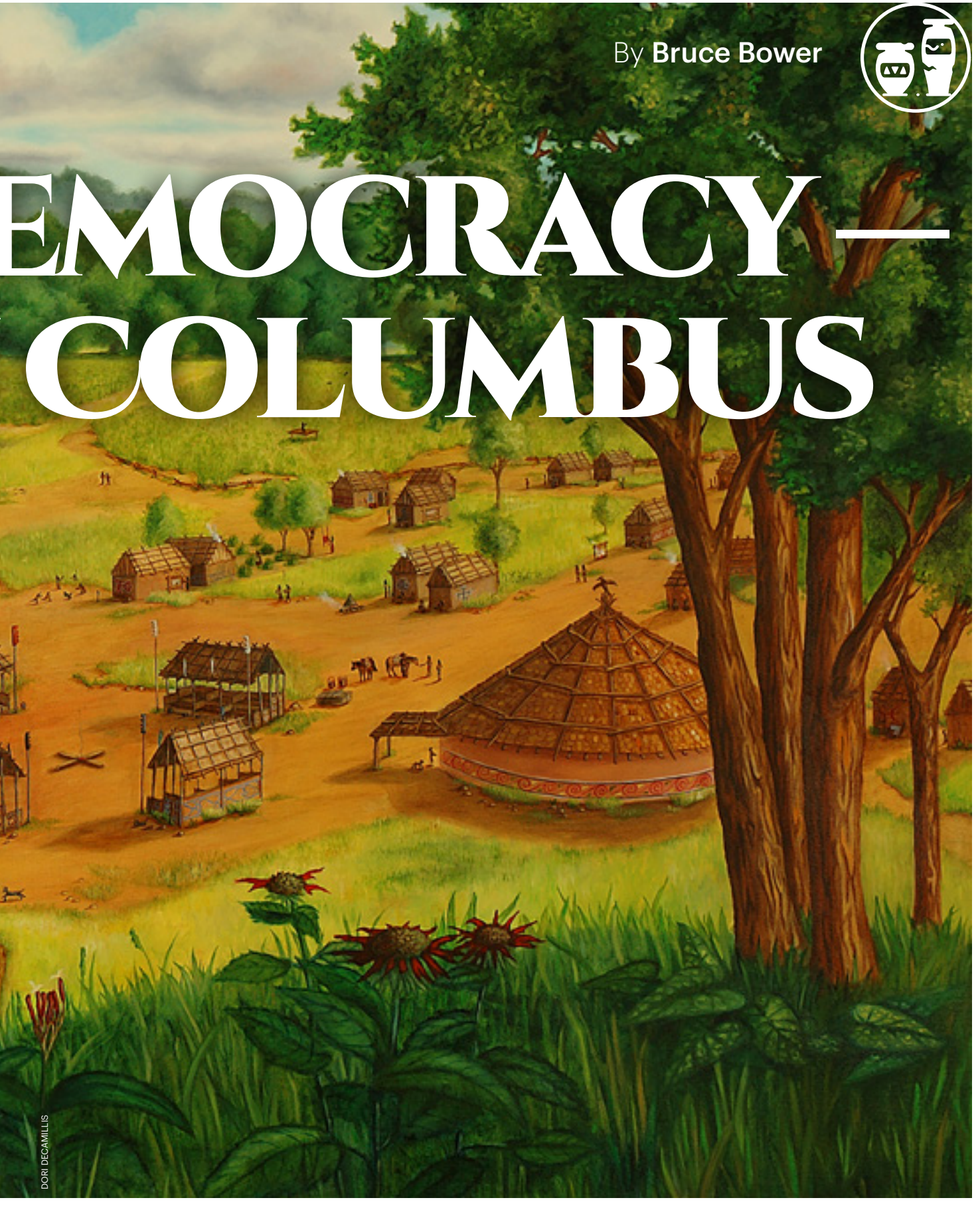


AMERICAN DI
OLDER THAN

Native peoples developed self-rule long before the pilgrims or U.S. Constitution >>

By **Bruce Bower**

EMOCRACY— COLUMBUS



DORI DEGAMILLIS

It's a sunny summer day in Georgia. Boats pull water-skiers across Lake Oconee. This reservoir is found east of Atlanta. For those without a need for speed, fishing beckons. But hidden beneath those waters is something special. It's the remains of a people who practiced democracy since around 500 A.D. That's some 1,000 years before Christopher Columbus "discovered" North America. And it's almost 1,300 years before the United States' Founding Fathers set up a Constitution and way of governing.

With the building of a nearby dam in 1979, the reservoir's waters flooded the valley. Those waters now partly cover remnants of a 1,500-year-old plaza. An ancient community built flat-topped earthen mounds here. At least three large, round buildings had bordered the plaza. Such structures have been linked to communities that governed themselves and made decisions as a group. It was an early form of democracy. And signs of this social structure have shown up at ancient sites throughout southeastern U.S. sites. Some date to nearly 1,000 years ago.

The site beneath the reservoir is now known as Cold Springs. Artifacts were found there before the valley was flooded. Now, research on those artifacts pushes back the origin of democratic governing in the Americas by several centuries. The research was led by Victor Thompson. He's an archaeologist at the University of Georgia in Athens. His team shared its findings in *American Antiquity*.

Such research offers evidence that democracy wasn't purely a European invention. Similar group governing emerged in many parts of the world. And that includes Native American societies in what's now Canada, the United States and Mexico.

This comes as no surprise to American Indigenous groups. Native peoples in the Americas have been trying to convey this for centuries, says S. Margaret Spivey-Faulkner. She's an archaeologist at the University of Alberta in Canada. She's also a citizen of the Pee Dee Indian Nation of Beaver Creek. That's in South Carolina. Many native communities, she notes, "have long-standing institutions [of] democratic and/or republican governance."

Democratic innovations

Democracy generally refers to rule by the people. Typically, people elect others to represent their interests. The United States is a democracy. Greece pioneered this form of government around 2,500 years ago. It then spread elsewhere in Europe. Many people have argued that democratic governments didn't exist in the Americas until Europeans arrived.

But that idea is misguided, says Jacob Holland-Lulewicz. He's an archaeologist. He works at Pennsylvania State University in State College. He's also a coauthor of the report on the Cold Springs site. Long before Columbus, he says, many Indigenous societies let communities govern collectively. And they were able to do this without kings or ruling chiefs.

There is a long history of this type of community decision-making. These arrangements go back thousands — and probably tens of thousands — of years. And they did so in many parts of the world. They kept any one person from amassing too much power and wealth.

But only in the last 20 years have researchers begun to seriously consider such claims. Informed by Indigenous partners, science will unveil past political realities that "most of us in Indian country take for granted," Spivey-Faulkner says.

This reconstruction of an Indigenous council house from the 1600s can be found in Tallahassee, Fla. In many parts of what's now the southeastern United States, such structures hosted public meetings and ceremonies.

UGA LABORATORY OF ARCHAEOLOGY

This pottery is stamped with a design distinctive to the region where it was made.

CERAMIC TECHNOLOGY LABORATORY/FLORIDA MUSEUM OF NATURAL HISTORY/UNIV. OF FLORIDA

To see who met in ancestral Muscogee council houses at a Georgia site, researchers compared the stamped designs on pottery unearthed there with pottery found at other sites across the southeastern United States, such as the ceramic fragments above.

Early consensus

A finding by Thompson's team at the Cold Springs project points to the early value of *consensus*: a value or decision arrived at by most people in a group.

Ancestors of today's Muscogee (Creek) people built structures throughout their homeland. The area stretched across a big chunk of what is now the U.S. Southeast. When European settlers arrived, they wanted to farm some of this land. So the early U.S. government entered into a series of treaties with the Muscogee. They allowed settlers into some of this land. Over time, the settlers wanted more and more land to farm. Treaties shrunk the area reserved for the Muscogee and other tribes.

Eventually, in the 1830s the U.S. government forcibly evicted the Indigenous peoples left here to lands west of the Mississippi River. This ended their democratic self-government. Their infamous relocation came to be known as the Trail of Tears.

Three members of the Muscogee Nation helped author the Cold Springs study. All three work at their nation's Department of Historic and Cultural Preservation. It's in Okmulgee, Okla. This trio provided other researchers with first-hand knowledge of Muscogee society. Even today, Muscogee councils make decisions based on consensus. Those agreements emerge through open debates. The Muscogee members told researchers that this style of governing comes from a tradition that goes back *hundreds* of generations.

Since the 1970s, researchers have found some evidence for this form of government at the Cold Springs site. They found it in materials there — some up to 1,500 years old. From roughly 500 A.D. to 700 A.D., Indigenous people, Thompson's team learned, had erected earthen mounds at the Cold Springs site. Those ancients also built at least three council-style roundhouses. Several of their smaller structures may have been used for temporary housing during meetings and ceremonies.

Small communities spread across the Oconee Valley formed tight-knit social networks. These were known as clans. Thompson's group now suspects that clans gathered at council houses (such as those at Cold Springs) through the 1700s. Spanish expeditions came through the region from 1539 to 1543. Many people had assumed that the Spanish caused a collapse of those societies and their traditions. But this was not the case, the researchers now argue.

And research at another Muscogee site supports that view.

It's called Dyar. The site also sits in the Oconee Valley. A square ground near Dyar includes remains of a council house. Activity there began as early as 1350. It continued until about 1670. This was about 130 years after the Muscogee's first encounters with the Spanish. Holland-Lulewicz and colleagues reported this finding in *American Antiquity*.

Spanish historians had mistakenly assumed that powerful chiefs ran Indigenous communities. Many researchers also have wrongly assumed that starting around 1,000 years ago, chiefs had all the power in these villages.

Today, members of the Muscogee Nation in Oklahoma gather — sometimes by the hundreds or more — in circular structures. These, too, are called council houses. And here, the people still reach consensus about community issues. Council houses typically border public squares. That's a modern-day parallel to the story being told by the ancient structures at Cold Springs.

"Muscogee councils are the longest-surviving democratic institution in the world," Holland-Lulewicz concludes.

Indigenous influencers

The early Muscogee people weren't alone in supporting group rule. Across North America, Indigenous peoples were building societies that had no kings or central national governments. Holland-Lulewicz and his colleagues reported this in *Frontiers in Political Science*.

People from households, clans and religious societies (to name a few) met as equals. They followed common rules to air their opinions. They hammered out decisions. These might have to do with anything from distributing crops to resolving disputes.

Consider this example from the early 1600s. Native peoples in northeastern North America — the Wendat (Hurons) and Haudenosaunee — had formed alliances. The alliances were known as confederacies, notes Jennifer Birch. She's a University of Georgia archaeologist. The peoples were governed through negotiations among clans. Clans were made of people from across society. Membership in a clan was inherited from mother to child.

Clans were — and still are — the social glue holding these peoples together. Residents of different villages or nations could belong to the same clan. This created a network of social ties. Excavations of Indigenous villages in eastern North America support this. They suggest that the earliest clans date to 3,000 years ago or more, Birch says.

Within clans, men and women held separate council meetings. Some councils addressed community affairs. Others addressed military and foreign policy. This typically happened after receiving advice from senior women in a clan.

Decisions hinged on negotiation and consensus. A member of any one clan had no right to interfere in the affairs of any other clan. Members of villages or nations could accept (or reject) a clan leader to represent them in their council. Clans also could join forces to pursue political or military goals.

Kandiaronk was a Wendat chief from the late 1600s. He was a philosopher and statesman. Some researchers today suspect he influenced ideas about democracy among people in France and elsewhere. Researchers now debate whether writers of the U.S. Constitution also had been influenced by the confederacy to which his people belonged. However, the U.S. Constitution stresses individual freedoms. Indigenous systems instead address as a group how to manage their lands, water, animals and people.

Excavations at the ancient Mexican city of Tlaxcallan unearthed these remnants of a house.

L. FARGHER

Anti-Aztec equality

One of the most interesting examples of democracy emerged around 700 years ago in what is now central Mexico. There, groups had allied themselves against the Aztec Empire. These native peoples came together in a multi-ethnic confederation of villages. It was called Tlaxcallan. A densely occupied city emerged there with the same name.

NORADOA/SHUTTERSTOCK

This scene (above) is part of a mid-20th century mural that can be found inside the Government Palace of Tlaxcala in Mexico. The massive artwork, painted by Mexican artist Desiderio Hernández Xochitiotzin, depicts the history of the Tlaxcala people, from their founding through their fall to Spanish conquistadors.

When Spaniards arrived in 1519, they wrote of Tlaxcallan as a city without kings, rulers or wealthy elites.

Until the last decade, Mexican historians had argued that Tlaxcallan was not a city. They called it a minor settlement. They dismissed what Spanish historians had written. But opinions have now changed. Lane Fargher is an archaeologist. He works in Merida, Mexico, at the Center for Research and Advanced Studies of the National Polytechnic Institute. He's part of a team that has studied the remains of Tlaxcallan structures. Those studies revealed a much larger and denser settlement than had been suspected.

This ancient city covers a series of hills, Fargher says. People there had carved large terraces out of hillsides. These supported homes, public structures, plazas, earthen mounds and roads. By the early 1500s, some 35,000 people lived in the area. It covered only about 4.5 square kilometers (1.7 square miles).

Artifacts from its plazas show that those open spaces hosted businesses. Political and religious activities also took place there. Houses clustered around the plazas. Even the largest homes were not very big.

Evidence there suggests all Tlaxcallan folks could participate in governing. Anyone known to provide good advice on local issues could be elected to a citywide council, or senate. As many as 4,000 people attended local council meetings. There they discussed important issues, such as whether to launch battles, Fargher says.

People chosen for council positions had to endure a public ceremony. In it, they were stripped naked, shoved, hit and insulted. This was a reminder that they served the people. Political officials who grew too wealthy could be publicly punished, replaced — even killed.

Yet Tlaxcallan was no paradise. Women, for instance, had limited political power. That's because military service was usually the main route into government. But in many ways, political participation at Tlaxcallan equaled or exceeded that of the democracy in ancient Greece. All Greeks could gather in public spaces to speak freely about politics. But in their society, commoners and the poor could not hold the highest political offices. And here, too, women were excluded. Fargher and his team shared what they learned in *Frontiers of Political Science*.

Tlaxcallan aligned itself with Spanish conquerors against Mexico's Aztec empire. It had been their common enemy. Then, in 1545, the Spanish divided Tlaxcallan into four parts. That ended its style of democratic rule.

This story illustrates, Fargher says, that when people are governed by systems that broadly distribute power, those systems may not last. People tend to be bad at building and maintaining democratic governments, he says.

But looking into the ways that past societies have experimented with democracy is good, Holland-Lulewicz says. It may inspire reforms to modern democratic nations. Many of these places face growing income inequalities and a distrust of authority. He suggests that people in stressed democracies could learn more about power-sharing from Indigenous societies.

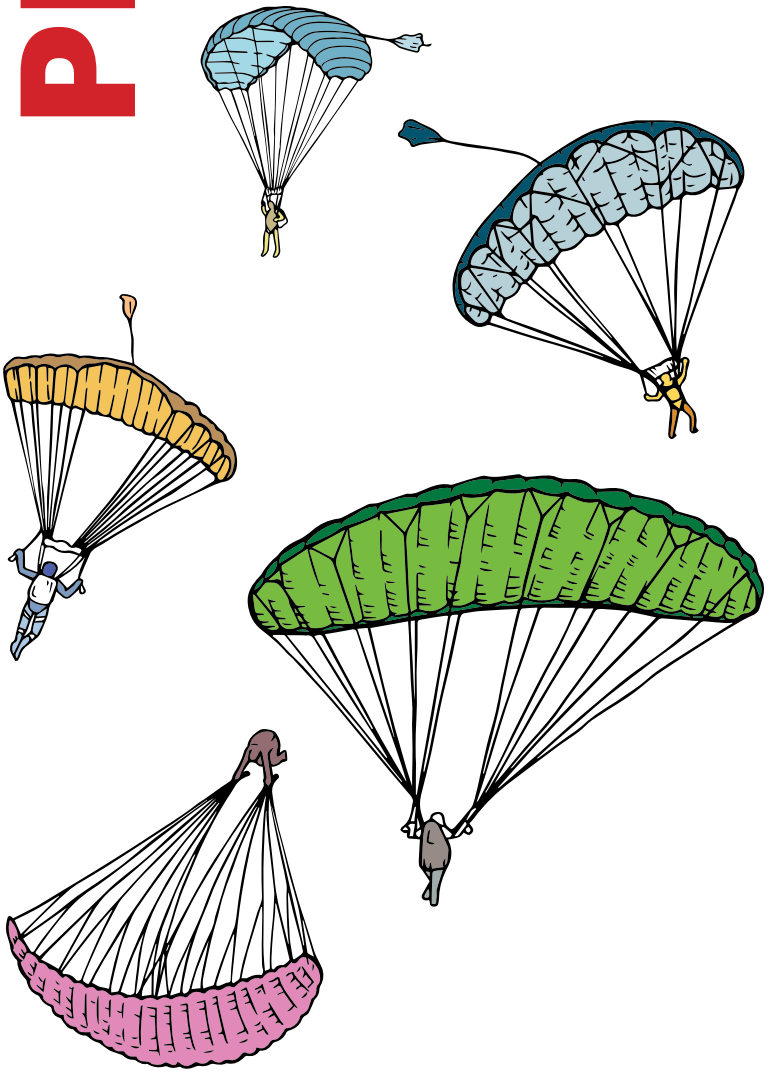
PHYSICS

Does a parachute's size matter?

Let's test whether bigger parachutes fall slower

By Science Buddies

When a skydiver leaps from an airplane, they use a parachute to slow their fall. The parachute does this by causing air resistance, or drag force. Air pushes the parachute upward, against the force of gravity pulling the skydiver down. As the skydiver falls, these forces nearly balance out. But do bigger parachutes slow skydivers more than smaller ones?



OBJECTIVE

Determine whether a parachute's size affects its flight.

EXPERIMENTAL PROCEDURE

1. Cut four garbage bags open into flat sheets.

2. Using a ruler, cut a square of plastic out of each sheet with widths of 20 centimeters, 30 cm, 40 cm and 50 cm.

3. Tie a knot at each corner of each parachute.

4. Cut 16 pieces of string, each 40 cm long.

5. Tie one end of each piece of string to a knot at the corner of a parachute.

6. Collect and tie together the free ends of each parachute's four strings.

7. Attach a washer to each bundle of strings with a twist tie. Or tape two pennies to each bundle of string.

8. Drop each parachute from the same height, and time how long it takes to reach the ground.

9. Test each parachute three times, and record your results in your notebook.

10. Average the three fall times for each parachute.

11. Graph your data, plotting a parachute's size on the X axis and its average time to fall on the Y axis.

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

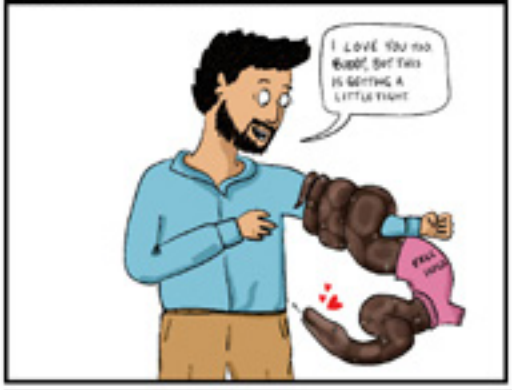
SCIENCE BUDDIES

ARTCHI ART/SHUTTERSTOCK

How boas keep squeezing while breathing

Written by Maria Temming
Illustrated by JoAnna Wendel

The boa constrictor's grip is one powerful flex. Coiled around its prey, a snake can squeeze the life out of a victim in mere minutes.



But how do these snakes squeeze so tight — or swallow large prey — without cutting off their own air supply?

To find out, researchers wrapped a blood pressure cuff around three boa constrictors.

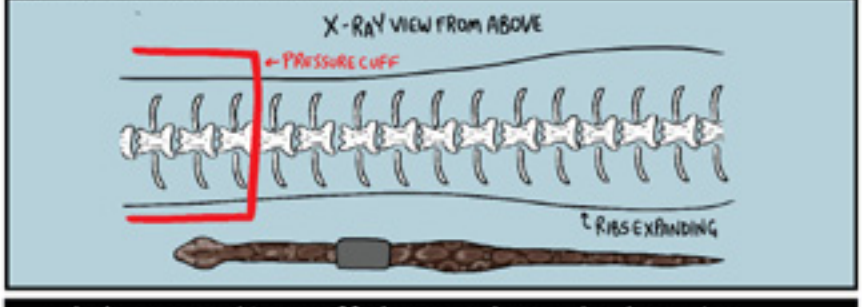
The cuff's squeeze mimicked the effect of a snake using part of its body to grip or gulp down prey.

It stopped a snake's ribs from moving — and lungs inflating — in that area.

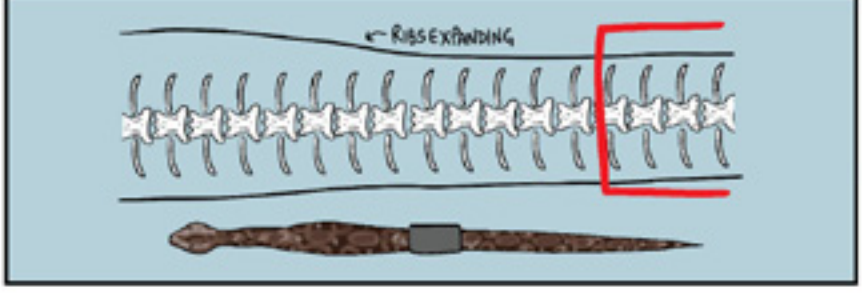
Not all the snakes were thrilled about this plan. "I had to watch my back a bit," says John Capano. He's a biologist at Brown University in Providence, R.I. But all the boas settled down once the cuff was on.

Snakes' lungs extend throughout much of their bodies. X-ray videos showed that boas use different parts of their lungs to breathe while being squeezed in different places.

When gripped by a cuff closer to their heads, the snakes breathed by moving ribs closer to their tails...



...and when gripped by a cuff closer to their tails, the snakes breathed by moving ribs closer to their heads.



Such carefully controlled breathing was probably crucial for snakes to start throttling and swallowing large prey. That, in turn, could have helped snakes adapt to habitats all over the globe.

MATERIALS

Fashion-forward fabrics change color as they stretch

A Nobel Prize-winning invention from more than 100 years ago inspired them

What if your clothing shifted from red to green to blue as you moved and stretched? A new fabric could make this possible.

"I want to have a leotard that changes color as I'm running around," explains graduate student Ben Miller, who studies mechanical engineering. He and his colleagues at the Massachusetts Institute of Technology in Cambridge created the new fabric.

The colors of crayons, paints and clothing usually come from chemicals in dyes and pigments. Those substances reflect one color and absorb others. For instance, the pigments in a red crayon reflect the red light that people's eyes detect.

The new material instead changes shades due to structural color. It's caused by an arrangement of surfaces inside a material that reflect only certain hues. For example, a blue butterfly has microscopic layers of scales in its wings. These are arranged so that they bounce back only blue light. All other colors pass through.

The angle at which a viewer looks at a structurally colored surface can alter how much light they see bouncing back. This often causes the colors to shimmer or shine. Structural color "makes a soap bubble shiny. It also makes a lot of animals shiny," explains Mathias Kolle. This mechanical engineer at MIT worked on the new fabric.

Many researchers have made structurally colored materials. But Miller's team is the first to create large, detailed, stretchy images using low-cost, widely available equipment.

They didn't even have to invent anything completely new. They used a technique from more than 100 years ago. The work appeared in *Nature Materials*.

INSPIRED BY ART AND HISTORY

Miller's inspiration for the stretchy material was first sparked in art class. His professor brought in examples of holographic art. Holography is a technique that makes images without using a camera. Instead, a laser records the 3-D shape of an object as tiny structures etched into a plastic film. That creates an image that changes shape depending on how you view it. To Miller, the holograms' tiny structures looked awfully similar to structural colors in nature.

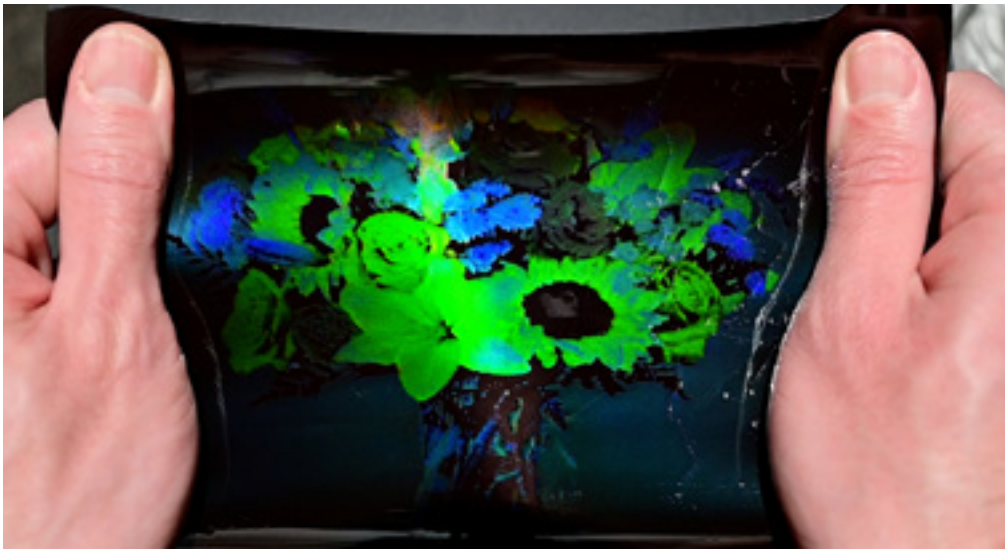
So Miller began studying the history of holography and stumbled upon the work of Gabriel Lippmann. This French scientist invented a way to make structurally colored photographs in 1891. Lippman won the Nobel Prize in physics for his invention. Unfortunately, the process was not only slow, but also "dangerous and messy," says Miller. So it never caught on. People found other ways to make color pictures.

Miller realized that modern materials could solve all the problems with Lippman's process. To create a Lippman photograph, he used a mirror, a piece of holographic film and a projector like ones you might find in a school classroom.

Here's how it works. A colored image from the projector shines through the layers of the film and onto the mirror. Then it bounces back through the film. These coming-and-going waves of colored light print a pattern of more-dense and less-dense areas into layers of the plastic film. The distance between each dense area matches up perfectly to the wavelength of light that created it. In this way, colors get recorded as tiny structures in the film.

Next, Miller stuck the structurally colored film onto a stretchy material. As it stretches, the dense areas within the film get closer together. That changes the color of light they reflect. An area that starts out red will now appear green and then blue.

If Lippman were alive today, Kolle thinks he might say: "Finally, somebody got this to work."



Stretch this fabric and watch red flowers turn green or blue.

WHY MAKE STRETCHY, COLOR-CHANGING STUFF?
Many artists and fashion designers might love working with stretchy, color-changing fabrics. Such materials could be useful in sensors, too. That's because the color reveals how much stress or pressure the material is experiencing.

"It's really cool," says Bruno Frka-Petesic. He's a physicist at the University of Cambridge in England who did not take part in the new research. The researchers managed to print small, micrometer-scale details of structural color over a large area of around half a meter (1.6 feet). And their process costs little, he says.

Structural color can create visual effects that aren't possible with pigments, adds Rupa Darji. She's a chemist at BASF Corp. in Tarrytown, N.Y. Darji, too, played no role in creating the new material. "I think people will be using structural color more widely in the future," she says. "It's exciting to think about new colors for coatings or cosmetics or just about anything!"
— *Kathryn Hulick*

These flowers aren't printed with ink. The colors come from the way light bounces off tiny dense spots inside the material. Stretching the film pulls those dense areas closer together and changes what color light they reflect.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

ROBOTICS

Can we build Baymax?

Roboticists break down what it would take to make a big, friendly robot

Even if you're not familiar with *Big Hero 6*, a comic series and Disney movie, or the recent Disney+ show *Baymax!*, the robot Baymax might look familiar. He's a six-foot-two-inch, round, white, inflatable robot nurse with a carbon-fiber skeleton. Tasked with health care duties, Baymax calmly cares for his patients. He supports a middle-school student who gets her period for the first time. He helps a cat that swallowed a wireless earbud. And though Baymax constantly gets poked with holes and must reinflate himself, he is still a great health care provider. He also makes a great pal.

Soft robots already exist, as do most of the pieces that you'd need to create a big, friendly Baymax. But putting them all together to form a robot that we would want to have in our homes is another story.

"There's all kinds of things that need to come together to make something as amazing as Baymax," says Alex Alspach. He's a roboticist at Toyota Research Institute in Cambridge, Mass. He also worked for Disney Research and helped develop the movie version of Baymax. To build a real Baymax, he says, roboticists will need to address not only hardware and software, but also human-robot interaction and the design or aesthetics of the robot.

The software — Baymax's brain, basically — might be something like Alexa or Siri, so that it gives personalized responses to each patient. But giving Baymax such a smart, humanlike mind will be hard. Building the body will probably be simpler, Alspach suspects. Still, even that will come with challenges.

The first challenge will be keeping the robot's weight down. Baymax is a big bot. But he needs to be lightweight to help keep people and pets safe, says Christopher Atkeson. This roboticist works at Carnegie Mellon University in Pittsburgh, Pa. His research focuses on soft robotics and human-robot interaction. He helped create a soft inflatable robotic arm that inspired the design of Baymax.

But keeping the robot inflated poses another problem. In the movie, whenever a hole is poked in Baymax, he covers himself with tape or a Band-Aid. Baymax can also inflate and deflate himself when he needs to, but it takes a long time. It's realistic, Alspach says. But complex hardware would be required.

In addition to safety, staying soft and lightweight would keep the robot's parts from getting damaged, Alspach says. But when making a life-size humanoid robot, that will be difficult, since so many moving parts — such as motors, a battery pack, sensors and the air compressor — will pack on weight.

These robots are "definitely not going to be squeezable, cuddly anytime soon," says Cindy Bethel. Bethel is a roboticist at Mississippi State University. She focuses on human-robot interaction and artificial intelligence. She also owns a stuffed Baymax. For now, she says, robots will look more like the Terminator than a massive, plump Squishmallow.

Another issue that will have to be overcome to build a giant soft robot is heat from the motors and other electronics. Anything soft covering the frame of a robot will trap heat.

Bethel created a soft dog robot called Therabot. It's a stuffed animal with robotic parts on the inside that helps patients with post-traumatic stress disorder (PTSD). Here the heat isn't such a big problem, since it makes Therabot feel more like a real dog.

MAXIMUM FILM/ALAMY

Therabot, a robotic stuffed dog, helps patients with post-traumatic stress disorder.

But Baymax will be much bigger than a dog and would generate more heat. Such a robot might overheat and shut down or even catch on fire.

Baymax's walk is yet another challenge. It's more like a slow waddle. But he is able to navigate around and squeeze through tight spaces. "I don't know of anybody who can make a robot move like that right now," Bethel says. And the electricity to power that movement might require Baymax to drag a long extension cord behind him.

BAYMAX WILL SEE YOU NOW

Bethel's Therabot cannot walk yet. But it does have sensors that respond differently if the stuffed dog is petted than if it is held by the tail. Baymax will also need sensors if he is to, for instance, hold and pet a cat, recognize that you're hurt or having a bad day, or accomplish many of his other tasks.

Medical scanning technologies that a robot nurse could use to diagnose illnesses or injuries are still being invented. But if you want a robot caretaker rather than a skilled nurse, that might be closer.

Will we see Baymax anytime soon? "There's going to be a lot of dumb robots before you get to something as smart as Baymax," says Alspach. But most experts agree that big steps toward making Baymax will come soon. "I think kids will get to see that in their lifetime," Alspach says. "I'm hoping I get to see it in my lifetime. I don't think we're that far."

— *Deborah Balthazar*

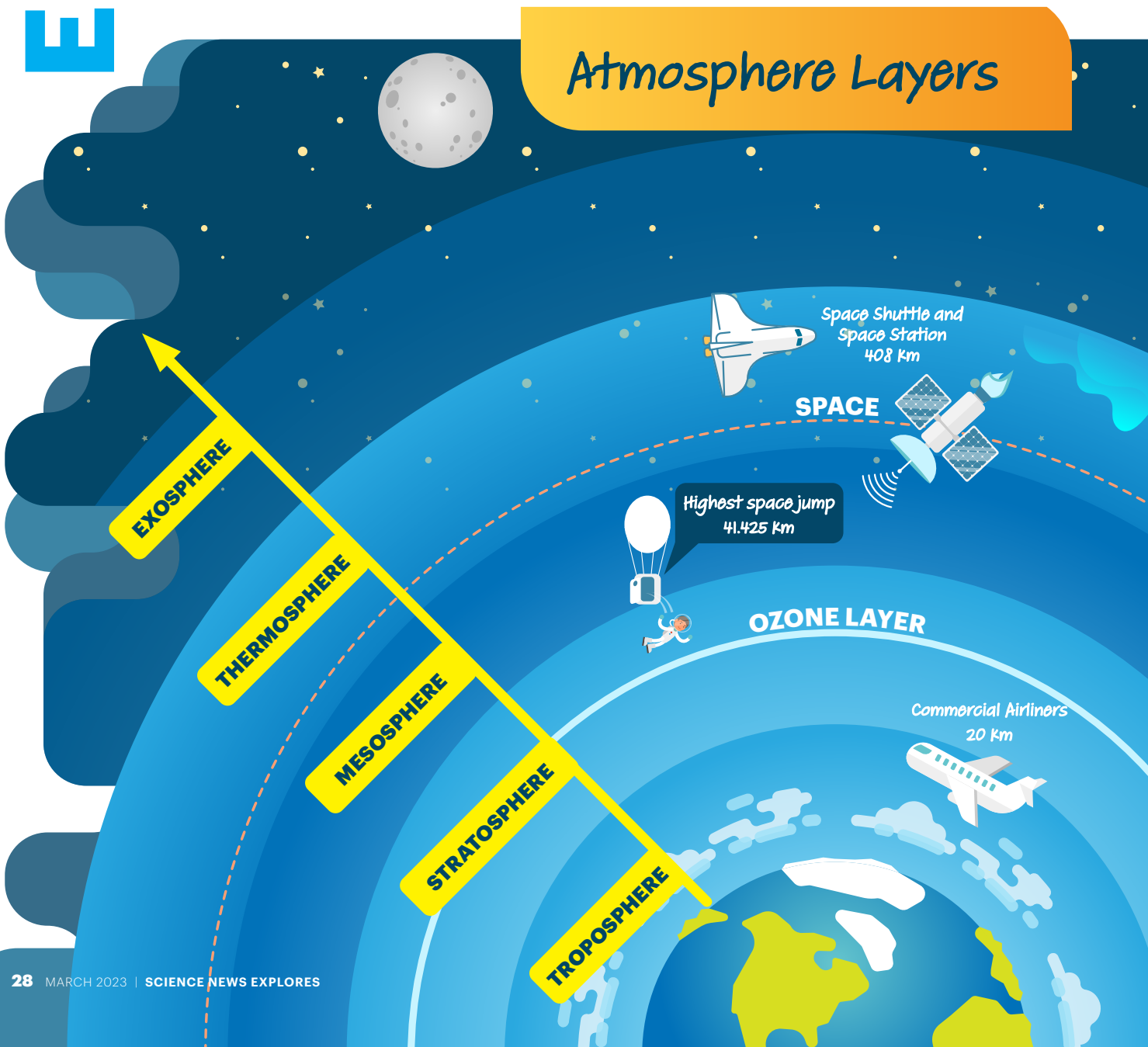
EARTH

Our atmosphere — layer by layer

Explore the air, from Earth's surface to the wispy edges where bits escape to outer space

Earth's atmosphere is all around us. Most people take it for granted. But don't. It shields us from radiation and prevents our precious water from evaporating into space. It keeps the planet warm and provides us with oxygen to breathe. In fact, the atmosphere makes Earth the livable, lovable home sweet home that it is.

The atmosphere is divided into five distinct layers. From the bottom layer to the top, the air in each has the same composition. But the higher up you go, the farther apart those air molecules are.



READY TO REACH FOR THE SKY? HERE'S AN OVERVIEW:

TROPOSPHERE

Earth's surface to between 8 and 14 kilometers (5 and 9 miles)

This layer holds nearly all of Earth's water vapor. It's where most clouds ride the winds and where weather occurs. Water vapor and air constantly circulate in turbulent convection currents. Not surprisingly, the troposphere also is the densest layer. It contains as much as 80 percent of the mass of the whole atmosphere.

VECTORMINE/SHUTTERSTOCK

STRATOSPHERE

14 to 64 km (9 to about 31 miles)

Clouds rarely form here because this layer is very dry. It also contains most of the atmosphere's ozone, triplet molecules of three oxygen atoms. This ozone protects life on Earth from the sun's harmful ultraviolet radiation. The stratosphere is also a very stable layer, with little circulation. For that reason, commercial airlines tend to fly in the lower stratosphere to keep flights smooth.

MESOSPHERE

64 to 85 km (31 to 53 miles)

Scientists don't know quite as much about this layer because it's harder to study. Airplanes and research balloons don't operate this high, and satellites orbit higher up. We do know that this is where most meteors harmlessly burn up as they hurtle toward Earth. If you ever travel this far (80 km or 50 miles), congratulations! You are officially a space traveler — aka astronaut — according to the U.S. Air Force.

THERMOSPHERE

85 to 600 km (53 to 372 miles)

This next layer soaks up x-rays and ultraviolet energy from the sun, protecting those of us on the ground from these harmful rays. The ups and downs of that solar energy also make the thermosphere vary wildly in temperature. This layer is also home to beautiful celestial light shows known as auroras.

EXOSPHERE

600 to 10,000 km (372 to 6,200 miles)

The exosphere has no firmly defined top; it just fades out into space. Air molecules here are so far apart that they rarely collide with each other. Earth's gravity still has a little pull here, but just enough to keep most of the sparse air molecules from drifting away. Still, some of those air molecules — tiny bits of our atmosphere — do float away, lost to Earth forever.

— *Beth Geiger*

ANIMALS

Octopuses may have favorite arms

They seem to prefer some arms for grabbing crabs and shrimp

With eight arms to choose from, octopuses may sometimes play favorites.

Researchers made this discovery by watching 10 California two-spot octopuses (*Octopus bimaculoides*) hunt. Marine biologist Flavie Bidel led the research while at the University of Minnesota in St. Paul.

The team placed each octopus inside a clay pot den in a tank of water. Then, either a live shrimp or crab was dropped into the tank. These two prey animals have different strategies for escaping a hungry octopus. A crab immediately skedaddles. But a shrimp might hang out for minutes before flinging itself away from a threat.

Octopuses used different hunting strategies, from waiting to ambush their prey to chasing them down. And when the octopuses went to snatch their snacks, they used their arms in two main ways. Octopuses sometimes grabbed with several arms at once in a synchronous attack. Other times, they used one arm at a time in a sequential attack. The octopuses favored different tactics for pursuing shrimp and crabs. And they seemed to have a preferred pair of arms.

The researchers shared their results in *Current Biology*.

— *Carolyn Wilke*

When researchers dropped crabs and shrimp into an aquarium, octopuses hunted the prey using a variety of strategies, from waiting in ambush to chasing it down.

DANIEL ESKRIDGE/SHUTTERSTOCK

OCTOPUSES' FAVORITE ARMS

To test which arms octopuses preferred, researchers dropped prey into their tanks. They tried to drop the prey in consistent positions. These spots were either on the right or left of the octopus and nearest the animal's front two arms. (Data for prey on octopuses' left sides are shown in yellow. Data for prey on the right are shown in orange.) Sometimes octopuses used one arm at a time to snatch their prey. Figure A shows how often octopuses used each of their arms first in this type of attack. (Left arms are labeled "L," right arms are labeled "R.") Other times, octopuses used several arms at once. Figure B shows how often octopuses used each of their arms in this attack strategy.

Prey position relative to field of view

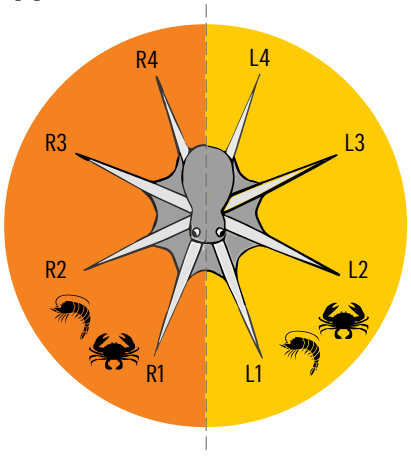


FIGURE A
First arm recruited in sequential strike

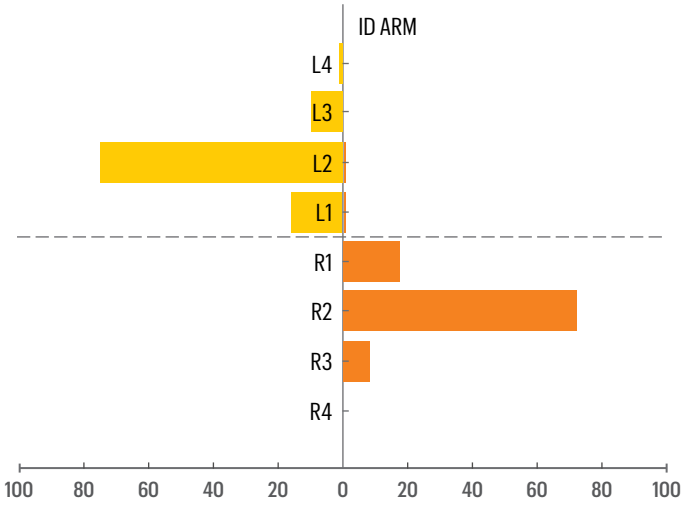
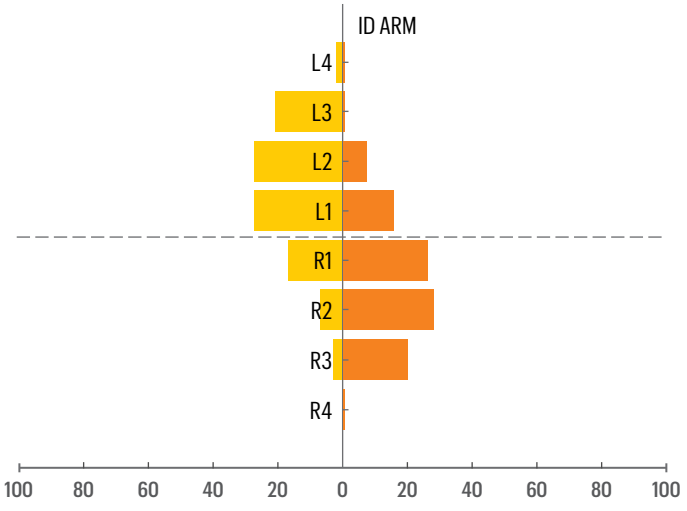


FIGURE B
Arm simultaneously recruited in synchronous strike



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DATA DIVE

1. Look at Figure A. This graph shows which arm the octopus uses first in a sequential attack. When the prey is on the left (yellow bars), which arm is usually the first used? What percentage of the time is this the first arm used? When the prey is on the right (orange bars), which arm is usually the first used? Compare how often the preferred arms are used first to the other two arms on the same side.

2. Look at Figure B. Which arm is most often part of the attack when prey is on the left (yellow bars)? Which arm is most often included when prey is on the right (orange bars)?

3. Based on your answers, which pair of arms may be octopuses' favorite?

4. The hand that you use most often is your dominant hand. Are you right-handed or left-handed? Write your name with your dominant hand. Now try writing it using your other hand. Which one looks better? What's the difference in how it feels to write these two different ways?

ANSWER

Jets may have sculpted the Cat's Eye nebula

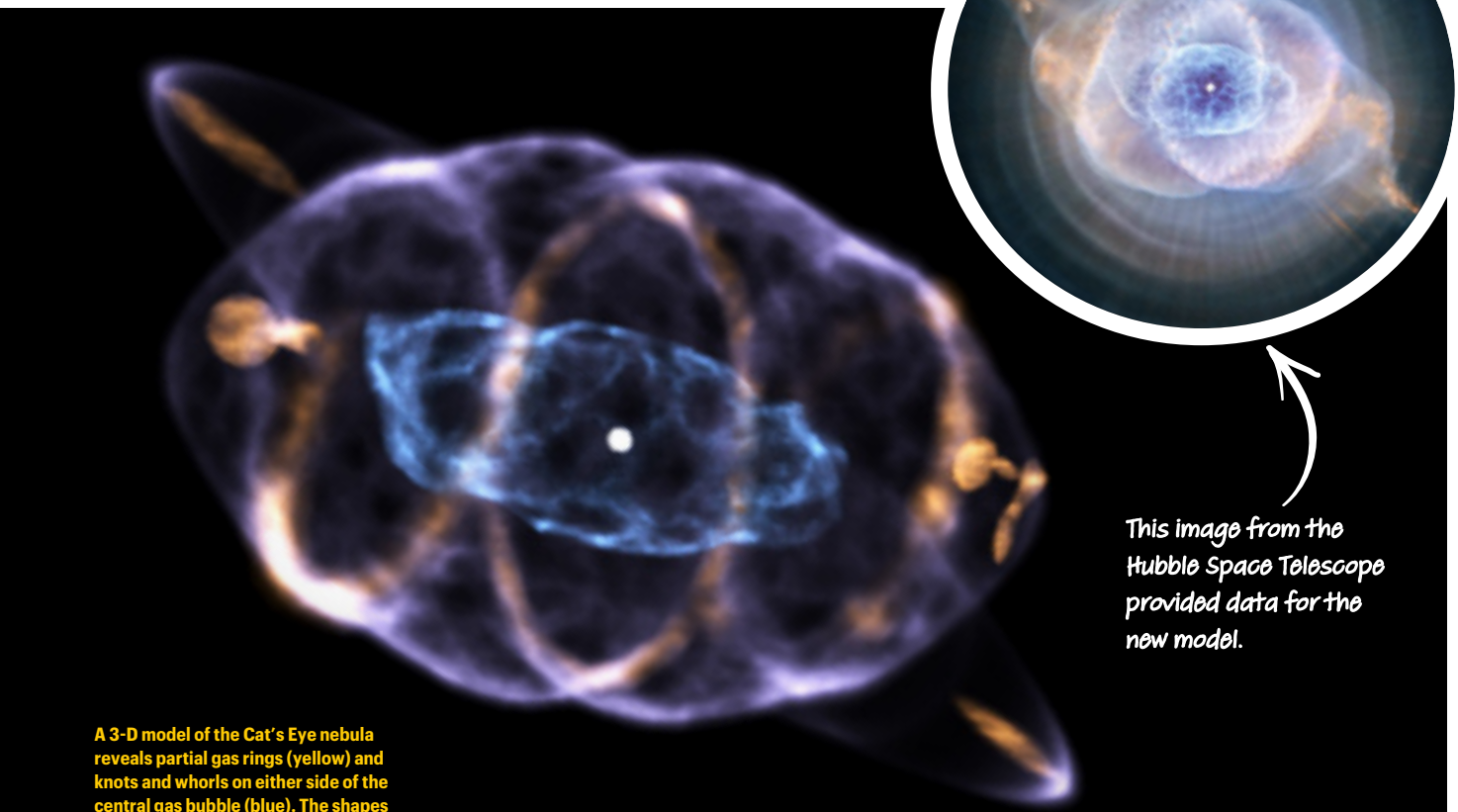
One student's curiosity unraveled this celestial mystery

The Cat's Eye nebula is a whirling cloud of gas and dust roughly 3,000 light-years from Earth. Left in the wake of a star's death, it is one of the most complex, mysterious nebulae out there. Now, a new computer model hints at how its intricate structure formed.

The model was based on observations from several telescopes, including the Hubble Space Telescope. The observations were taken in different wavelengths of light. Together, they revealed motions in the nebula's gas. That movement helped unveil its 3-D structure.

The team spotted two partial rings on either side of the nebula's center. The rings are symmetrical but not complete circles. Those details suggest that two stars in the nebula's center teamed up to launch two jets of plasma. These jets would have blasted out in opposite directions and formed the rings on either side of the nebula as they swiveled around. But the jets were probably snuffed out before completing a full circle, so the rings appear unfinished.

Ryan Clairmont, a college student at Stanford University in California, led the research. The results appeared in the *Monthly Notices of the Royal Astronomical Society*. — *Lisa Grossman*



A 3-D model of the Cat's Eye nebula reveals partial gas rings (yellow) and knots and whorls on either side of the central gas bubble (blue). The shapes were probably sculpted by jets erupting from the nebula's core.

This image from the Hubble Space Telescope provided data for the new model.

VISUALIZATION: R. CLAIRMONT; IMAGE: NASA, ESA, HEIC AND THE HUBBLE HERITAGE TEAM/STSCI/AURA (CC BY-NC-SA 4.0)

INSIDE THE MIND OF A SCIENCE AWARD WINNER

A winner of the Regeneron ISEF — a competition of Society for Science — answers three questions about science

Science competitions can be fun and rewarding. But what goes on in the mind of a winner? Regeneron International Science and Engineering Fair (ISEF) 2021 champion Neha Mani shares some of her science inspiration and ideas.

Q Which sci-fi advancement do you wish we had by now?
A I wish we could have dynamic oxygen tanks that extract dissolved oxygen from the oceans and compounded it with nitrogen so we could breathe underwater for as long as we want. Scuba diving has been a passion of mine. I've always wanted to wander along the majestic reefs and sandy shelves for longer than my tank allowed.

Q Which scientist — alive or deceased — would you want to solve scientific mysteries with and why?
A I have always admired the work of Sidney Farber (especially after reading *The Emperor of All Maladies* by Siddhartha Mukherjee). His seemingly simple discovery of the association between folic acid and leukemic cell proliferation paved the way for antifolate drugs to be administered as the first working, hematologic cancer therapeutic. If he were alive today, I would be so humbled and eager to work with him.

Q What would you like to be most renowned for?
A I think beyond scientific discovery and dreams of innovation, I would want to be renowned for humanizing my science. Though I have not settled on a career path yet, I believe any field combining medicine and research requires empathy for the problem at hand. While some say emotion is the enemy of rational thought, in science research, I find that it is perhaps the greatest motivator.

H. Robert Horvitz Prize for Fundamental Research

Neha Mani

Bronx, New York, native Neha Mani placed in the top seven of the nation's largest high school science fair, the Regeneron ISEF. She won for creating a novel tool distinguishing between bacterial swarming and swimming, which can be applied as a diagnostic device for inflammatory bowel disease (IBD). Neha's research has the potential to diagnose intestinal diseases that can sometimes be difficult to pinpoint, such as Crohn's disease and ulcerative colitis. Neha, now 19, is studying biochemistry and linguistics at Columbia University in New York City.

HAPPY BIRTHDAY
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